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The relative contributions of phonological, morphological, and orthographic awareness to word decoding in Chinese as a second language

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Decoding ability plays a fundamental role in reading acquisition and development. It is generally agreed in the literature that decoding is influenced by the ability to represent and manipulate linguistic components. Although extensive research has examined individual aspects of phonological, morphological, and orthographic awareness in Chinese acquisition, few empirical studies have simultaneously investigated the interrelationships among these three types of awareness and their combined contributions to decoding ability. The present study aimed to explore the differential effects of phonological, morphological, and orthographic awareness on decoding performance in Chinese as a second language. A total of 71 elementary-level (average vocabulary size of 1979 words) L2 Chinese learners completed four computer-based tests. Correlation and hierarchical regression analyses revealed two key findings: (1) Morphological awareness and orthographic awareness were significantly correlated with decoding ability, whereas phonological awareness did not exhibit a significant correlation with decoding ability. (2) After controlling for native language, morphological awareness, and orthographic awareness, decoding ability was independently influenced. Specifically, morphological awareness accounted for 7.3% of the variance in decoding, while orthographic awareness explained 7.7% of the variance in decoding. The findings suggest that Chinese language instruction should emphasize the development of morphological and orthographic awareness through structured activities, which can effectively enhance learners' decoding abilities and overall literacy skills in Chinese.

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Introduction

Reading constitutes a fundamental mechanism through which humans acquire knowledge, underpinning successful social and cultural engagement while exerting a profound influence on personal development (Peng et al., 2020). Decoding, defined as the ability to translate a word's written form into its spoken form, is a crucial skill for reading development and comprehension, and serves as a foundation for learning new visual word forms (Ricketts et al., 2011; Share, 1995; Sun et al., 2018). In languages where the degree of form-to-sound correspondence is relatively inconsistent, decoding ability is particularly important (Tong and McBride, 2009). This challenge is especially pronounced in Chinese, where characters exhibit complex visual configurations and lack consistent grapheme-phoneme correspondence rules (Leong et al., 2011). For example, while the phonetic component "青 (qīng)" indicates pronunciation in "晴 (qíng)," it does not provide the speech cues in "猜 (cāi)." For L2 (second language) Chinese learners, a substantial amount of effort must be devoted to enhancing decoding skills over a considerable period.

The process of associating printed words with their corresponding sounds relies fundamentally on phonological awareness, which provides essential information for accurate pronunciation (Sun et al., 2018). Orthographic awareness further enhances decoding efficiency through both visual word form memorization and statistical learning of spelling patterns (Dehaene and Cohen, 2011; Lin and Zhang, 2025). Additionally, morphological awareness facilitates word meaning identification and contributes to pronunciation accuracy (Kuo and Anderson, 2006; Xie and Yeung, 2024). Extensive research has established strong relationships between English learners' phonological, orthographic, and morphological awareness and their word decoding abilities (Chen and Li, 2022; Georgiou et al., 2008; Jeon, 2011).

However, significant cross-linguistic differences exist in orthographic-phonological mapping principles. While English employs alphabetic grapheme-phoneme correspondence, Chinese utilizes morphosyllabic character-syllable mapping (Ziegler and Goswami, 2005), suggesting potentially distinct decoding mechanisms. Furthermore, emerging evidence indicates a differential utilization of metalinguistic awareness (e.g., phonological awareness, morphological awareness, and orthographic awareness) between Chinese L1 and L2 learners. For example, Ke's (2025) meta-analysis demonstrated substantially weaker correlations between morphological awareness and decoding in L1 learners compared to L2 learners.

Therefore, systematically investigating the interrelationships among these three types of awareness and their combined effects on decoding ability will significantly advance both theoretical frameworks of cross-linguistic reading acquisition and practical approaches to Chinese character literacy instruction.

Phonological, morphological, and orthographic awareness. Research has shown that learners who demonstrate advanced abilities in discriminating, memorizing, and manipulating various levels of speech units often achieve superior results in word acquisition and reading (Liu et al., 2020). These linguistic processing abilities are primarily manifested through three types of awareness, all of which operate on basic linguistic units such as morphemes, syllables, characters, and words.

Specifically, phonological awareness refers to the ability to discriminate, remember, and manipulate speech sounds (Peng et al., 2020). For example, perceiving that *qing* consists of *q* and *ing* enables combining them into qing and distinguishing *qǐng* from *qīng* as different sounds. Morphological awareness refers to the sensitivity to the internal structure of words and the ability to manipulate the morphological structure of words (Zhang and Koda, 2011). For example, the ability to recognize that "自行车 (bicycle)" consists of two smaller morphemes, "自行 (self-moving)" and "车 (vehicle)," enables the segmentation of the word into two meaningful units. Orthographic awareness refers to learners' cognitive and manipulative abilities concerning the structural characteristics of written words (Conrad et al., 2013). For example, the ability to distinguish that the correct character in "电脑 (computer)" is "脑 (brain)" rather than "恼 (annoy)."

The methods for assessing these three types of awareness in Chinese vary considerably across studies. For phonological awareness, Liu et al. (2020) employed initial and final recognition tests, where participants were instructed to circle Chinese characters containing specific target phonetic components. However, this method only assessed learners' awareness of initials and finals, overlooking the importance of syllables and tones. Koda and Zehler (2008) argued that receptive tasks are more suitable for L2 learners as they allow for a more direct investigation of phonological awareness. Therefore, this study adopted the oddity task designed by Zhang and Roberts (2019), which is considered an effective method for comprehensively evaluating phonological awareness. Participants were required to listen to audio recordings and identify the odd item from groups of three phonological units. The task included four types of judgments: initials, finals, syllables, and tones.

Chinese morphological awareness can be distinguished into sublexical morphological awareness (i.e., the ability to use meaning cues from semantic radicals embedded within compound characters) and lexical morphological awareness (i.e., the ability to understand and manipulate single characters that form Chinese compound words) (McBride-Chang et al., 2003; Shu and Anderson, 1997; Tong et al., 2017). Crucially, a substantial body of research has established that the ability to identify and appropriately combine morphemes contributes uniquely to the development of word-reading skills (Tong et al., 2017). To assess this ability, researchers commonly employ three key tasks: the compound structure task, the homophone awareness task, and the homograph awareness task (Ke, 2025). In line with the present study's focus on the relationship between structural awareness and decoding ability, we adopted a word segmentation task based on Zhang and Koda's (2018) approach, which effectively measures adult L2 Chinese learners' sensitivity to multi-morphemic word structures.

Methods for assessing orthographic awareness in Chinese contexts differ from those used in alphabetic languages due to the unique characteristics of Chinese characters. While alphabetic languages often use spelling tasks or letter order rearrangement, these approaches are not suitable for Chinese, which uses strokes as basic units (Wong, 2019). Chinese orthographic processing places greater emphasis on learners' knowledge of Chinese radicals and their sensitivity to the spatial configurations of these radicals within characters (Zhang, 2017). Building on the experimental design of Leong et al. (2011), we presented learners with both real words with correct orthographic forms and pseudowords containing one orthographic error, asking them to make judgments between the two.

The relationship between decoding and three awarenesses. At present, most research on English reading has indicated that phonological awareness, morphological awareness, and orthographic awareness impact decoding ability (e.g., Chen and Li, 2022; Deacon and Kirby, 2004; Georgiou et al., 2009). Nevertheless, there is still controversy regarding the contributions of these three awarenesses in Chinese reading.

The role of phonological awareness in Chinese decoding has been a topic of considerable debate, with existing research presenting conflicting findings. While some studies report strong positive relationships, others find null effects. For instance, Zhang et al. (2017) conducted a study with 123 fourth- and fifth-grade L1 Chinese children and found that phonological awareness significantly explained the variance in decoding accuracy and fluency. Liu et al. (2020) and Hao and Wang (2020) demonstrated that phonological awareness significantly contributed to character decoding among 30 elementary-level L2 Chinese learners (with a vocabulary size of 1,200 words). In contrast, Tong and McBride (2009), in their research involving 163 second-grade and 163 fifth-grade native Chinese speakers, found that after controlling for age and nonverbal intelligence, phonological awareness did not significantly predict decoding ability. Similar inconsistencies have also been observed in studies on L2 Chinese speakers. Hao and Zhou (2019) examined 30 beginner-level L2 Chinese learners who had only three months of study experience in China. Their findings indicated that only orthographic awareness and tone awareness significantly predicted character decoding accuracy, whereas neither visual nor auditory phonological awareness showed significant predictive power. These findings highlight the complexity of decoding processes in Chinese and suggest that the relative contributions of phonological awareness may vary depending on learners' proficiency, age, and native language.

As previously discussed, morphological awareness has been widely recognized as a key predictor of Chinese decoding ability. In studies on native Chinese-speaking children, Tong and McBride (2009) found that morphological awareness significantly predicted decoding ability, with its influence being stronger in older children. Similarly, Cheng et al. (2018) observed that morphological awareness and word-reading fluency in first-grade children grew significantly over time. They also noted that morphological awareness influenced reading comprehension indirectly through its effect on decoding fluency. For L2 Chinese learners, Hao and Wang (2020) demonstrated that beginning learners' morphological awareness predicted both decoding accuracy and fluency. However, for adult L2 Chinese learners whose proficiency exceeds the beginner level but has not yet reached intermediate proficiency, it remains unclear how morphological awareness predicts decoding ability.

Compared to alphabetic languages such as English, Chinese characters often lack direct correspondence between visual form and pronunciation (Shu et al., 2003). Therefore, learners need to develop a sophisticated understanding of Chinese orthographic features to achieve successful character decoding. Most research supports the importance of orthographic awareness in Chinese decoding. For example, in a study on L1 Chinese children, Hsuan et al. (2018) found that orthographic awareness could significantly predict decoding abilities for students in the lower grades. This orthographic-decoding relationship is further substantiated in L2 Chinese reading. Hao and Zhou (2019) and Liu et al. (2020) confirmed that orthographic awareness significantly contributed to decoding ability. Similarly, Chen et al. (2022), in a study involving 55 beginning L2 Chinese learners (vocabulary size between 300 and 500), demonstrated that orthographic awareness not only predicted decoding ability but also indirectly influenced reading comprehension through the mediation of decoding. Furthermore, it is uncertain whether the relationship between orthographic awareness and decoding ability is influenced by other metalinguistic awarenesses.

In summary, while phonological awareness, morphological awareness, and orthographic awareness are all recognized as important contributors to decoding ability in English reading, their roles in Chinese reading—particularly for L2 learners—remain less clear and subject to ongoing debate. The inconsistencies in findings regarding phonological awareness highlight the complex nature of Chinese decoding, suggesting that its influence may vary depending on factors such as learners' proficiency, age, and linguistic background. Similarly, although morphological and orthographic awareness have been consistently shown to play significant roles in character decoding, the precise mechanisms underlying their contributions, as well as their interactions with other metalinguistic skills, require further exploration.

The present study. Some controversies and unresolved issues remain regarding how different types of linguistic awareness influence decoding ability. First, it is uncertain whether phonological awareness has a distinct effect on L2 Chinese learners' decoding ability and whether morphological and orthographic awareness have relatively greater impacts. Second, existing research on Chinese decoding has mainly focused on native-speaking children, with limited attention to factors influencing L2 learners' decoding ability, especially adult learners. Third, existing studies have employed various methods to measure these different types of awareness, and different testing methods inevitably influence the research results. In this study, we used judgment tasks that were more suitable for L2 learners to assess their phonological, morphological, and orthographic awareness, aiming to minimize the interference caused by issues such as Chinese character writing on the assessment results.

Currently, basic-level reading subskills tests for L2 Chinese learners mainly target two groups: beginners who have just started learning Chinese and elementary learners at approximately HSK Level 3. According to the Guidelines of the *Chinese Proficiency Standards for International Chinese Education* (Ministry of Education of the People's Republic of China, 2021), learners at the new HSK Level 3 are able to understand simple language materials and engage in effective social communication, representing a large proportion of learners in Chinese language education. To better compare with previous research, we also chose to explore how phonological awareness, morphological awareness, and orthographic awareness relate to elementary-level L2 Chinese learners' decoding ability. Specifically, we addressed two research questions:

RQ1: Is there any relationship between word decoding ability and the three types of awareness (phonological, morphological, and orthographic) among elementary-level L2 Chinese learners?

RQ2: To what extent do phonological, morphological, and orthographic awareness contribute uniquely and jointly to L2 Chinese word decoding performance?

Methods

Participants. We recruited 88 L2 Chinese learners for testing with the help of five Chinese language instructors teaching overseas. To assess the participants' Chinese proficiency, both self-reports and the L2 Chinese vocabulary test were employed in this study. According to the vocabulary test results, the vocabulary range of 71 participants was between 1,000 and 2,700 words, with an average vocabulary size of 1,979 words, which is close to the HSK Level 3 vocabulary standard (2245 words) set by the *Chinese Proficiency Standards for International Chinese Education* (Ministry of Education of the People's Republic of China, 2021). The reliability of the vocabulary task was good (Cronbach's $\alpha = 0.81$). The description of the vocabulary test is provided in the Supplementary. The study investigated the impact of metalinguistic awareness on the decoding ability of 71 L2 Chinese learners, including 28 L1 English speakers (18 males and 10 females), 38 L1 Vietnamese speakers (9 males and 29 females), and 5 L1 Thai speakers (2 males and 3 females). The self-reported

data indicated that all participants ranged in age from 18 to 45 years, and none had a Chinese-speaking household background. Furthermore, all participants were either actively preparing for or had recently achieved passing scores on the HSK Level 3 examination.

Instruments

Phonological awareness test. The phonological awareness test, based on the oddity task in Zhang and Roberts' (2019) work, examined learners' ability to perceive and manipulate phonological units through judgment tasks involving syllables, initials, finals, and tones, with each subtask containing five questions. The materials for the phonological awareness test were all selected from the elementary and intermediate syllables in *The Graded Chinese Syllables, Characters and Words for the Application of Teaching Chinese to the Speakers of Other Languages* (National Language Commission, 2010). The participants were required to click a button to play a set of three items and to choose the odd one. Each correct answer was scored as 1 point; the maximum possible score was 20 points. The reliability of the vocabulary task was good (Cronbach's $\alpha = 0.85$). For example:

Listen and choose the one with a different syllable. (Audio play) A. gènggāo B. dònggǎn C. chùdòng

Morphological awareness test. The morphological awareness test was adapted from Zhang and Koda (2018) to assess learners' ability to segment morphemic structures within words or phrases. The test included 17 trisyllabic Chinese words that could be categorized into three types: words that can be divided as "1 + 2" (e.g., 大自然), words that can be divided as "2 + 1" (e.g., 自行车), and words that cannot be divided (e.g., 巧克力). The test materials were selected from Levels 1–3 of the *Chinese Proficiency Standards for International Chinese Education* (Ministry of Education of the People's Republic of China, 2021) and were supplemented with loanwords frequently used in Chinese people's daily life. During the test, the participants were required to determine whether the word could be segmented into smaller morphemes and to choose the correct option. Each correct answer was scored as 1 point; the maximum possible score was 17 points. The reliability of this task was good (Cronbach's $\alpha = 0.76$). For example:

Judge whether the word can be divided into smaller units, and choose the correct answer. A. 大|自然 B. 大自|然 C. 大自然

Orthographic awareness test. The orthographic awareness test measured learners' understanding of and ability to manipulate the structural characteristics of Chinese characters. Adapted from Zhang (2017), the test comprised 15 bisyllabic Chinese words selected from Levels 1–3 of the *Chinese Proficiency Standards for International Chinese Education* (Ministry of Education of the People's Republic of China, 2021). During the test, words were presented randomly in either correct (e.g., 电脑) or incorrect forms (e.g., 电恼). Participants were instructed to make rapid judgments about the orthographic accuracy of each displayed word: pressing "F" on the keyboard for correct words and "J" for incorrect ones. Each correct response was awarded 1 point, with a maximum possible score of 15 points. The task demonstrated moderate reliability (Cronbach's $\alpha = 0.61$).

Chinese word decoding test. This study adopted the Chinese word-reading task developed by Ke and Koda (2021), which to assess learners' ability to accurately read multi-character items. The reading materials were divided into four categories: (a) bisyllabic real words (e.g., 机会); (b) trisyllabic pseudowords (e.g., 开始方); (c) trisyllabic nonwords (e.g., 方喜欢); and (d) combinations of three unrelated morphemes (e.g., 孩放而). The test procedure began with a fixation cross "+" displayed on the screen, followed by the target word after a 500-ms interval. The 16 test items were presented in random order, with each item appearing only once. Each correct answer was scored as 1 point; the maximum possible score was 16 points. Given the participants' beginner-level status, tonal errors were not penalized, and self-corrections were accepted as valid responses. The task demonstrated good reliability (Cronbach's $\alpha = 0.73$).

Procedures. The study was conducted using the Gorilla Experimenter Builder platform (Version 2022), which facilitated an online computer-based assessment comprising five tasks, including the Chinese vocabulary test. Instructions were available in English, Vietnamese, and Thai to accommodate participants' native languages, while the test content was presented in Chinese. To ensure standardized testing conditions, participants were instructed to complete the tasks in a quiet environment with stable internet connectivity. Prior to the main experiment, a pilot study was conducted with three L2 Chinese learners. Based on the pilot feedback, minor adjustments were made to the task instructions and timing parameters to optimize the testing procedure. The test was distributed to participants via web links or QR codes generated by the Gorilla platform. Participants were required to complete all tasks using either a laptop or desktop computer, as mobile devices were not supported due to display and response timing requirements. To ensure data quality and minimize fatigue effects, test sessions exceeding one hour were automatically invalidated by the system. The performance data were automatically recorded by the Gorilla platform and exported for analysis. Raw scores from the task performances were standardized and subsequently analyzed using IBM SPSS Statistics (Version 27.0) for statistical processing.

Results

Descriptive statistics and correlational analyses. The descriptive statistics for all the tasks are presented in Table 1. A total of 71 participants were included in the data analysis.

Pearson correlation analyses were conducted to examine the intercorrelations among all variables (see Table 2). Results indicated significant correlations among morphological awareness, orthographic awareness, and decoding ability ($p < 0.05$). However, the correlation between phonological awareness and decoding ability was not significant ($p = 0.43$). According to Cohen's (1988) benchmarks for interpreting effect sizes in

Table 1 Descriptive statistics ($N = 71$).

	k	Mean	SD	95% Confidence interval	
				Lower bound	Upper bound
Phonological awareness	20	13.62	4.76	12.49	14.75
Morphological awareness	17	10.08	3.82	9.25	10.95
Orthographic awareness	15	10.35	2.66	9.72	10.99
Decoding ability	16	11.72	3.01	11.02	12.41

Table 2 Correlations among all variables ($N = 71$).

Measures	1	2	3	4
1. Phonological awareness	-	0.50***	0.31**	0.10
2. Morphological awareness		-	0.56***	0.31**
3. Orthographic awareness			-	0.32**
4. Decoding ability				-

Note. ***$p < 0.001$, **$p < 0.01$.

Table 3 Partial correlation analysis controlling for native language ($N = 71$).

Measures	1	2	3	4
1. Phonological awareness	-	0.49***	0.29*	0.08
2. Morphological awareness		-	0.52***	0.27*
3. Orthographic awareness			-	0.28*
4. Decoding ability				-

***$p < 0.001$, *$p < 0.05$.

correlation analyses, an effect size of $r = 0.30$ is considered moderate. Thus, morphological awareness and orthographic awareness demonstrated moderate correlations with decoding ability ($r = 0.31$, $r = 0.32$, respectively).

Considering the potential influence of participants' native language background on variable relationships, native language was included as a control variable in the partial correlation analysis (see Table 3). After controlling for native language background, morphological awareness ($r = 0.27$, $p < 0.05$) and orthographic awareness ($r = 0.28$, $p < 0.05$), remained significantly correlated with decoding ability, though effect sizes slightly varied.

Hierarchical regression analysis: effects of morphological and orthographic awareness on decoding ability. Hierarchical regression analysis was conducted to examine the unique contributions of morphological awareness and orthographic awareness to decoding ability (see Table 4). In the Step 1, native language was entered as a control variable to account for potential confounding effects. It explained 3.0% of the variance in decoding ability ($R^2 = 0.030$), which was not statistically significant ($F(1,69) = 2.150$, $p = 0.147$).

In Step 2, morphological awareness and orthographic awareness were added individually to the regression model. The inclusion of morphological awareness significantly improved the model, increasing the explained variance to 10.3% ($\Delta R^2 = 0.103$, $p < 0.05$), with a significant incremental variance of 7.3% ($F(1,68) = 5.540$, $p < 0.05$). Similarly, orthographic awareness significantly improved the model, increasing the explained variance to 10.7% ($\Delta R^2 = 0.107$, $p < 0.05$), with a significant incremental variance of 7.7% ($F(1,68) = 5.828$, $p < 0.05$). No significant multicollinearity issues were detected for morphological awareness ($VIF = 1.075$) or orthographic awareness ($VIF = 1.155$). However, when morphological awareness and orthographic awareness were entered simultaneously into the model, neither predictor made a significant unique contribution (morphological awareness: $p = 0.199$; orthographic awareness: $p = 0.167$). Furthermore, the interaction term between morphological awareness and orthographic awareness did not significantly predict decoding ability ($p = 0.570$).

These findings indicated that morphological awareness and orthographic awareness independently contribute to decoding ability when considered separately, with each predictor significantly enhancing the explanatory power of the regression model.

Discussion

The present study examined the contributions of phonological, morphological, and orthographic awareness to word decoding ability among elementary-level L2 Chinese learners. The main findings were as follows:

(1) Phonological awareness, morphological awareness, and orthographic awareness were significantly interrelated. However, only morphological awareness and orthographic awareness demonstrated significant correlations with decoding ability.
(2) Hierarchical regression analyses further clarified these relationships. After controlling for the potential confounding effect of native language background, morphological awareness ($\beta = 0.235$, $p < 0.05$) and orthographic awareness ($\beta = 0.315$, $p < 0.05$) emerged as significant independent predictors of decoding performance.

The impact of morphological awareness and orthographic awareness on decoding ability. The study results revealed a significant correlation between morphological awareness and decoding ability. Although morphological awareness has traditionally been identified as a critical predictor of literacy skills primarily in higher grades among learners of alphabetic languages (e.g., third-grade native-speaking children), recent studies indicate that it serves as a unique predictor of early reading development in the context of Chinese (Ke, 2025). Furthermore, the transfer facilitation model proposed and validated among bilingual Chinese-speaking children suggests that morphological awareness functions as a cross-linguistically transferable resource between learners' L1 and L2 (Ke and Koda, 2021). Moreover, the significant contribution of morphological awareness to reading proficiency in second-language Chinese learning contexts has also been partially substantiated by previous empirical studies. For instance, Hao and Wang (2020) investigated the relationship between homophonic and homographic morphemes and decoding ability, whereas the current study and Tong and McBride (2009) focused specifically on compound structure awareness. Despite differences in focus, all three morphological awareness dimensions (i.e., homophonic morphemes, homographic morphemes, and compound structure awareness) have been consistently found to be closely associated with decoding ability. Learners with strong morphological awareness are more adept at decomposing compound words into constituent morphemes, enabling them to shift their analytic focus from whole words to individual morphemes or characters (Lin et al., 2019). In other words, enhanced morphological awareness facilitates deeper semantic analysis and comprehension of Chinese characters and words.

In addition to morphological awareness, orthographic awareness also exhibited a significant correlation with decoding ability. As we mentioned above, phonological information in Chinese is encoded less transparently and less reliably than in alphabetic languages such as English, prompting Chinese learners to rely more heavily on orthographic forms and the semantic information of characters. Consequently, familiarity with orthographic structures significantly enhances learners' decoding abilities (Perfetti et al., 2005). Mastery of Chinese orthographic rules enables learners to efficiently link visual character forms with their corresponding pronunciations and meanings, thereby improving reading efficiency and accuracy. Empirical evidence further supports this assertion. For example, Hsuan et al. (2018) identified a significant correlation between orthographic

Table 4 Hierarchical regression analysis with decoding as the dependent variable ($N = 71$).

	R	R^2	B	SE	β	t	Sig.
Step 1	0.174	0.030					
Native language			-0.034	0.023	-0.174	-1.466	0.147
Step 2							
Model 1	0.321	0.103*					
Native language			-0.020	0.023	-0.100	-0.838	0.405
Morphological awareness			0.235	0.100	0.280	2.354	0.021
Model 2	0.327	0.107*					
Native language			-0.013	0.024	-0.065	-0.527	0.600
Orthographic awareness			0.315	0.131	0.297	2.414	0.018
Step 3	0.359	0.129					
Native language			-0.010	0.024	-0.053	-0.430	0.668
Morphological awareness			0.150	0.116	0.180	1.299	0.199
Orthographic awareness			0.213	0.152	0.201	1.398	0.167
Step 4	0.365	0.133					
Native language			-0.009	0.024	-0.045	-0.365	0.717
Morphological awareness			-0.077	0.414	-0.091	-0.185	0.854
Orthographic awareness			0.024	0.364	0.022	0.065	0.948
Interaction item			0.326	0.571	0.408	0.571	0.570

*$p < 0.05$.

awareness and decoding ability among native Chinese-speaking learners. Similarly, Chen et al. (2022) demonstrated that orthographic awareness indirectly influences reading comprehension among L2 Chinese learners through its impact on decoding processes. Liu et al. (2020) also emphasized that early development of orthographic awareness aids learners in recognizing structural features of Chinese characters, thereby laying a solid foundation for subsequent vocabulary acquisition and reading skills. Consistent with these findings, the current study suggests that even beginner-level L2 Chinese learners can effectively leverage both form-sound and form-meaning associations during decoding tasks, ultimately facilitating their reading development.

In summary, the present findings underscore the critical roles of morphological and orthographic awareness in promoting decoding ability among L2 Chinese learners. Future research should continue exploring instructional strategies aimed at enhancing these linguistic awareness skills to support learners' reading proficiency and language development.

The relationship between phonological awareness and decoding ability. The present study found that phonological awareness was not significantly correlated with decoding ability among beginner-level L2 Chinese learners. This finding contrasts with existing research on alphabetic languages, where phonological awareness consistently emerges as a strong predictor of decoding skills (e.g., Georgiou et al., 2009; Hao and Wang, 2020; Liu et al., 2020). A plausible explanation for this discrepancy is the distinctive orthographic nature of Chinese characters. The inconsistent grapheme-phoneme correspondences and the high frequency of homophones in Chinese characters may reduce beginner-level L2 learners' reliance on phonological awareness. Although some radicals within Chinese characters contain phonetic and semantic cues, these radicals do not demonstrate systematic or reliable correspondences to phonemes. Moreover, even when radicals provide pronunciation hints, these hints are far less systematic compared to the letter-phoneme mappings typical of alphabetic languages (Perfetti et al,. 2005). Consequently, learners who rely exclusively on form-sound correspondences often struggle to accurately decode graphic information. Instead, effective decoding in Chinese typically requires learners to utilize form-meaning correspondences to mitigate interference from homophonic elements.

Notably, the findings from this study also diverge from certain prior studies conducted on Chinese reading (e.g., Liu et al., 2020; Hao and Wang, 2020; Zhang et al., 2017). Methodological differences may account for this divergence. Specifically, Liu et al. (2020) and Hao and Wang (2020) employed phonological awareness tasks requiring participants to visually identify Chinese characters containing target initials or finals from a set of 60 or 40 characters. These tasks inherently involved integrating phonological and orthographic information, thereby activating processing pathways similar to those used in decoding tasks. In contrast, the present study employed auditory-based phonological tasks, in which participants were required to identify differences among phonological units (initials, finals, syllables, and tones) presented solely via audio recordings. Participants in this study thus did not need to link phonological units to their corresponding orthographic forms, instead focusing exclusively on auditory discrimination. Additionally, differences in participant characteristics may have contributed to the inconsistent findings. Although the vocabulary sizes of participants in the aforementioned studies were similar to those in the current study, their native language backgrounds varied significantly (including English, Italian, Thai, and Vietnamese) and were not statistically controlled. Variations in native language backgrounds can lead to differences in participants' L1 phonological awareness, potentially influencing their sensitivity to phonological processing in Chinese (McDowell and Lorch, 2008).

Despite differences in participant profiles between this study and those conducted by Hao and Zhou (2019) and Tong and McBride (2009), our findings nevertheless align with their conclusions that phonological awareness does not significantly contribute to decoding ability in Chinese reading contexts. This phenomenon may be attributed to two primary factors: first, the inherent irregularity and opacity of Chinese grapheme-phoneme correspondences, and second, the developmental stage of learners, who may have already attained sufficient reading proficiency to rely less heavily on auditory-based phonological processing during decoding tasks.

Implications, limitations, and conclusions

Consistent with previous research findings (e.g., Bessy and Knouse, 2020; Hao et al., 2020), the present study suggests that morphological awareness and orthographic awareness

significantly influence decoding ability, which is critical in developing reading skills during the early stages of language learning. Phonological, morphological, and orthographic awareness collectively play essential roles in word decoding and reading comprehension, and purposeful instructional interventions can effectively enhance these metalinguistic abilities.

To develop these awareness skills, Chinese teachers should design activities focusing on analyzing the structure of Chinese characters. For example, after introducing the basic structures of Chinese characters, teachers could distribute cards containing common radicals and character components. Students could then analyze these components, construct new characters, and explain their reasoning. This engaging activity enhances learners' understanding of character structure and strengthens their orthographic awareness. Additionally, morpheme games can contribute to enhancing morphological awareness. Teachers can first explain the basic morphological structure of Chinese vocabulary, such as common morphemes and their combinational rules. Students then combine these morphemes to form as many valid Chinese words as possible, with the group creating the most correct words within the allotted time winning the game. Following the activity, teachers can analyze and explain any incorrect words. By mastering these basic rules of character and word formation, students can develop automatic processing of unfamiliar words during reading comprehension, ultimately achieving fluent decoding.

Admittedly, this study has several limitations. First, the relatively small sample size may restrict the generalizability of the findings. Second, the study focused primarily on word-level morphological and orthographic awareness and their impact on decoding. Future studies could incorporate character-level tests, such as analyzing learners' sensitivity to radicals and character structures, to more comprehensively examine the relationship between metalinguistic awareness and decoding ability. Additionally, this study only examined metalinguistic awareness and decoding ability among learners with an elementary level of Chinese proficiency. Future research could examine whether phonological, morphological, and orthographic awareness have differential impacts on decoding ability. Specifically, it is necessary to compare these impacts across elementary and advanced stages of L2 Chinese reading development.

In conclusion, this study highlighted the roles of morphological and orthographic awareness in decoding ability among elementary-level L2 Chinese learners. The findings underscore the importance of morphological and orthographic awareness, suggesting these should be prioritized in language instruction to enhance decoding skills. Although phonological awareness did not significantly impact decoding ability, its role at different stages of language acquisition warranted further exploration. Future research should continue to investigate these relationships across various proficiency levels and methodologies to better support L2 learners in improving their literacy skills.

Data availability

The data is not publicly available due to privacy restrictions and the terms of the participants.

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Author contributions

Wenwen Zhu and Xintong Xu drafted the manuscript. Xintong Xu conducted data collection. Tianxu Chen and Sihui Ke provided professional guidance. All authors proofread the manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This study was conducted in accordance with the principles of the Declaration of Helsinki. Approval was obtained from the Ethics Committee of the Research Ethics Committee, School of Linguistic, Speech and Communication Sciences, Trinity College Dublin (May 12, 2023; No. HT41). All research activities were carried out in compliance with the relevant guidelines applicable to studies involving human participants.

Informed consent

Informed consent was obtained in written form directly from participants during the data collection period from June 15, 2023, to August 1, 2023. All participants gave informed consent electronically prior to participating in the study. The participants whose consent was obtained were adult native speakers of English, Vietnamese or Thai. All participants were informed about the purpose of the research, the voluntary nature of participation, and their right to withdraw at any time without consequences. The informed consent covered the research purpose, the test components, the target participants, data protection and privacy measures, as well as the participants' rights.

Additional information

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