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META-ANALYSIS

Effectiveness of Reading Interventions on Literacy Skills for Chinese Children with and Without Dyslexia: a Meta-analysis of Randomized Controlled Trials

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Abstract

This meta-analysis synthesizes 49 standardized mean-change differences between control and treatment groups as effect sizes from 28 independent studies, investigating the efficacy of existing reading interventions on literacy skills for Chinese children. Six potentially important moderators were considered in this study. These moderators included intervention outcome, intervention method, intervention timing, participant type, intervention form, and intervention implementer. Overall, the existing reading intervention significantly impacted Chinese children's literacy achievement ($g = 0.68$). Different intervention methods showed somehow different effects on literacy outcomes. Specifically, fluency training ($g = 1.78$) appeared as the most effective intervention method with a large effect. Working memory training ($g = 0.80$), phonological training ($g = 0.69$), orthographic training ($g = 0.70$), and morphological training ($g = 0.66$) had significant and medium effects on improving literacy skills of Chinese children. In addition, reading intervention improved literacy skills of older children ($g = 0.90$) and younger children ($g = 0.63$) comparably. However, children with dyslexia ($g = 0.87$) seemed to benefit more than typically developing children ($g = 0.49$) from reading interventions. Reading interventions seemed to have a better effect on word spelling ($g = 0.93$) than word reading ($g = 0.63$). Interventions delivered in group ($g = 0.78$) seemed to be more effective than interventions delivered individually ($g = 0.45$). Children gained more from interventions administered by researchers ($g = 0.85$) or combined implementers ($g = 1.11$) than by parents ($g = 0.27$). These findings suggest that appropriate reading interventions are effective and essential for improving the literacy outcomes of Chinese children, but the efficacy might be different depending on the intervention methods, children's literacy status, outcome measures, and intervention settings.

Keywords Intervention · Dyslexia · Literacy skill · Chinese children

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Introduction

Reading is a crucial ability and foundation not only for education but also for daily life. Any impairments in reading ability can affect the quality of life in numerous ways (Jamshidifarsani et al., 2019). Reading is a complex and multifaceted process involving different skills, such as executive functions and cognitive-linguistic skills. It can be challenging for some individuals to acquire reading ability. This situation becomes more demanding for Chinese learners because Chinese is a script with extreme visual complexity (Chang et al., 2016). Therefore, facilitating literacy acquisition for Chinese children, especially for children with dyslexia, should be a common concern for teachers and parents. Many reading difficulties and disabilities can be prevented or alleviated if children are provided with appropriate reading interventions (Petersen et al., 2016). Current reading interventions for Chinese children differ widely in focus, duration, etc. Differences among interventions may be related to differential effects on literacy skills. The present study employs a meta-analysis approach to synthesize research on the effectiveness of reading interventions designed to enhance word-level skills among Chinese children. The aim is to determine the overall efficacy of these interventions and identify factors that influence their effectiveness.

The Chinese Writing System and Chinese Reading Acquisition

The basic writing unit of the Chinese writing system is the character, which is composed of strokes. Each Chinese character represents a syllable and a morpheme simultaneously. Many Chinese characters are compound characters that consist of a semantic radical indicating the meaning and a phonetic radical cueing the pronunciation of the character (Shu et al., 2003). For example, 骑 (qi 2, ride) contains the semantic radical 马 (ma 3, horse), and the phonetic radical 奇 (qi 2, strange). However, the phonetic radical is not always reliable for predicting the character's pronunciation. The connections between the pronunciation and the written characters are relatively arbitrary. Many Chinese words are compound words that are composed of two or more morphemes/characters. For example, 骑 can be combined with many other morphemes to build words with different meanings. These words include 骑马 (ride a horse), 骑车 (cycling), 骑行 (riding), and 轻骑 (light cavalry). In addition, there are many homophones and homographs in Chinese.

Chinese word reading acquisition involves many meta-linguistic and cognitive skills. Peng et al. (2021) expanded the Simple View of Reading (SVR, Gough & Tunmer, 1986) by adding meta-linguistic skills into the model and investigated the new model in the Chinese population. Meta-linguistic skills in the supposed model by Peng et al. (2021) included phonological awareness, rapid automatized naming (RAN), orthographic awareness, and morphological awareness. Their result showed that SVR could be applied to Chinese and meta-linguistic skills made significant direct and unique contributions to decoding. The result suggested that these meta-linguistic skills were essential for Chinese word reading acquisition. The Interactive Dynamic Literacy Model (IDLM, Kim, 2020) supports these results. In this

model, lexical-level literacy (i.e., word reading and spelling) acquisition requires a comprehensive set of emergent literacy skills and domain-general cognitive skills. The emergent literacy skills are the same as the meta-linguistic skills in Peng et al.'s (2021) model. The domain-general cognitive skills in IDLM mainly refer to executive functions. Working memory is one of the primary representative executive functions in the IDLM. According to IDLM, working memory is the essential base for the development of word reading and spelling. IDLM could be applied to many orthographies, including Chinese (e.g., Pan & Lin, 2023). Studies in Chinese children have found that working memory directly and indirectly contributes to Chinese word reading and spelling (e.g., Pan & Lin, 2023). In addition, working memory training appears to be the most frequently used method for improving literacy skills among the executive functions in Chinese studies (e.g., Luo et al., 2013; Yang et al., 2017). In conclusion, as reviewed above, Chinese reading acquisition requires a comprehensive set of meta-linguistic and cognitive skills. Training these skills would be possible to improve Chinese literacy.

A single character can be a word but most Chinese words consist of two or more characters. Character reading and word (composed of multiple characters) reading are highly correlated (e.g., Ruan et al., 2023b). However, several previous studies have suggested that character and word reading are likely to be two distinct processes in Chinese literacy (e.g., Pan et al., 2021; Wang & McBride, 2016). Character reading depends particularly on the understanding of the orthographic composition of the writing unit and its meaning; while word reading requires not only the meanings of the morphemes but also how they are combined into words (Pan et al., 2021). Therefore, orthographic awareness was found to explain unique variance in character reading even after statistically controlling for word reading (Wang & McBride, 2016). In contrast, rapid automatized naming and morphological awareness (especially in the form of lexical compounding) additionally explained variance in word reading even after statistically controlling for character reading (Pan et al., 2021). The model of the development of character and word learning in McBride (2016) also proposed that visual-orthographic skills play a prominent role in character learning and lexical compounding awareness plays a primary role in word learning. These distinctive aspects between character and word reading processes result in different focuses and effectiveness of reading interventions at the character or word level for Chinese children.

The Profile of Chinese Dyslexia

Previous studies have highlighted several common deficits in cognitive-linguistic skills of children with dyslexia across alphabetic and logographic languages (e.g., McBride et al., 2018). These skills include phonological sensitivity, morphological awareness, orthographic knowledge, and fluency. However, the degree and significance of these deficits might differ among different languages. Children with dyslexia in alphabetic languages often manifest the strongest difficulty in phonological skills (e.g., Morris et al., 1998). Nevertheless, some studies in Chinese have found that phonological skills tended to be less powerful in distinguishing Chinese children

with and without dyslexia as the phonological structure is relatively simple in Chinese (e.g., Ho et al., 2004). In contrast, impairments in morphological awareness, orthographic knowledge, and fluency are more significant in Chinese dyslexia. For example, some studies have demonstrated that difficulty in orthographic processing of character structure was one of the most dominant deficits underlying Chinese dyslexia (e.g., Ho et al., 2002). Chinese is a morphosyllabic language with many homophones (DeFrancis, 1984). Therefore, many researchers have suggested that the inability of Chinese dyslexia to differentiate among meanings of homophones and to discriminate morphemes results in their word reading failure (e.g., Peng et al., 2017). Moreover, Chinese is visually complex, and the correspondences between the pronunciations and characters in Chinese are relatively arbitrary. Some researchers suggested that deficits in orthographic knowledge and fluency might result in unstable and weak orthographic representations that lead to problems in automaticity and rapid retrieval, thus contributing to failures in word reading (Ho et al., 2002).

Different Types of Reading Intervention for Chinese Children

Several comprehensive systematic reviews on reading interventions in the alphabetic language system have suggested that intervention type might be a significant moderator of effect size (e.g., Scammacca et al., 2016). According to the Interactive Dynamic Literacy Model (Kim, 2020), literacy acquisition involves a comprehensive set of emergent literacy skills and domain-general cognitive skills. Emergent literacy skills included phonological, morphological, orthographic skills, and RAN. Other researchers have also suggested that phonological sensitivity, morphological awareness, orthographic knowledge, and fluency are four required components for successful Chinese reading (e.g., McBride & Wang, 2015). Working memory is the primary representative domain-general cognitive skill in the Interactive Dynamic Literacy Model. Effective interventions for most children involve explicit instruction and address different reading components. Based on these main linguistic components for reading acquisition, we classified reading interventions into five types: phonological, morphological, orthographic, fluency, and working memory interventions.

The phonological intervention aims to enhance children's sensitivity to syllables or phonemes and enable them to grasp the pronunciations of characters or words (e.g., Chen et al., 2016). This type of intervention often engages children in learning how to manipulate sounds in speech, including identifying, segmenting, deleting, or adding sounds in words (Alqahtani, 2020). While interventions aimed at training phonological sensitivity have been shown to improve the phonological skills of Chinese children, they do not appear to have a significant impact on their reading or writing abilities. For example, a phonological intervention study in Hong Kong applied activities related to syllable awareness, lexical tone sensitivity, and rhyme sensitivity to training children (Zhou et al., 2012). Results found that children in the training group outperformed children in the control groups on phonological sensitivity but not on the character recognition task. Another study focused on training Pinyin skills in a group of Chinese kindergarteners in Mainland China (Wang &

McBride, 2017). The results were that the training improved children's Pinyin skills compared with no training controls but not their word reading and writing skills. However, some other studies have also demonstrated that phonological training could improve Chinese reading abilities in the sample of Hong Kong primary school students with dyslexia (e.g., Ho & Siegel, 2016; Wang, 2017a). Many studies on the effect of phonological training in alphabetic languages also found that this type of intervention positively affected word reading (e.g., Müller et al., 2020). In addition, several previous meta-analysis studies in alphabetic language systems have indicated the relatively strong effects of phonological training on reading achievement (e.g., Bus & van IJzendoorn, 1999; Ehri et al., 2001). Chinese language depends less on phoneme-level skills, and the phonological structure of Chinese is simpler than that in alphabetic languages (e.g., Wong et al., 2012). Therefore, it is unclear whether the effect of phonological training would be different for Chinese children.

Morphological awareness refers to the perception and manipulation of morphemes and morphological structures (Carlisle, 1995). Morphological intervention often has activities to train children's ability to reflect on and manipulate morphemes and morphological structures and to distinguish homophones in Chinese. The essential characteristic of morphological intervention is that the meaning aspects of characters and lexical compounding are the main focus during the whole training procedure. Some meta-analyses of morphological interventions in alphabetic language systems have revealed a significant effect size on literacy achievement (e.g., Goodwin & Ahn, 2010). Intervention studies have found that training focused on morphological awareness significantly improved the literacy skills of Chinese children as well. One type of morphological intervention in Chinese includes combined instructions on the shape-to-meaning connections in pictographs and ideographs, the function of the semantic radicals to the meaning of characters, and the contribution of different morphemes/characters to the meaning of multiple character words. For example, one study applied this type of morphological intervention to Chinese first- and second-graders (Wu et al., 2009). They found that children who received the intervention made significant progress on reading and writing tasks after training when compared with the control group. Wang & McBride (2017) also used the same method and compared the efficacy of this morphological intervention with two other types of reading interventions (i.e., copying intervention and copying plus Pinyin intervention) for kindergarten children in Mainland China. The results revealed that this type of morphological intervention yielded the most remarkable improvements in word reading. Morphological awareness in the form of lexical compounding may help children to recognize unfamiliar characters within orally familiar words and to combine morphemes together to build new word forms (Wang & McBride, 2016). In addition, knowing the way to combine individual morphemes into multi-morphemic words helps children make educational guesses for the meaning of words and thus facilitate word reading (Zhou et al., 2014). Another type of morphological intervention applied homophone training to facilitate children's reading. Homophone training is targeted at sensitizing children's awareness to distinguish the same syllable with different meanings (Chow et al., 2008). In homophone training, children are often trained to match the homophones to pictures that correspond to their meanings. Homophone training as one type of morphological intervention showed good

efficacy for Chinese children (e.g., Chow et al., 2008; Zhou et al., 2012). Enhancing homophone sensitivity might help children map oral syllables onto printed words and become more aware of the morphosyllabic nature of Chinese (Chow et al., 2008).

Orthographic knowledge in Chinese involves recognizing and processing character configuration and structure, radical information, and positional and functional aspects of character components (e.g., Ho, 2014). The orthographic intervention involves systematic instruction to teach children the conventional rules of Chinese characters and draw their attention to the structure of the characters. The primary feature of orthographic intervention is that it focuses on the character level. One method often used in orthographic intervention is radical awareness training. This method is specific to Chinese script because radical is a unique structure for Chinese characters, not for alphabetic scripts. Different from training children to realize the contribution of semantic radical to characters' meaning in morphological intervention, radical awareness training in orthographic intervention mainly focuses on both phonetic and semantic radicals and emphasize the positional information of radicals. During the training of radical awareness, children are often presented with a group of characters sharing the same phonetic radical or semantic radical and instructed to understand the usage of radicals. Several studies have demonstrated that radical awareness training could improve word reading performance in Chinese children with and without dyslexia (Chen et al., 2015). This might be because paying attention to radical structure enhances the memorization of Chinese characters (Wang et al., 2004). Nevertheless, relatively few studies have explored the efficacy of other orthographic intervention methods individually. Lam & McBride-Chang (2013) provided orthographic instruction (i.e., stroke order training) and morphological instruction (i.e., the function of semantic radical) for parents to facilitate their children's literacy skills in Hong Kong. The results found that only the group of morphological training improved kindergarteners' performance in the dictation task compared with the control group. A study showed that orthographic intervention had its effect only when it was conducted together with other reading strategies (Leong et al., 2011). Research on the efficacy of orthographic intervention indicates that it has potential effects on Chinese reading ability.

Fluency intervention often utilizes two techniques as primary ways to improve reading ability. They are accelerated reading and repeated reading. Accelerated reading presents children with different sentences or paragraphs word by word or sentence by sentence. The presented speed will be adjusted according to the performance of children in responding to some questions. Repeated reading requires children to read the same passage multiple times with increasing speed. The importance of fluency in reading acquisition has been well-established across languages (e.g., Moll et al., 2014). Fluency training involves simultaneously processing phonological and orthographic information (Norton & Wolf, 2012). Intervention studies focused on training fluency in Chinese children have revealed good efficacy. For example, Dai et al. (2016) explored the effectiveness of a reading acceleration program for Chinese children with and without word reading disabilities. Their results showed that this type of intervention was effective in helping children to read faster. However, the indicator for the intervention effect of this study was

reading comprehension rather than word reading or spelling. Gao et al. (2020) applied another type of fluency intervention named Rapid Reading Skills Training (RRST) to train primary school children. They found that this method significantly improved the character reading performance of children who received the intervention. There are limited number of Chinese studies on the effect of fluency training. Therefore, the efficacy of fluency training should be concluded with caution, and more strict-designed investigations are needed.

Working memory intervention is another type of intervention focused on in the present meta-analysis. Working memory is not only a dynamic mechanism that involves simultaneous storage and processing of verbal and visuospatial information over short periods of time, but also a limited capacity of holding and manipulating informational chunks to handle complex cognitive activities (Mo et al., 2018). Given the complexity of visual-orthographic features and the relatively arbitrary and inconsistent correspondences between characters and pronunciations, working memory should play an important role in Chinese literacy acquisition. The Chinese writing system has many homophones and homographs. Successful Chinese literacy acquisition might require working memories to store as many morphemes of each syllable as possible, as well as to retrieve the correct morpheme effectively in different contexts (Pan & Lin, 2023). In addition, some researchers have proposed that working memory is probably essential for Chinese literacy because Chinese children traditionally learn to read by rote (Siu et al., 2018). Previous studies have suggested that working memory was a strong correlate of Chinese literacy skills (e.g., Mo et al., 2018). It could contribute to Chinese word reading and spelling even after controlling other cognitive-linguistic skills like morphological awareness (Pan & Lin, 2023). A specific focus on working memory may be particularly helpful for promoting literacy skills for Chinese children. This type of training often focuses on two components: verbal working memory and visuospatial working memory. Working memory intervention typically involves asking children to remember stimuli and complete related tasks after the stimuli have disappeared. For example, Luo et al.'s (2013) training used two tasks to train the working memory of Chinese children with dyslexia. The first task was a visuospatial task, in which children needed to remember the positions of some colored squares in a matrix. The second one was a visual verbal task, in which children were asked to memorize a sequence of the presented first three target characters. Children were required to recall these stimuli after the matrix or the characters disappeared. Studies on working memory training in Chinese children have revealed that this type of intervention positively affected word reading fluency (e.g., Luo et al., 2013; Yang et al., 2017). Training visuospatial working memory is effective for Chinese might be because reading and writing in Chinese rely greatly on visual-spatial skills. Chinese children need to attend to the subtle visual difference of radicals, individual strokes, and their positions within and between characters (e.g., Mo et al., 2018).

Some other types of reading interventions in Chinese have been investigated relatively rarely but still show good efficacy. One of them focuses on training the temporal processing skills of children. For example, Wang et al. (2019) and Zhang et al. (2018) used auditory and visual temporal processing tasks to train children's temporal processing skills. Both studies found that the performance of character reading

was improved after training. Additionally, intervention such as multisensory training was also found to enhance word reading and spelling in Chinese children (e.g., Ho, 2001).

Different types of reading interventions for Chinese children have received initial investigations in the last few decades. However, there are still some gaps. For example, the efficacy of some specific types of interventions is inconsistent and unreliable given limited evidence in Chinese studies. In addition, we do not know which kind of intervention is the most effective for Chinese children. The intervention method seems to be an essential factor in affecting the efficacy of reading interventions. For example, a study compared three types of interventions on three groups of kindergarteners: phonological awareness, lexical compounding, and homophone awareness interventions (Zhou et al., 2012). Their results showed that only the lexical compounding intervention improved children's word reading ability. This study indicates that different types of interventions might have different efficacy for Chinese children. Therefore, it is necessary to investigate the overall effect of the existing reading interventions for Chinese children and examine the best intervention specific to them.

Intervention Effects for Children with and Without Dyslexia

Different types of intervention participants between studies might possibly result in some variations in the intervention efficacy. The present study focused on children with and without dyslexia. Dyslexia is a word-level reading disability characterized by problems in accurate and fluent word recognition, decoding, and spelling (American Psychiatric Association, 2013). Diagnosis criteria for dyslexia are inconsistent across regions in China. For example, a standardized test battery containing the word reading task is used for identifying children with dyslexia in Hong Kong; while a character recognition task is commonly used for diagnosing dyslexia in Mainland China (McBride et al., 2018). Various diagnosis criteria might result in different focuses of interventions for Chinese dyslexia in different regions. Studies regarding whether children with low or high initial reading levels would benefit differently from interventions received inconsistent conclusions. For example, a study explored the effectiveness of a parent coaching approach on the literacy skills of Chinese children with and without dyslexia (Ruan et al., 2023b). The result found that children with dyslexia and typically developing children benefit similarly from the intervention regarding word spelling ability. However, only children with dyslexia significantly improved word reading ability after intervention. A meta-analysis on the effects of intensive early reading interventions in alphabetic language found that the level of initial reading achievement was not a significant moderator of the intervention effect (Wanzek et al., 2018). Some researchers suggested that children with different initial reading levels benefit from various aspects of interventions (e.g., Steenbeek-Planting et al., 2013). One study conducted working memory training for German grade 3–4 typically developing children and revealed that the training had significant and positive effects on children's word reading ability (Loosli et al., 2012). However, another German study also trained grade 3 children with

dyslexia by working memory intervention and found that these children did not benefit from the training (Maehler et al., 2019). In contrast, several studies have examined that at-risk children or children with dyslexia could befit more from the same type of intervention as compared with typically developing children (e.g., Baker et al., 2017; Wise et al., 2000). These inconsistent findings indicate the necessity to further examined the moderation effect of participant type on intervention efficacy. By comparing the intervention effects between children with dyslexia and typically developing children, we can determine whether the interventions are equally effective for both populations. This information is important for evaluating the generalizability and applicability of the interventions across different populations.

Intervention Effects on Different Outcomes

Word reading and spelling are two fundamental literacy skills (Ruan et al., 2023a). Word reading and spelling might influence each other in all phases of literacy development (Galuschka et al., 2020). However, these two abilities also involve their own specific processes. Therefore, we evaluate the effects of reading interventions separately for word reading and spelling in the present study. The ultimate goal of many reading interventions is to help children improve their literacy skills, which should include both reading and spelling. Many of the reading intervention studies showed that interventions improve not only children's reading ability but also their spelling ability. For example, Wang & McBride (2017) assessed the effects of different intervention programs for Chinese literacy development in kindergarteners. They examined that the intervention groups progressed significantly more than the control group in both reading and spelling abilities. Reading interventions work similarly for reading and spelling might be because most linguistic skills essential for reading acquisition are also crucial for spelling ability (Galuschka et al., 2020). Nonetheless, some studies showed that reading intervention only had an effect on reading ability but not spelling ability. For example, Ho & Ma (1999) applied phonological strategies training to facilitate the literacy skills of children with dyslexia. They found that only the character reading of the trained children improved after intervention but not word spelling. The presence of inconsistent findings suggests a need for further investigation into potential variations in intervention efficacy across different literacy skills (i.e., word reading and word spelling).

Influence of Intervention Timing on Intervention Effects

Intervention timing here refers to the ages at which participants received the intervention. Some researchers have suggested that distinct developmental periods when children first received reading intervention would yield different training effects (e.g., Snow et al., 1998). On the one hand, interventions conducted at an earlier age are supposed to be more effective than those conducted at a later age (Bogdanowicz et al., 2016). Some researchers suggest that children in upper elementary grades are not only expected to master basic word-level reading skills but are also required to be able to read text with comprehension (Wanzek et al., 2010). Therefore, it

becomes challenging for older children to benefit from basic reading interventions. On the other hand, interventions conducted at different grade levels seem to have similar efficacy. For example, a meta-analysis of intervention for struggling readers in grades 4–12 in alphabetic language systems found no significant differences in pairwise comparisons between mean effect sizes for studies that included children from different grades (Scammacca et al., 2015). It is possible that older children have mastered some compensated skills with experience so that they may become more competent in handling the intervention materials. Hence, it seems unnecessary that older children tend to gain less from reading interventions than younger children. Whether the intervention timing can affect intervention efficacy in Chinese children needs further investigation.

Influence of Intervention Setting on Intervention Effects

Many factors related to intervention setting can be moderators for intervention effectiveness. The intervention form (i.e., intervention delivered in groups or individually) might be a possible factor to influence the intervention effect. Some studies have evidenced that individual intervention is the most effective form of instruction (e.g., Pinnell et al., 1994). Other studies have shown that interventions implemented in groups for children with reading problems are as effective as or more effective than those conducted individually. For example, Ehri et al.'s (2001) meta-analysis on the effectiveness of phonemic awareness instruction showed that instruction was more effective when children were taught in small groups than individually or in the whole class. Some researchers suggest that the influence of the intervention form is probably dependent on the participants' individual needs, their intellectual potential, and the extent of the deficit (Bogdanowicz et al., 2016).

Another possible influencing factor for the intervention effect is the intervention implementer. Interventions targeted at improving children's literacy skills are often conducted by researchers, teachers, and parents. Some systematic review and meta-analysis studies on the effectiveness of reading instructions found that intervention implementers might influence the intervention effectiveness. For example, Ehri et al. (2001) found that phonemic instructions delivered by classroom teachers produced a statistically smaller effect size on the reading outcome than the effect size of researchers. Galuschka & Schulte-Körne (2016) summarized in their study that the effectiveness of the intervention reached significance when initiated by teachers and researchers, while the efficacy was not unequivocally confirmed when administered by parents. It seems that interventions implemented by experts in literacy development might facilitate children to make more improvements. The moderation roles of these influencing factors in intervention effectiveness should be further investigated in future studies.

The Present Study

The present study aimed to examine the overall effectiveness of different reading intervention approaches and the impact of various moderators on the efficacy of

interventions. We focused on six moderators: intervention method, intervention outcome, intervention timing, participant type, intervention form, and intervention implementer. Reading intervention studies in Chinese received researchers' attention only in recent decades. The results of these studies are not always consistent and reliable. Although some studies have examined the effects of different interventions for Chinese children, it remains unclear which type of intervention has the best efficacy and how various factors affect the intervention effects. In addition, intervention studies differed in focus, participants, intervention timing, etc. Hence, it is necessary to conduct a meta-analysis to synthesize findings across multiple studies. Meta-analysis is one of the best ways to analyze the overall tendency of existing studies through rigorous statistical analysis. Most current systematic reviews and meta-analyses on reading interventions were performed in alphabetic language systems. To our knowledge, the present study is the first meta-analysis to synthesize reading intervention studies for Chinese children. Understanding the effects of different types of interventions and the factors that influence intervention effects can help develop more effective and suitable interventions specifically for Chinese children, especially those with dyslexia.

The present study has two main research questions. First, what is the overall effect of current reading interventions on literacy skills of Chinese children with and without dyslexia? We expected to find that current existing reading interventions might have medium to large effects on improving the literacy skills of Chinese children. The reason for this hypothesis is that almost all reading intervention studies in Chinese report an improvement when compared intervention groups with the control groups. Some meta-analysis studies on the effects of different types of reading interventions in alphabetic language systems also reveal a significant result (e.g., Goodwin & Ahn, 2010). Second, how intervention method, intervention outcome, intervention timing, participant type, intervention form, and intervention implementer influence the effect of reading interventions? Phonological, morphological, orthographic, and fluency skills are core components required for successful reading acquisition (McBride & Wang, 2015). In addition, cognitive skills such as working memory were found to be correlated with literacy development (e.g., Siu et al., 2018). Therefore, meta-regression analysis for the comparison among different intervention methods might show that interventions focus on training different metalinguistic and cognitive skills have significant effects on improving skills but the magnitude of effectiveness might be different. Participant type might be another significant moderator for intervention effects. Children with dyslexia might gain more than typically developing children from reading interventions. Some researchers have observed that interventions conducted for children with dyslexia were more effective than those conducted for typically developing children (e.g., Baker et al., 2017). In addition, based on the results from previous studies, intervention form and implementer might be also significant moderators of intervention effects. However, intervention outcome and intervention timing might not emerge as significant moderators of intervention effects.

Method

Literature Search

Following the PRISMA guidelines (Moher et al., 2009), studies that potentially related to the topic of the present meta-analysis were searched in different databases. These databases included ERIC, PsycINFO, PubMed, and ProQuest. CNKI, an academic database used in Mainland China, was also used to search related work written in Chinese. We endeavored to search for relevant published and unpublished literature through these databases. We also searched relevant studies manually by checking the references of review or meta-analysis papers. The time range of the literature search started from the earliest possible date to the date of the present study conducted (i.e., March 2023). The following terms were used for the literature search: ("Chinese" OR "Mainland China" OR "Hong Kong" OR "Taiwan") AND ("dyslexia" OR "dyslexic" OR "reading difficulties" OR "reading difficulty" OR "reading disability" OR "reading disabilities" OR "reading disorder" OR "poor reader" OR "poor reading" OR "reading" OR "reader") AND ("intervention" OR "treatment" OR "training" OR "coaching" OR "instruction" OR "therapy" OR "remediation"). When searching in the CNKI database, these terms were translated into Chinese. The Chinese terms used for searching were as follows: ("汉语" OR "大陆" OR "香港" OR "台湾" OR "中文" OR "中国") AND ("阅读障碍" OR "阅读困难" OR "阅读差" OR "阅读" OR "读者") AND ("干预" OR "治疗" OR "训练" OR "辅导" OR "指导" OR "疗法" OR "补救"). Titles and abstracts of the searched studies were reviewed first to exclude those significantly unrelated papers. Considering the efficient data management, the first author and a trained undergraduate major in psychology were independently responsible for searching the literature and screening titles and abstracts in different databases. This approach could help expedite the initial screening process when dealing with a large volume of literature and improve overall efficiency. Several measures were taken to ensure the reliability of screening titles and abstracts between two coders. First, the two coders agreed on the same eligibility criteria and screening guidelines before searching and screening. Both coders adhered to the pre-set guidelines while screening titles and abstracts. Second, only those significantly unrelated papers were excluded. Papers with uncertainty all remained to be thoroughly read by the two coders. Any discrepancies or problems during the screening process of titles and abstracts were resolved through discussion and consensus between the coders. We intended to ensure that papers that might be eligible for the present meta-analysis were read thoroughly by all coders. The remaining papers were downloaded and read thoroughly for further processing.

Criteria for screening searched studies for the present meta-analysis are described below.

1. Study design: the study must use the pretest–posttest control-group design. The study should have a treatment group compared with a control group. The control

groups could be groups with no training or controlled training. To guarantee the observed effect sizes were likely attributed to the conducted interventions, the present study only included randomized controlled trials (RCTs). RCTs are considered to be the "gold standard" of education evaluation (Stentiford et al., 2018). It can reduce the risk of bias in the intervention efficacy and minimize the influence of confounding variables. Research has shown that the effects of interventions can be misjudged when meta-analyses include studies whose allocation concealment is inadequate (Pildal et al., 2007). To provide more accurate results of interventions' efficacy for Chinese readers, only including RCTs can ensure a high methodological quality of the meta-analysis. Moreover, comparing the effectiveness of different treatment approaches is available if they all used the RCT design. Many previous meta-analyses on the effects of reading interventions only include RCTs in their analyses as well (e.g., Galuschka et al., 2014; Goodwin & Ahn, 2010). In addition, interventions aimed at improving Chinese reading-related skills should be introduced in detail in the study.

2. Participants: the participants should be children with dyslexia or typically developing children. No other developmental, mental, or physical disorders were reported in the participants. We included studies on typically developing children because reading interventions for average readers could also provide significant implications for developing practical training for dyslexia. Some researchers have suggested that the same instructions may contribute less to typically developing readers but may make a big difference for children who have failed to make normal progress in learning to read (Ehri et al., 2001). Many previous meta-analysis studies on the effectiveness of reading interventions in the alphabetic language system also include both studies on typical readers and dyslexic readers in their analyses as we did (e.g., Bus & van IJzendoorn, 1999; Ehri et al., 2001; Jamshidi-farsani et al., 2019). In addition, as the number of intervention studies for children with dyslexia is limited, combining the two groups could increase the sample size and improve the statistical power. Including typically developing children allows us to examine the overall effectiveness of interventions for a broader range of readers and explore the moderation effect of participant type on the intervention efficacy. Furthermore, participants in the studies must be school-aged children (i.e., from preschool to the sixth grade), and they were native Chinese speakers.
3. Intervention indicators: studies should report at least one word-level literacy-related indicator. In the present study, we focused on two word-level indicators: character/word reading and spelling. The indicators tests should be administered before and after treatment.
4. Others: the study must provide sufficient statistics (e.g., sample sizes, means, and standard deviations) for computing effect size. The written language of the paper should be English or Chinese.

Figure 1 summarizes the process of selecting eligible papers for the present meta-analysis. As shown in Fig. 1, the initial database search resulted in 18814 records. We removed duplicate articles and significantly irrelevant articles after initial screening by reading the titles and abstracts. Afterward, 98 full-text articles remained and were carefully evaluated for eligibility. Based on the abovementioned

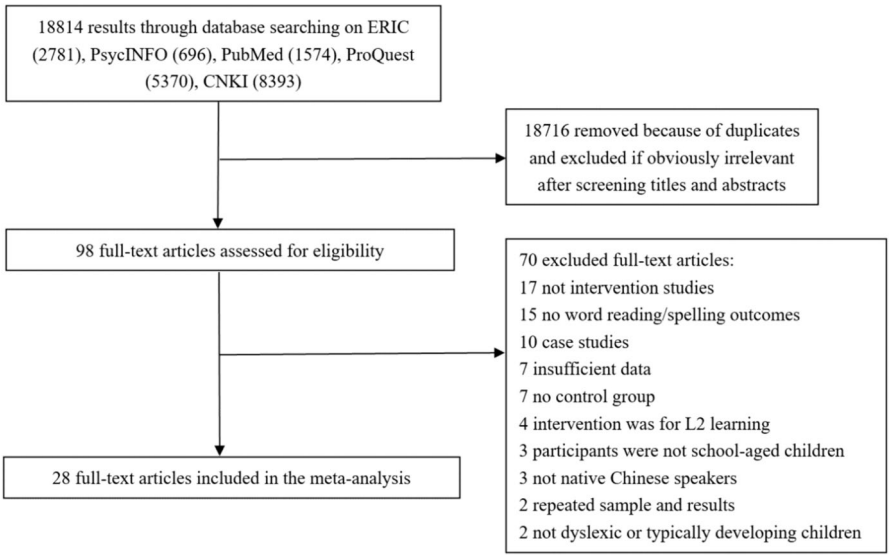

Fig. 1 Flowchart of the study selection process

criteria, we finally included 28 studies for analysis in the current meta-analysis. None of the studies were excluded because of the quasi-experimental design.

Coding Procedure and Interrater Reliability

Characteristics reflecting potential moderators for the intervention effects were coded. These characteristics included participant type, grade, age, intervention method, intervention outcomes, implementer, duration, the technology used or not, and intervention form. However, in the present meta-analysis, we focus on the influence of intervention timing, intervention method, intervention outcomes, participant type, intervention form, and intervention implementer. Table 1 provides the characteristics of the included studies. The moderators were dummy coded for further analysis. Intervention timing represented the mean age/grade of the intervention group. We classified intervention timing into two categories: young ages and old ages. Children younger than age 9 (group means) or in preschool to the third grade were classified as young ages, and children older than age 9 (group means) or in the fourth grade to the sixth grade were classified as old ages. This criterion was chosen because preschool to the third grade is often defined as the early elementary grades and the fourth grade to the sixth grade is often defined as the upper elementary grades in previous studies (e.g., Wanzek et al., 2018). Some researchers suggest that a shift from "learning to read" to "reading to learn" occurs in the fourth grade (Wanzek et al., 2010). The mean age of Chinese children in the third grade is about 9 years old. Therefore, age 9 was used to classify young ages and old ages in the present study. The intervention method was grouped into six categories according to the focus of the intervention in each study. These categories included phonological,

Table 1 Characteristics of the included studies

Study	Participant	Mean age	Grade	Intervention	Outcome	Implementer	Duration	Technology	Form	Control group type
Ho & Ma (1999)	Dyslexic	8.50	P2-P5	PI + O + M	Reading + spelling	-	5 sessions	Yes	Individual + group	Untrained
Ho (2001)	Dyslexic	9.96	P3-P5	Multisensory training	Reading + spelling	Researcher	10 h	No	Group	Another training
Liu, (2006)	Dyslexic	8.99	P3	O + PI + M + Audiovisual training	Reading	Researcher	2700 min	No	Group	Untrained
Chow et al. (2008)	Typical	5.32	K	Group 1: M + Dialogic reading Group 2: dialogic reading	Reading	Parent	480 min	No	Individual	Untrained
Wu et al. (2009)	Typical	6.75	P2	M + O + PI	Spelling	Teacher	1 year	No	Group	Untrained
Chow et al. (2010)	Typical	5.23	K	Dialogic reading	Reading	Parent	480 min	No	Individual	Untrained
Ho et al. (2012)	Typical	6.29	P1	M + O + Oral language + syntactic skills	Reading	Teacher	3 years	No	Group	Untrained
Zhou et al. (2012)	Typical	6.17	K	Group 1: M Group 2: M Group 3: PI	Reading	Teacher	400 min	No	Group	Another training + untrained
Lam & McBride-Chang (2013)	Typical	5.37	K	Group 1: O Group 2: M	Reading + spelling	Parent	320 min	No	Individual	Untrained
Luo et al. (2013)	Dyslexic	10.55	P3-P5	WM + central executive function	Reading	Researcher	1400 min	Yes	Individual	Placebo training

Table 1 (continued)

Study	Participant	Mean age	Grade	Intervention	Outcome	Implementer	Duration	Technology	Form	Control group type
Chen et al. (2015)	Dyslexic	7.28	P2	O	Reading + spelling	Teacher	7880 min	No	Group	Untrained
Bai (2016)	Dyslexic	8.04	P2-P3	PI + lexical network	Reading	-	-	No	Group	Untrained
Chen et al. (2016)	Dyslexic	6.54	P1	PI + O + F + grammar + book reading	Reading + spelling	Teacher	17 weeks	No	Group	Untrained
Yang et al. (2016)	Typical	7.34	P1	Story books reading	Reading	Teacher	5 months	No	Individual	Untrained
Wang (2017a)	Dyslexic	8.21	P3-P6	PI	Reading	Researcher	300 min	No	Group	Untrained
Wang & McBride, (2017)	Typical	6.28	K	Group 1: O Group 2: M + O Group 3: PI + O	Reading + spelling	Researcher	480 min	No	Group	Untrained
Wang (2017b)	Dyslexic	8.83	P3	F	Reading	Researcher + teacher	12 h	No	Group	Untrained
Yang et al. (2017)	Dyslexic	9.77	P3-P5	Group 1: WM Group 2: WM	Reading	Researcher	225 min	Yes	Individual	Another training
Ruan et al. (2018)	Dyslexic	7.57	P2	Multisensory training	Reading + spelling	Researcher	240 min	Yes	Group	Another training
Siu et al. (2018)	Typical	7.50	P2	Group 1: M + PI Group 2: WM	Reading	Parents + researcher	1440 min	Yes	Individual	Untrained
Zhang et al. (2018)	Dyslexic	10.21	P3-P5	Auditory temporal perception	Reading	-	210 min	Yes	Individual	Untrained

Table 1 (continued)

Study	Participant	Mean age	Grade	Intervention	Outcome	Implementer	Duration	Technology	Form	Control group type
Wang et al. (2019)	Dyslexic	7.86	P3-P6	Group 1: auditory temporal processing Group 2: visual temporal processing	Reading	Teacher	360–480 min	Yes	Individual	Untrained
Xu (2019)	Dyslexic	8.23	P2	M	Reading	Researcher	1800 min	No	Group	Untrained
Yin (2019)	Dyslexic	-	P3	Action video games	Reading	Researcher + teacher	500 min	Yes	Individual	Another training
Gao et al. (2020)	Typical	11.79	P6	F + visual attention	Reading	Researcher	540 min	Yes	-	Untrained
Shen et al. (2021)	Dyslexic	9.85	P3-P5	WM	Reading	Teacher	960 min	Yes	Individual	Placebo training
Chung et al. (2022)	Typical	5.36	K	M + PI + oral vocabulary	Reading	Teacher	900 min	No	Group	Untrained
Ruan et al. (2023b)	Typical	8.36	P2-P4	Dialogic reading + M + PI + F + memory	Reading + spelling	Parent	1 month	No	Individual	Untrained

This table lists information of the included studies. *K* kindergarten, *P* primary school year, *PI* phonological intervention, *F* fluency intervention, *M* morphological intervention, *O* orthographic intervention, *WM* working memory intervention. The outcome represents the indicator of intervention effectiveness. Technology means whether a technology (e.g., computer and cell phone) was applied during the intervention. The form represents whether the intervention was conducted in groups or individually. The symbol "-" means incomplete or no relevant information in the study

fluency, morphological, orthographic, working memory, and other methods. If the study used combined methods to train children, the technique with a more significant proportion in the whole intervention was coded. Studies were coded placing the outcomes of intervention effectiveness into two categories: character/word reading and spelling. These two outcomes were chosen because dyslexia is a word-level disability, and we wanted to examine how much reading intervention affects the core problem (i.e., word reading/spelling difficulties). Participant type was classified as either children with dyslexia or typically developing children. Intervention form was classified into two categories: in groups and individually. The intervention implementer was grouped into four categories: researchers, parents, teachers, and combined implementers (i.e., more than one type of implementer). Statistics for calculating effect size were coded as well. These statistics included sample size, mean of pre-intervention, mean of post-intervention, SD of pre-intervention, and SD of post-intervention for both intervention and control groups.

The coding procedure was conducted independently by the first author and a trained student helper who was an undergraduate majoring in psychology. Inter-rater reliabilities for the coding of the intervention outcome (agreement = 90.0%, $k = 0.76$), intervention method (agreement = 80.0%, $k = 0.68$), intervention timing (agreement = 96.7%, $k = 0.93$), participant type (agreement = 100.0%, $k = 1$), intervention form (agreement = 86.7%, $k = 0.77$), and intervention implementer (agreement = 90.0%, $k = 0.85$) were computed as the percentage of agreement and the Cohen's kappa values (Cohen, 1960). The result indicated a fairly good coding reliability. The disagreements were solved upon consulting the original article and discussion between the two raters before data analysis.

Analytic Approach

A three-level meta-analysis was performed in the present study. This method controls for the dependency of effect sizes and makes it possible to include available effect sizes from the same study (Shi et al., 2022). Sampling variance of the observed effect sizes (level 1), variance between effect sizes from the same study (level 2, $\sigma^2_{\text{level 2}}$), and between-studies variance (level 3, σ^2_{level3}) are modeled in the three-level meta-analysis. Between-studies variance (level 3, σ^2_{level3}) is equivalent to the τ^2 in the traditional meta-analysis method. All analyses in this meta-analysis were conducted in R 4.2.3 (R Core Team, 2023) with the "metafor" package (Viechtbauer, 2010). The overall effect size of interventions on literacy skills (i.e., character/word reading and spelling) for Chinese children was estimated first. Next, meta-regression analyses were performed to examine the moderation effects of the intervention method, intervention timing, intervention outcome, participant type, intervention implementer, and intervention form.

Computation of Effect Sizes

Hedges's g (Hedges, 1981) was used to calculate the standardized mean-change difference (SMD) between the treatment and control groups. This index was often used in meta-analysis of intervention studies with the pretest–posttest control-group

design as the effect size (Morris, 2008). Sample sizes, pretest- and posttest means and standard deviations of both treatment and control groups were considered in the calculation. The formula for calculating Hedges's g is $g = \left[1 - \frac{3}{4(n1+n2)-9}\right]d$ ($d = \frac{\overline{X1}-\overline{X2}}{S_p^2}$, $S_p^2 = \sqrt{\frac{(n1-1)S_1^2+(n2-1)S_2^2}{(n1-2)+(n2-1)}}$). Among the formulas, $\overline{X1}$ and $\overline{X2}$ are the pretest–posttest mean changes, $n1$ and $n2$ are the sample sizes, S_1 and S_2 are standard deviations of intervention and control groups. The 95% confidence intervals (*CI*) were also calculated. The inverse variance was used to calculate the weights of individual studies (Hedges & Olkin, 1985). The restricted maximum-likelihood estimator was used to calculate the between-study variance (e.g., Galuschka et al., 2020). If studies included more than one intervention group (Chow et al., 2008; Lam & McBride-Chang, 2013; Siu et al., 2018; Wang & McBride, 2017; Wang et al., 2019; Yang et al., 2017; Zhou et al., 2012), effect size was calculated for each subgroup. If studies had both word reading and spelling indicators, effect sizes were calculated for both indicators (Chen et al., 2015, 2016; Ho, 2001; Ho & Ma, 1999; Lam & McBride-Chang, 2013; Ruan et al., 2018, 2023b; Wang & McBride, 2017). If studies used different tests to measure word reading or spelling ability (Siu et al., 2018), we combined the tests for the same ability and calculated only one effect size for that ability. If studies trained both types of children (Wang, 2017b), we calculated the effect size for each type of participant.

Heterogeneity Test

Two separate one-sided log-likelihood-ratio tests (Assink & Wibbelink, 2016) were used to evaluate the existence or absence of heterogeneity for the within-study variance and between-study variance. In the tests, the deviance of the full model was compared with the deviance of the model without one of the two variance parameters (Assink et al., 2018). Significant results implied the significant variance at the second or third level of the model, and that effect sizes were heterogeneously distributed (Geerlings et al., 2020). A forest plot was drawn as an additional reference for heterogeneity. If heterogeneity existed, meta-regression analysis should be performed to statistically test and identify the cause of heterogeneity (Shim & Kim, 2019). Knapp-Hartung adjustment (2003) was applied to determine the significance of the estimated regression coefficients. In this method, *t*-distribution was used for testing individual coefficients, and *F*-distribution was used for the omnibus test of all coefficients in the model (e.g., Assink et al., 2018).

Publication Bias

A funnel plot was constructed to verify the existence of publication bias visually. In addition, a modified Egger's test (Egger et al., 1997; Shi et al., 2022) was performed to test the publication bias statistically. Moreover, we also computed Rosenthal's fail-safe *N* to determine the situation of publication bias. A value of Rosenthal's fail-safe *N* larger than $5 \times k + 10$ (k = the total number of effect sizes) indicates a negligible risk of bias (Rosenthal, 1991).

Quality Assessment

The present meta-analysis assessed study quality with the guideline of quality indicators for group experimental research in special education published by the Council for Exceptional Children (CEC, Gersten et al., 2005). This guideline includes ten essential quality indicators and eight desirable quality indicators. The essential quality indicators are classified into four aspects: describing participants, implementation of the intervention and description of comparison conditions, outcome measures, and data analysis. A 3-point rating scale (i.e., a score of 3 = indicator met, 2 = indicator partially met, and 1 = indicator not met) was employed to evaluate the included studies on the 18 quality indicators. A study received a minimum score of 2 on at least nine of the ten essential quality indicators and at least one desirable quality indicator was considered as a study with acceptable quality; a study received a minimum score of 2 on at least nine of the ten essential quality indicators and at least four desirable quality indicators was considered as a study with high quality; a study received a score of 1 on more than one of the ten essential quality indicators was considered as a study with low quality. These criteria were suggested by Jitendra et al. (2011) and used in many previous studies (e.g., Park & Kim, 2015).

Results

Results of the Literature Search and Studies' Quality

The procedure of literature search and study selection resulted in 28 studies that met the inclusion criteria and were included in the current meta-analysis. These studies involved 49 effect sizes (37 for word reading and 12 for word spelling). Among these effect sizes, 23 of them were training for children with dyslexia, and 26 of them were training for typically developing children. For the intervention method, 9 effect sizes for phonological training, 3 for fluency training, 10 for morphological training, 7 for orthographic training, 5 for working memory training, and 15 for other training methods, such as multisensory training (e.g., Ho, 2001) and temporal processing (e.g., Wang et al., 2019). Forty-one of them trained children younger than 9 years old and 8 of them trained children older than 9 years old. Twenty-six of them were delivered in groups and 20 of them were delivered individually. One study did not report information about intervention form and two effect sizes were excluded as they were delivered in groups combined with individual tutoring. For the intervention implementer, 16 effect sizes for researcher, 9 for parent, 15 for teacher, and 5 for more than one type of implementer. Three studies with four effect sizes did not report information about implementer. Twenty-three studies were published in peer-reviewed journals, and 5 studies were unpublished postgraduates' theses.

Based on the quality coding criteria, 16 of the included studies with high quality, 4 with acceptable quality, and 8 with low quality. The average rating scores of essential and desirable quality indicators for each included study were reported in Table S1 in the Appendix/Supplementary Information.

Overall Effectiveness of Reading Interventions on Literacy Skills for Chinese Children

We first conducted a meta-analysis that included all the studies to evaluate the overall effect of reading interventions on literacy skills for Chinese children. The results of the log-likelihood-ratio tests showed that $\sigma^2_{level2} = 0.11$, $\chi^2(1) = 8.80$, $p < 0.01$ for variance among effect sizes from the same study (i.e., within-study variance at level 2), and $\sigma^2_{level3} = 0.15$, $\chi^2(1) = 2.88$, $p < 0.05$ for variance among effect sizes from different studies (i.e., between-study variance at level 3; also known as τ^2 in traditional meta-analytic method). These results suggested the existence of heterogeneity. Therefore, the random effect model was used for computing the overall effects. The forest plot (Fig. 2) was also constructed to verify heterogeneity visually. Meta-analysis results showed that the effect size of the random effect model was 0.68 (95% CI, 0.48 to 0.89; $p < 0.001$) with a *SE* of 0.10. This result indicates that the overall effect of all interventions achieves a statistically significant improvement in literacy skills. In other words, children who received interventions yielded more improvements in literacy skills when compared to control groups.

Moderators for the Effectiveness of Reading Intervention

Since the heterogeneity was examined, we then conducted a series of meta-regression analyses to test the possible cause of heterogeneity statistically. These moderators included intervention outcome, intervention method, intervention timing, participant type, intervention form, and intervention implementer. Table 2 summarizes the results of meta-regression analyses for the six moderators, including the omnibus test, within-study variance (σ^2_{level2}), and between-study variance (σ^2_{level3}). Table 3 displays the effects of interventions under different categories of moderators.

Intervention Outcome

Two types of outcomes were classified as the intervention indicators: word reading outcome ($k = 37$) and word spelling outcome ($k = 12$). The test of the moderator suggested that reading intervention effects marginally significantly differ by the type of intervention outcome (F (1, 47) = 3.95, $p = 0.05$). Children's word spelling ($g = 0.93$; $SE = 0.16$; 95% CI, 0.61–1.26) received more benefits than reading ($g = 0.63$; $SE = 0.11$; 95% CI, 0.40–0.86) from the existing interventions.

Intervention Method

The focus of the reading intervention was classified into six categories: phonological ($k = 9$), fluency ($k = 3$), morphological ($k = 10$), orthographic ($k = 7$), working memory ($k = 5$), and others ($k = 15$). Test of moderator showed that the intervention effects significantly differed depending on the intervention method, F (5, 43) = 3.14, $p < 0.05$. Interventions focus on training fluency ($g = 1.78$; $SE = 0.33$;

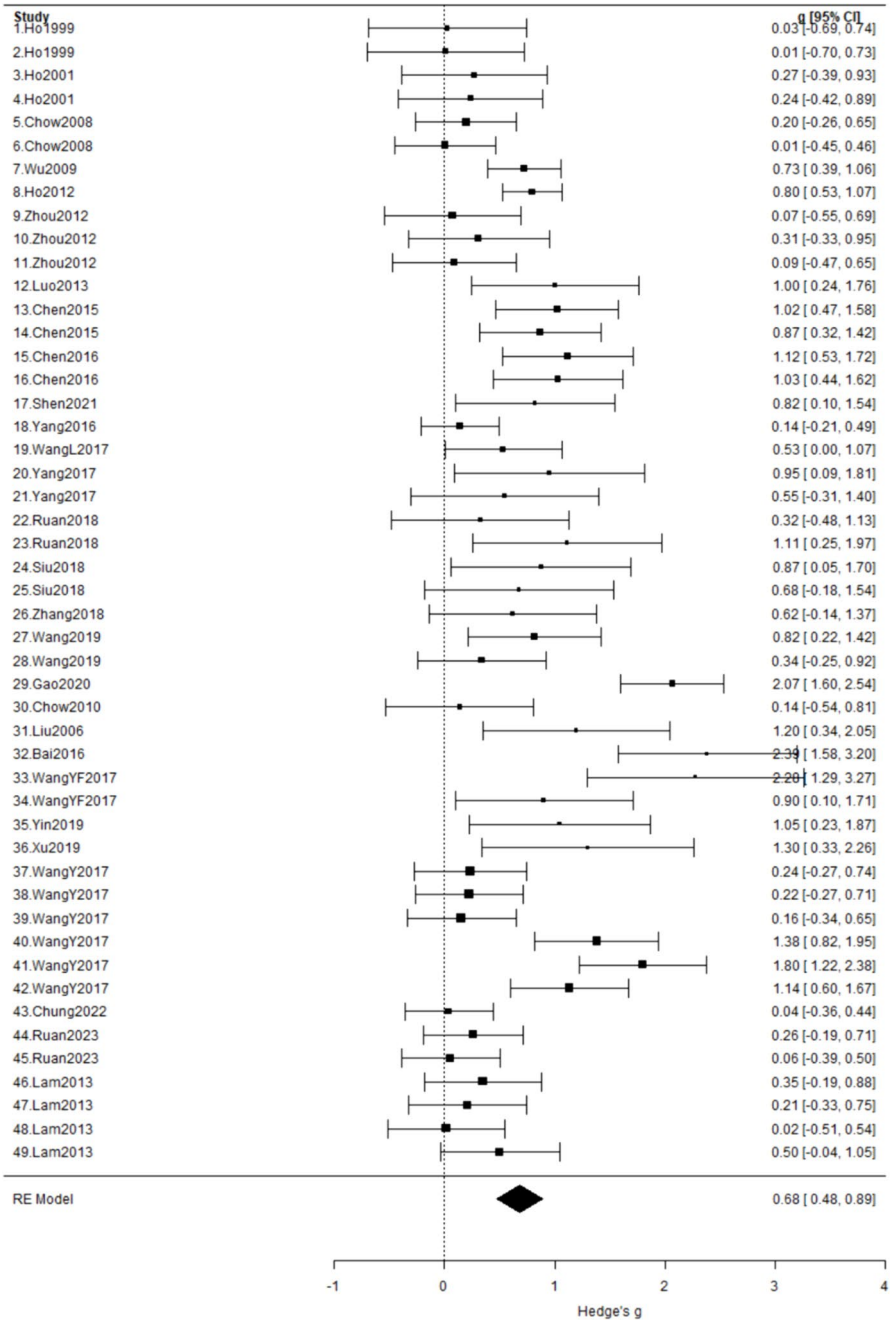

Fig. 2 Forest plot of all effect sizes

Table 2 Meta-regressions of the six moderators for the whole study pool

Moderator	Omnibus test	p	σ^2_{level2}	σ^2_{level3}
Intervention outcome	$F(1, 47) = 3.95$	0.05	0.07	0.21
Intervention method	$F(5, 43) = 3.14$	0.02	0.11	0.06
Intervention timing	$F(1, 47) = 1.11$	0.30	0.11	0.15
Participant type	$F(1, 47) = 3.75$	0.06	0.10	0.14
Intervention form	$F(1, 44) = 3.94$	0.05	0.11	0.05
Intervention implementer	$F(3, 41) = 3.36$	0.03	0.13	0.03

Table 3 Effects of reading intervention under different conditions

Condition	k	g	SE	t	df	95% CI
Overall	49	0.68	0.10	6.68***	48	[0.48, 0.89]
Intervention outcome						
Reading	37	0.63	0.11	5.61***	47	[0.40, 0.86]
Spelling	12	0.93	0.16	5.75***	47	[0.61, 1.26]
Intervention method						
Phonological	9	0.69	0.18	3.81***	43	[0.32, 1.05]
Fluency	3	1.78	0.33	5.37***	43	[1.11, 2.45]
Morphological	10	0.66	0.17	4.01***	43	[0.33, 1.00]
Orthographic	7	0.70	0.20	3.48**	43	[0.30, 1.11]
Working memory	5	0.80	0.27	3.00**	43	[0.26, 1.34]
Others	15	0.39	0.14	2.85**	43	[0.11, 0.66]
Intervention timing						
≤ 9 years old	41	0.63	0.11	5.62***	47	[0.40, 0.86]
> 9 years old	8	0.90	0.24	3.84***	47	[0.43, 1.38]
Participant type						
Dyslexia	23	0.87	0.14	6.17***	47	[0.59, 1.16]
Typically developing	26	0.49	0.14	3.56***	47	[0.21, 0.77]
Intervention form						
In groups	26	0.78	0.11	6.94***	44	[0.56, 1.01]
Individual tutoring	20	0.45	0.13	3.57***	44	[0.20, 0.70]
Intervention implementer						
Researcher	16	0.85	0.15	5.90***	41	[0.56, 1.15]
Parent	9	0.27	0.18	1.54	41	[-0.08, 0.63]
Teacher	15	0.55	0.13	4.27***	41	[0.29, 0.81]
Combined	5	1.11	0.27	4.09***	41	[0.56, 1.67]

**$p < 0.01$; ***$p < 0.001$; *SE* standard error, *CI* confidence interval

95% CI, 1.11–2.45) was significantly more effective than other methods on improving children's literacy skills. Morphological training ($g = 0.66$; $SE = 0.17$; 95% CI, 0.33–1.00), working memory training ($g = 0.80$; $SE = 0.27$; 95% CI, 0.26–1.34), phonological training ($g = 0.69$; $SE = 0.18$; 95% CI, 0.32–1.05), and orthographic

training ($g = 0.70$; $SE = 0.20$; 95% CI, 0.30–1.11) all showed significant and medium effects on improving literacy skills. Other intervention methods as a whole also showed a significant but small effect on literacy skills ($g = 0.39$; $SE = 0.14$; 95% CI, 0.11–0.66).

Intervention Timing

Intervention timing was categorized into two subgroups based on the mean age or grade of children in the intervention group. One subgroup contained children below 9 years old or children in preschool to grade 3 ($k = 41$); another subgroup had children above 9 years old or children in grade 4 to grade 6 ($k = 8$). Results showed that the effect of intervention was not different depending on the intervention timing, F (1, 47) = 1.11, $p = 0.30$. Reading intervention had similar impact for children with older ages (i.e., aged above 9; $g = 0.90$; $SE = 0.24$; 95% CI, 0.43–1.38) and with younger ages (i.e., aged below 9; $g = 0.63$; $SE = 0.11$; 95% CI, 0.40–0.86).

Participant Type

Participants were identified as dyslexia ($k = 23$) or typically developing children ($k = 26$). Meta-regression analysis showed that participant type was a marginally significant moderator for intervention effect (F (1, 47) = 3.75, $p = 0.06$). Children with dyslexia ($g = 0.87$; $SE = 0.14$; 95% CI, 0.59–1.16) could benefit from reading interventions more than typically developing children ($g = 0.49$; $SE = 0.14$; 95% CI, 0.21–0.77).

Intervention Form

Intervention form was classified as delivered in a group ($k = 26$) or delivered individually ($k = 20$). Meta-regression analysis showed that intervention form was a marginally significant moderator for intervention effect (F (1, 44) = 3.94, $p = 0.05$). Interventions delivered in groups ($g = 0.78$; $SE = 0.11$; 95% CI, 0.56–1.01) seem to be more effective than interventions delivered individually ($g = 0.45$; $SE = 0.13$; 95% CI, 0.20–0.70).

Intervention Implementer

The intervention implementer was classified into four categories: researcher ($k = 16$), parent ($k = 9$), teacher ($k = 15$), and combined implementer ($k = 5$). Test of moderator showed that the intervention effects significantly differed depending on the intervention implementer, F (3,41) = 3.36, $p < 0.05$. Interventions conducted by researchers ($g = 0.85$; $SE = 0.15$; 95% CI, 0.56–1.15) and combined implementers ($g = 1.11$; $SE = 0.27$; 95% CI, 0.56–1.67) were significantly more effective than interventions conducted by parents ($g = 0.27$; $SE = 0.18$; 95% CI, − 0.08–0.63) on improving children's literacy skills. The effect size of interventions administered by parents did not reach a significant level ($p = 0.13$). The effect size of intervention conducted by

teachers (g = 0.55; *SE* = 0.13; 95% CI, 0.29–0.81) reach a significant level, but it did not significantly differ from other categories.

The method for moderator analyses in the present study was successfully used by many previous three-level meta-analysis studies (e.g., Luo et al., 2023; Shi et al., 2022). In the present study, four of the included studies had missing information on the intervention form or implementer. These four studies will be omitted from model fitting if all the moderators are put in one model when performing moderator analysis. Other valid data in these studies could not be fully used. To fully utilize data from the included studies, we performed a moderator analysis by putting participant type, intervention timing, intervention method, and intervention outcome in one model to further verify the above analyses. The result showed that the test of moderators was significant (F (12, 31) = 3.42, $p < 0.01$; $\sigma^2_{level2} = 0.05$, $\sigma^2_{level3} = 0.00$). The intervention method ($p < 0.01$), participant type ($p < 0.01$), intervention outcome ($p < 0.05$) were still significant moderators after including all the moderators in one model. Intervention timing ($p = 0.61$) was still a not significant moderator. These results support the single-moderator analysis and indicate that the single-moderator analysis makes sense to some extent.

Publication Bias

A funnel plot (Fig. 3) was constructed to examine the publication bias. The figure shows that most of the studies were distributed within the funnel symmetrically. However, there were several studies outside the funnel. It indicated that a publication bias might exist. Therefore, Egger's test was then performed to statistically test the publication bias. The result showed that t (47) = 2.60, $p = 0.01$, indicating possible existence of publication bias. Nevertheless, the fail-safe N of the present study was 3913, which was larger than 5 × k + 10 ($k = 49$ in the present study). The result of fail-safe N indicated the publication bias was unlikely to affect the result.

Sensitivity Analysis

To further evaluate the impact of studies' quality on the overall effect size, we conducted a sensitivity analysis by excluding the low-quality studies. The result showed a similar significant overall effect size as previous analysis ($g = 0.60$; $SE = 0.10$; 95% CI, 0.39–0.81), indicating that our result is relatively robust. In addition, Egger's test showed no existence of publication bias after excluding low-quality studies (t (36) = 1.69, $p = 0.10$).

Discussion

This meta-analysis of 28 independent studies examined existing reading interventions for Chinese children with and without dyslexia. Overall, the interventions were effective, but the level of effectiveness varied depending on the intervention method, participant type, intervention outcome, and intervention

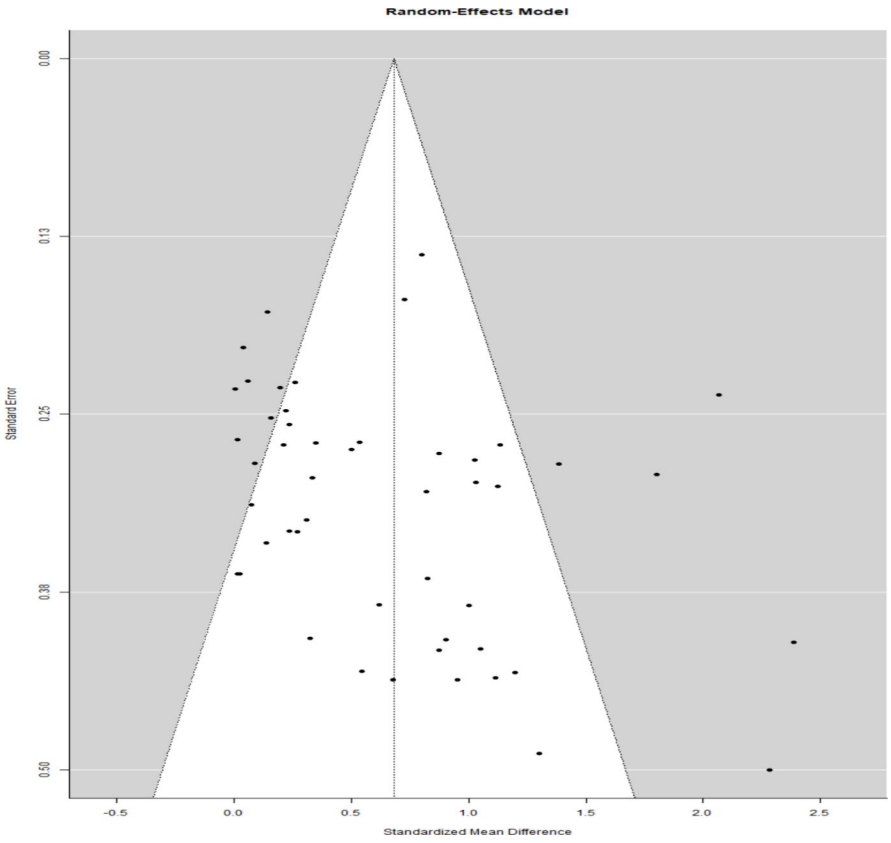

Fig. 3 Funnel plot of all effect sizes

settings. A statistically significant medium overall effect size was found for literacy skills ($g = 0.68$). Meta-regression analyses examined all the different types of interventions yielded significant effects on literacy skills. Training focused on fluency ($g = 1.78$) was more effective than other methods. Interventions focused on training phonological, morphological, orthographic, and working memory skills all showed medium effects on improving literacy skill ($g = 0.66$–0.80). Interventions showed equal efficacy for younger and older children. However, children with dyslexia showed a tendency to gain more from reading interventions than typical children did. Interventions tended to benefit word spelling more than word reading. Interventions delivered in groups were more effective than delivered individually. Interventions administered by researchers and combined implementers had larger effects than by parents. These results suggest that appropriate reading interventions can successfully improve reading and spelling skills for Chinese children.

What Is the Best Reading Intervention for Chinese Children?

The result of the present meta-analysis showed that reading interventions produce overall positive efficacy for Chinese children. This result is consistent with findings from meta-analyses on reading intervention effects in the alphabetic language system (e.g., Wanzek et al., 2018). Some previous meta-analyses and systematic reviews in alphabetic language systems have concluded that effective interventions for most children involve explicit instructions and address different reading components, such as phonological awareness and fluency (Barquero et al., 2014). Most included studies in the present meta-analysis conducted explicit instruction to children and focused on training specific linguistic or cognitive components during the instruction. Reading is a multifaceted process involving multiple cognitive-linguistic skills such as phonological sensitivity, morphological awareness, orthographic processing, and fluency. Training studies focused on improving these skills have led to improvements in literacy skills overall (McBride et al., 2018). Therefore, the overall effectiveness was significant in the present study. However, the intervention efficacy varied based on the type of intervention.

Fluency intervention was found to be more effective than other intervention methods. Fluency reflects the ability to connect the orthographic representations with the corresponding phonological representations and to automate this connection. Some researchers acknowledged reading fluency as a composite of critical cognitive processes, including phonological, orthographical, and semantic processes (Horowitz-Kraus & Finucane, 2016). There are several essential processes involved in fluency training, for example, the attentional processes to the stimulus and the integration of visual features and pattern information with stored orthographic representations (Norton & Wolf, 2012; Wolf & Denckla, 2005). Fluency training might also improve the ability to automatically retrieve orthographic representations of children. Therefore, fluency intervention showed great effectiveness for Chinese literacy. It should be noted that only two intervention studies (Gao et al., 2020; Wang, 2017b) with three effect sizes used fluency training approaches to facilitate reading ability were included in this meta-analysis. These inclusions might result in some bias for the fluency intervention effect. Systematic reviews and meta-analyses in the alphabetic language system also reported a very limited number of programs focused on fluency (e.g., Jamshidifarsani et al., 2019). The difficulty of designing a fluency-based intervention might result in the existing uncertainty about the effectiveness of the fluency intervention approaches (Jamshidifarsani et al., 2019). Therefore, the result of fluency training should be interpreted with caution. However, many previous studies have found that fluency was a universal skill that predicted children's literacy ability across writing systems (e.g., Moll et al., 2014). The training procedures in both included studies required synchronization and integration across various processes. Hence, it is likely that the large effect sizes reflected the actual effectiveness of fluency training.

Morphological, working memory, phonological, and orthographic training showed significant and medium effects on improving literacy skills. In addition, their effects did not differ significantly with each other. Lexical compounding training (e.g., Wang & McBride, 2017) and homophone training (e.g., Zhou et al.,

2012) are two approaches commonly used in Chinese morphological intervention. Direct instruction in the units of meaning and morphological structure of words can help children determine the meaning of unfamiliar words and distinguish different morphemes (Goodwin & Ahn, 2010). The morphological intervention that has a prominent effect on literacy skills in Chinese children might be closely related to the characteristics of Chinese script. Peng et al. (2017) proposed three possible reasons for the influences of morphological awareness in Chinese reading. First, the semantic radical in 80% of Chinese characters is directly linked to meaning. Second, Chinese is relatively transparent semantically, and the complex vocabulary can often be built by compounding morphemes. Third, there are many homophones in Chinese. These three reasons can also be used to explain why morphological intervention is effective for Chinese children. Based on these special features of Chinese script, morphological intervention might be more effective for Chinese readers than readers in alphabetic languages. Our meta-analysis found that morphological intervention had a moderate effect size ($g = 0.66$), which was larger than that found in the alphabetic language system (Goodwin & Ahn, 2010). Goodwin & Ahn (2010) conducted a meta-analysis to investigate the effect of morphological intervention for children with literacy difficulties in the alphabetic language system. The result showed that the overall effect size ($d = 0.33$) of morphological intervention was small, although it reached statistical significance. In addition, researchers suggested that the effectiveness of morphological intervention might be generated by remediating the phonological processing challenges in alphabetic languages (Goodwin & Ahn, 2010). However, the efficacy of morphological intervention is probably due to the particular morphological features contained in Chinese, which were mentioned above.

Reading relies on many primary executive and cognitive functions, including memory (Horowitz-Kraus & Finucane, 2016). Several studies have found that working memory was a strong correlate of Chinese literacy skills (e.g., Mo et al., 2018). The connections between Chinese characters and their corresponding pronunciations are relatively arbitrary (e.g., Chan et al., 2006). Children are required to match the character and pronunciation by rote memorization sometimes and retain these connections in memory. During this process, working memory should play an important role in storage and manipulation of the connections temporarily and repeated practices lead these connections to become long-term memory. In addition, working memory intervention often involves training the visuospatial aspect, which might enhance children's ability to attend to the positional information included in Chinese characters. Therefore, working memory intervention shows promising efficacy in the literacy skills of Chinese children. However, a meta-analysis in the alphabetic language system found that the effect of interventions that teach memorization strategies to improve spelling could not be confirmed (Galuschka et al., 2020). This result is somewhat inconsistent with the present study. One main reason is that memorization interventions included in Galuschka et al. (2020) were mainly strategies that provided cues to help children memorize a word rather than directly trained the memory ability. In contrast, studies included in the present study all directly trained the working memory ability of children. Such training might improve the cognitive functions of children, which in turn facilitate literacy skills.

The phonological intervention was also found to be effective in Chinese literacy. Making children sensitive to phonemes in Pinyin and syllables in characters/words as well as lexical tones in characters enables them to grasp the pronunciations of characters and helps them decode the characters and words effectively. Therefore, phonological intervention is an effective intervention for improving the literacy skills of Chinese children. However, it might not be the best choice for enhancing literacy skills as it is in the alphabetic language system. Phonological intervention method appeared to be not only the most frequently investigated treatment approach, but also the most effective approach for reading acquisition in alphabetic languages (e.g., Galuschka et al., 2014). Galuschka et al. (2014) conducted a meta-analysis to examine the effectiveness of treatment approaches for children and adolescents with reading disabilities. Their result found that only the efficacy of phonics instruction was statistically confirmed; other methods, such as fluency training, did not significantly affect reading and spelling. Phonological skills seem to dominate in literacy acquisition in the alphabetic language system. Compared with alphabetic languages that use letters as the writing unit, Chinese script has less obvious phonological cues to facilitate word pronunciation. Learning to read and spell in Chinese depends less on analyzing phonemes and other phonological units (McBride, 2016). Instead, Chinese readers may rely more on the semantic cues contained in the characters/words to learn to read. In addition, the phonological structure of Chinese is simpler than that in alphabetic languages (e.g., Wong et al., 2012). Many studies have examined the fact that phonological awareness significantly predicted English reading and spelling but not Chinese reading and spelling (e.g., Ruan et al., 2023a). Phonological skills are more directly correlated with literacy acquisition in alphabetic languages. Therefore, phonological intervention might have different extents of importance across the alphabetic language and Chinese systems.

The main focus of orthographic training procedures was the conventional rules of Chinese characters. In particular, the training often emphasizes the strategies to help children manipulate the orthographic components of characters and aware the positional information of each component (e.g., Chen et al., 2015). The complexity of Chinese characters requires learners to pay more attention to the details of the characters' structures. Orthographic training might arouse the awareness of children to notice the components of characters and to understand how these components build the characters. This procedure might enhance the memorization of Chinese characters (Wang et al., 2004). Therefore, orthographic intervention seems to be a particular way to improve Chinese literacy. Orthographic training is less commonly used in alphabetic languages. One reason is that the alphabetic script is less visually complex than the Chinese script. In the alphabetic language system, letters form a word from left to right. In the Chinese system, characters are square-shaped, with radicals placed in different parts. Therefore, Chinese characters can have various structures, such as top-down structures (e.g., 想, means "miss") and semi-enclosed structures (e.g., 原, means "original"). Hence, Chinese characters contained richer orthographic information than alphabetic words. In addition, letter-sound correspondence is an important aspect of teaching literacy in the alphabetic language system. Training in letter-sound correspondence was found to be effective in improving reading and spelling performance in alphabetic languages (e.g., Galuschka &

Schulte-Körne, 2016). However, the correspondences between characters and pronunciation in Chinese are relatively arbitrary. Chinese readers should rely more on the orthographic information contained in characters to learn to read and spell. Therefore, orthographic training might be used more in Chinese than in alphabetic languages.

Other intervention methods (e.g., temporal processing training) as a whole in the present study also show a significant but small efficacy for Chinese literacy even these methods received limited attention. This result indicates the potential of these training methods in improving children's literacy acquisition and calls for more research in the future to further examine their effectiveness.

In summary, the present meta-analysis found that different types of reading interventions effectively improved Chinese children's literacy performances. However, some included studies involved more than one component in their interventions. We coded the intervention method for these studies based on their main focuses or the component that took the dominant proportion in the whole intervention. Successful reading depends on the cooperation of a complex set of cognitive and linguistic processes. Children need to master multiple skills in order to become competent readers. Hence, intervention programs combining different types of methods may be more effective than containing purely one type of method. A meta-analysis conducted by Peng et al. (2024) investigated the effectiveness of reading comprehension strategy for struggling readers found that no single method could produce the strongest effect. However, instruction of more strategies also did not necessarily have better effects on reading comprehension (Peng et al., 2024). Hence, it is important for future studies to explore the effects of multiple-component trainings and compared them with single-component method for Chinese readers.

Who Profits More from Reading Interventions?

In this meta-analysis, we focused on two moderators associated with the characteristics of participants. The first one is the participant type, which was classified as children with dyslexia and typically developing children. Our result showed that children with dyslexia could benefit more from interventions than typically developing children did. Children with dyslexia have a lower level of literacy achievement before interventions. Therefore, they have more space to make progress on literacy skills during interventions. In contrast, typically developing children might have mastered literacy skills relatively well before interventions and additional interventions might do little for these children to improve literacy skills. Moreover, the role of intervention may decrease as typically developing children are more skilled and better able to apply different strategies to learn word reading. This result is consistent with some previous intervention meta-analyses. For example, a previous meta-analysis was conducted to explore the effectiveness of phonemic awareness interventions for learners with different levels of reading proficiency in the alphabetic language system (Ehri et al., 2001). The results showed that reading at-risk children gained statistically more than typically developing children on reading outcomes from interventions. Commonly, children with dyslexia manifest poorer performances

on a series of literacy and cognitive-linguistic skills than their typically developing peers (e.g., Peng et al., 2017; Ruan et al., 2023b). In addition, the dyslexic status often persists throughout primary school unless effective interventions are provided early (Wong et al., 2012). Therefore, it is anticipated that children with dyslexia will likely need reading interventions to a greater extent than their typically developing counterparts. Our result brings some hope to schools and families that have children with dyslexia because children with dyslexia exhibit greater improvements in literacy skills following interventions compared to their typical peers.

The second moderator related to participants was intervention timing, representing the mean age of the group when children received the intervention. The present study found that intervention timing was not a significant moderator for the intervention effect. Meta-regression analysis suggested that older children appeared to benefit similarly from interventions as younger children. This result is inconsistent with several previous studies examining that younger children may profit more from training programs (e.g., Bus & van IJzendoorn, 1999; Galuschka & Schulte-Körne, 2016). However, some other meta-analyses found that upper elementary and middle school students showed great gains from reading interventions (e.g., Scammacca et al., 2015). The question of the right starting point for different types of instruction resulted in an ongoing theoretical debate in reading research (Galuschka et al., 2020). It seems premature to conclude that younger children benefit more from reading interventions than older children. Older children have more reading experiences and might be able to understand and master the training materials more efficiently. In contrast, the training materials and format used in research might not be attractive enough for younger children who demand vivid and interesting content. Therefore, we found that younger children gain similarly as older children from the intervention in this meta-analysis.

Do Reading Interventions Have Different Effects on Word Reading and Word Spelling?

The present study revealed that reading interventions improved word spelling slightly more than word reading in Chinese children. A meta-analysis on the effect of phonological awareness instructions for children in alphabetic languages found that the intervention only improved reading but not spelling in disabled readers (Ehri et al., 2001). This inconsistent result might remind us that different types of intervention might affect reading and spelling differently. Dictation task is often used to measure the spelling skill in Chinese literacy research (e.g., Ruan et al., 2023b). Phonological intervention focusing mainly on speech sounds that might more important for reading acquisition. In contrast, other types of trainings that require attention to the script's characteristics might be helpful for spelling acquisition. In the present study, we combined different types of intervention and investigated the overall effects for reading and spelling separately. Hence, we found the reading intervention benefited spelling as well. Some other meta-analyses of treatment approaches for children and adolescents with reading disabilities also reported that reading instructions could improve both reading and spelling performances (e.g., Galuschka &

Schulte-Körne, 2016; Galuschka et al., 2014, 2020). Word reading and spelling are closely correlated (e.g., Ruan et al., 2023b). Word reading and spelling acquisitions share many common cognitive-linguistic correlates, such as orthographic and morphological knowledge (Galuschka et al., 2020). Therefore, interventions that prove effective for reading are likely to yield benefits for spelling and vice versa. In addition, word spelling is usually thought to be more difficult than word reading (Ruan et al., 2023b). Hence, instructions on helping children's literacy skills might benefit more for the more difficult spelling process.

How Different Intervention Settings Affect the Efficacy of Intervention?

This meta-analysis focused on two moderators associated with the intervention settings. The first one is the intervention form, which was classified as delivered in groups and delivered individually. Our result showed that the effects of interventions delivered in groups were greater than those provided individually. This result is consistent with some previous meta-analysis studies in the alphabetic language system. For example, Ehri et al.'s (2001) meta-analysis on phonemic awareness instruction showed that instruction was more effective when children were taught in small groups than individually. The procedure and intensity of interventions are unified for all children if the interventions are implemented in groups. In contrast, individual instructions might cause some variability; for example, the attention and time paid to each participant might be different. This might lead to unstable efficacy among participants and a less effect when considering all participants' results together. In addition, training with other peers might increase the interest and fidelity of children in the intervention. Although interventions delivered in a group seem more effective than interventions delivered individually, the optimum size of the intervention group still needs further exploration.

The second moderator related to participants was the intervention implementer, which included researchers, teachers, and parents. The present study found that the intervention implementer was a significant moderator for the intervention effect. Meta-regression analyses suggested that interventions conducted by researchers, teachers, or combined implementers produced more powerful effects than those performed by parents. This result is consistent with the conclusions of several previous systematic reviews suggesting that the interventions were effective when initiated by teachers and researchers but not by parents (e.g., Galuschka & Schulte-Körne, 2016). Researchers and teachers are more knowledgeable in the cognitive processes involved in word reading than parents. Researchers and teachers have often been trained to understand literacy learning and reading difficulties and to master skills to facilitate the literacy learning of school-aged children. Therefore, they were more competent in preparing materials and following scientific procedures during the intervention. In contrast, many parents are anxious to help their children acquire the knowledge and skills needed to succeed in reading (Ehri et al., 2001). They are often confused when facing misguided therapy and sharp business practices (Bogdanowicz et al., 2016).

Limitations, Implications, and Future Directions

The findings presented in this study are limited by the available research literature on reading interventions for Chinese children in preschool to primary school. The present meta-analysis focused on randomized controlled experiments because this design provides more robust scientific evidence supporting causal inferences about the impact of reading intervention on literacy skills. One limitation of the present study is that not all moderators were analyzed in the present study due to incomplete information in some articles. In addition, we could not control all variations during the meta-regression analyses due to the limited number of included studies and the intention to fully utilize all valid data. However, our results reflect the general patterns of intervention effects depending on the six different moderators. The results still provide implications for developing appropriate interventions for improving the literacy skills of Chinese children with and without dyslexia. Another limitation is that character reading was used to represent the word reading ability in some included studies during the analysis. Some researcher suggests that word reading and character reading are likely to be two distinct processes (e.g., Pan et al., 2021). Therefore, different interventions might have various effects on these two abilities. For example, orthographic training that focuses more on the structure of characters might help more with character recognition, and morphological training could help more with word reading. However, word reading and character reading have high correlations with each other (e.g., Ruan et al., 2023b). A single Chinese character could be a word as well. Character reading might still reflect a general level of word-reading ability of children. The third limitation is that the inter-coder reliability for the screening of titles and abstracts could not be calculated in the present study. Despite the rigorous screening procedure employed in this meta-analysis study, it is still important to acknowledge the absence of inter-coder reliability calculation for the screening of titles and abstracts. A series of measures were taken in the present study to minimize potential bias. These measures included providing detailed screening guidelines, conducting regular meetings among coders to discuss ambiguous cases, and only those significantly unrelated papers were excluded in this stage.

While mindful of the limitations, this study represents the first meta-analysis to systematically examine the efficacy of existing reading interventions for Chinese children with and without dyslexia. The period of preschool to primary grades is particularly important because many reading difficulties can be prevented if children are provided with appropriate reading interventions (Wanzek et al., 2018). Efforts to enhance literacy outcomes for Chinese children, both with and without dyslexia, have only been underway for a few decades. The present study suggests that the current existing reading interventions are generally effective ways to improve Chinese children's literacy outcomes. Therefore, classroom instruction and remediation efforts might benefit from including different types of evidence-based instructional strategies as part of their teaching. For example, teachers might incorporate activities on training fluency, morphological awareness, and working memory in the class to facilitate the teaching of Chinese literacy. In addition, the present study showed that children with dyslexia benefit more than typically developing children from interventions. Interventions for dyslexia might require

special arrangements (e.g., Bogdanowicz et al., 2016). For example, children with dyslexia may need more direct instruction and more intensive teaching. Designing proper training materials and formats according to participants' characteristics might help increase the intervention effect.

There are many directions that research can investigate further in the future. We provide some main directions here. First, exploring other potential moderators for the effectiveness of reading interventions for Chinese children will be necessary. For example, the duration of the training and intervention fidelity were found to have some influences on the intervention effect (e.g., Ehri et al., 2001). Second, investigating the long-term effects of reading interventions can help us better understand the efficacy of different trainings. The present study only focused on the immediate effects of reading interventions. It is possible that the positive effects immediately after the instructions might diminish or disappear with time development. Therefore, knowing how to keep a lasting intervention effect is essential. Third, examining the transfer effects of basic reading interventions on higher-level reading (e.g., reading comprehension) and writing (e.g., discourse) abilities will have significant implications for reading education in school settings for children in high grades. Finally, considering the influence of bilingual/multilingual issues on the effectiveness of reading intervention might also be essential in future studies. Some previous studies have examined bilinguals, monolingual typical readers, and children with reading disabilities showed different profiles of reading skills (e.g., Bonifacci & Tobia, 2016; Bonifacci et al., 2017). For example, bilingual language-minority children who learned English as a foreign language performed similarly to Italian monolingual typical readers in English literacy tasks but not in Italian literacy tasks; children with dyslexia performed more poorly on literacy tasks of both languages than typical readers (Bonifacci et al., 2017). Hence, comparing the patterns of responding to interventions across children with various language backgrounds will provide a comprehensive understanding of the influence of participant type on interventions' effects. Nevertheless, the prerequisite of these directions is a sufficient number of Chinese reading intervention studies with rigorous design. There are still not enough strictly designed intervention studies conducted on Chinese children. Therefore, more research is needed to examine the efficacy of different reading interventions for Chinese children. In addition, quasi-experimental studies with high quality might be considered in future meta-analysis research to increase the analysis power.

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Data Availability The data that support the findings of this study are available upon reasonable request.

Declarations

Competing Interests The authors declare no competing interests.

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