

**Within- and Cross-Language Pathways from Morphological Awareness to Reading
Comprehension in Chinese-English Bilingual Children**

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Abstract

Morphological awareness is a critical predictor of reading comprehension, yet its direct and indirect contributions within and across languages remain complex in bilingual children, particularly in typologically distinct language pairs. We examined pathways from morphological awareness to reading comprehension within and across first language (L1) Chinese and second language (L2) English in Chinese-English bilinguals. A cross-sectional sample of 467 Hong Kong students in Grade 2 ($n = 150$, age = 8.10 years), Grade 5 ($n = 158$, age = 11.19 years), and Grade 8 ($n = 159$, age = 13.79 years) completed measures of morphological awareness, vocabulary, word reading, and reading comprehension in both L1 and L2. Grade-specific structural equation models showed that L1 morphological awareness predicted L1 reading comprehension indirectly via vocabulary in Grade 2, but directly in Grades 5 and 8. L2 morphological awareness predicted L2 reading comprehension directly and indirectly via vocabulary and word reading in Grade 2, directly in Grade 5, and directly and indirectly via vocabulary in Grade 8. Across languages, L1 morphological awareness supported L2 reading comprehension through L2 morphological awareness, vocabulary, and word reading and L2 morphological awareness supported L1 reading comprehension through L1 morphological awareness and vocabulary in Grade 2. By Grade 5, there was an indirect pathway from L1 to L2 via L2 morphological awareness. In Grade 8, significant indirect effects emerged bidirectionally via morphological awareness in the other language. Findings reveal a dynamic role of morphological awareness in bilingual reading comprehension, highlighting the need for grade-tailored, language-general and language-specific morphological instruction in literacy support for bilingual children.

Keywords: morphological awareness, bilingual reading comprehension, cross-language effects, Chinese-English bilingual children

Within- and Cross-Language Pathways from Morphological Awareness to Reading Comprehension in Chinese-English Bilingual Children

Morphological awareness is the ability to analyze and manipulate the morphemic structure of words (Carlisle, 1994). It is a critical contributor to reading comprehension in both alphabetic (e.g., English, Spanish, Greek; Carlisle, 2000; Deacon & Kirby, 2004; Deacon & Levesque, 2024; Giazitidou et al., 2024, 2025) and nonalphabetic languages (e.g., Chinese; Ku & Anderson, 2003). A substantial body of work with monolingual children shows that morphological awareness supports reading comprehension beyond phonological awareness, vocabulary and word reading (e.g., Carlisle, 2000; Deacon & Kirby, 2004; Tong et al., 2011). In bilinguals, however, the role of morphological awareness is less clearly specified. Although previous studies have examined its contribution to bilingual children's reading comprehension (Zhang & Koda; 2012; Marks et al., 2022), most have largely focused on a single age group, relied on a narrow and often first language (L1)-dominant set of tasks, and used non-parallel or non-multidimensional measures of morphological awareness across L1 and second language (L2). Consequently, it remains unclear to what extent morphological awareness contributes to reading comprehension at different ages, particularly in bilingual children learning typologically distinct languages such as Chinese and English. In Hong Kong, approximately 88.7% of children aged 5 years and above could read and write both Chinese and English (HKSAR 2021 Population Census). Therefore, clarifying these developmental and cross-linguistic pathways is essential. The present study is among the first to systematically investigate these relationships across a broad age range of Chinese-English bilingual children using a comprehensive set of language-general and language-specific measures of morphological awareness in both L1 and L2.

The Role of Morphological Awareness in Reading Comprehension

Morphology is the system of linguistic rules governing the internal structure and formation of words (Rastle, 2019). It links spoken and written language through meaning because morphemes, the smallest linguistic units of meaning combine to form words (e.g., *information*, *informative*, and *informer*),

while inflectional morphemes mark grammatical information such as tense, number, and case. According to the Morphological Pathways Framework (Levesque et al., 2021), morphological awareness supports reading comprehension through two theoretically distinct but related routes: a form-based pathway, in which awareness of morphemic structure facilitates morphological decoding, word identification, and fluent word reading; and a meaning-based pathway, in which morphological analysis supports the extraction and integration of word meanings, thereby contributing to vocabulary growth and text-level comprehension.

Empirical evidence is broadly consistent with these two pathways. In the form-based pathway, morphological awareness is strongly related to word reading (Gilbert et al., 2014; Levesque & Deason, 2022), which in turn supports reading comprehension (Deacon et al., 2014; Levesque et al., 2017). Morphological awareness may facilitate word reading by helping children recognize familiar morphemic units in complex words and decode unfamiliar words more efficiently, thereby enhancing lexical access and strengthening lexical representations (Perfetti, 2007). In the meaning-based pathway, morphological awareness enables children to analyze unfamiliar words into meaningful units, such as prefixes, roots, suffixes, or compound constituents. This analysis supports vocabulary acquisition and retention, and stronger vocabulary knowledge provides an important semantic foundation for reading comprehension (Carlisle, 2007; McBride-Chang et al., 2005b; Sparks & Deacon, 2015). Morphology may also interact with other aspects of the linguistic system, such as phonology and syntax, to support higher-level text understanding (Perfetti & Stafura, 2014).

However, the extent to which morphological awareness contributes to reading comprehension directly or indirectly through these component skills remains unresolved. Some studies have reported a direct effect of morphological awareness on reading comprehension after controlling for phonological awareness, vocabulary, and word reading (Deacon & Kirby, 2004; Levesque et al., 2017), whereas others have highlighted indirect pathways mediated by vocabulary knowledge and word reading (Kieffer & Box, 2013; Kieffer & Lesaux, 2012). These findings suggest that morphological awareness may influence reading comprehension through multiple developmentally sensitive routes.

Morphological Awareness in Bilingual Reading Comprehension

According to a recent meta-analysis of 44 studies on morphological awareness and reading comprehension (Liu et al., 2024), all come from monolingual readers. In the bilinguals, although many studies have documented significant links between morphological awareness and reading comprehension, the pattern of effects is more complex, especially when the two languages differ in morphological structure and writing system (e.g., English-Chinese, English-Hebrew). Different languages prioritize different units in reading. In Chinese, morphemes often correspond to syllables and characters, and meaning-based cues such as semantic radicals and compound structures are highly salient. For example, the semantic radical 氵, which is associated with water, appears in characters such as 河 (*river*), 湖 (*lake*), and 海 (*sea*). In English, morphological processing is closely tied to phonology, with letters mapping onto phonemes. For example, in *jumped*, children may recognize the base morpheme *jump* and the past-tense suffix *-ed*, while decoding the word phonological as /dʒʌmpɪd/. As a result, the same broad construct of morphological awareness may support reading comprehension through distinct pathways within each language and may transfer asymmetrically across languages.

When examining the effect of morphological awareness on reading comprehension within the same language, i.e., within-language effect, bilingual studies have reported both direct and indirect effects with inconsistent findings (Marks et al., 2022; Zhang & Koda; 2012; Sun & Curdt-Christiansen, 2016; Zhang et al., 2014). For example, Marks et al. (2022) found that in Spanish-English bilingual children aged 6-10, L2 English morphological awareness directly predicted L2 reading comprehension, whereas L1 Spanish morphological awareness influenced L1 reading comprehension indirectly through vocabulary and word reading. In contrast, Zhang and Koda (2012) examined the effect of L2 morphological awareness on L2 reading development in Chinese adult learners of English and showed no direct effect but significant indirect effects through both vocabulary knowledge and lexical inferencing ability. These findings suggest that, although morphological awareness is a robust predictor of reading comprehension

within language, whether its effects are direct or mediated remains unclear, and may depend on language, proficiency and development stage.

On the other hand, when examining the effect of morphological awareness in one language on reading comprehension in another language, i.e., cross-language transfer, a central question arises: To what extent does morphological awareness in one language support reading comprehension in the other? This question is theoretically and practically significant because it addresses whether and how literacy skills developed in one language can facilitate learning in another. Theoretical frameworks offer different predictions. The contrastive-typological framework (Lado, 1957) emphasized shared structures (e.g., compounding in both Chinese and English) as a basis for transfer. The linguistic interdependence hypothesis (Cummins, 1979) posits that strong L1 language skills can support L2 literacy given sufficient, explicit L1 instruction, emphasizing the role of educational context and linguistic input. The transfer facilitation model (Koda, 2008) proposes that transfer reflects an automatic activation of L1 competencies triggered by L2 input, with transfer more likely from the language of higher proficiency. Based on these theories, it seems plausible that cross-language transfer of morphological awareness is multifaceted and shaped by linguistic similarity, educational context, and proficiency level.

Empirical evidence on cross-language transfer is mixed. Some studies have found significant transfer from morphological awareness in one language to reading comprehension in the other language (Pasquarella et al., 2011; Wang et al., 2006; Zhang et al., 2014; Zhang & Koda, 2014), whereas others identified only within-language effects, i.e., the influence of morphological awareness in one language on reading in the same language (Marks et al., 2022). For example, Pasquarella et al. (2011) examined Chinese-English bilingual children in Grades 1, 2, and 4, and showed that L2 English compound awareness significantly predicted L1 Chinese reading comprehension, in support of cross-language transfer. By contrast, Marks et al. (2022) found that Spanish-English bilingual children exhibited a within-language effect only from L2 morphological awareness to L2 reading comprehension and no cross-language effects. A common limitation of these studies is the use of a narrow set of morphological awareness, typically compounding and/or derivational awareness, which does not capture the

multidimensional nature of morphological awareness (Li et al., 2025). Consequently, the condition under which morphological awareness transfer across languages and through which pathways, remains poorly specified.

Chinese-English Bilinguals: A Unique Window for Morphological Awareness Transfer

Chinese-English bilinguals provide a unique and informative context for studying contributions of morphological awareness to reading comprehension and cross-language transfer. Chinese and English are typologically distinct: Chinese is a morphosyllabic language with an extensive use of compounding, whereas English is an alphabetic language with rich derivational and inflectional morphology. At the lexical level, both languages using compounding (e.g., 黑板 “blackboard”), although compounding is more prevalent in Chinese. At the sublexical level, within-word units smaller than a whole word, both languages encode meaning through cues: English through affixes (e.g., “un-” for negation, “-ful” for adjectives), and Chinese through semantic radicals embedded in characters (e.g., 足 ‘foot’ in 跑 ‘to run’). In Chinese, many characters are semantic-phonetic compounds composed of a meaning-bearing radical plus a phonetic component. Semantic radicals are processed during character recognition and function as representational units, supporting a distinct level of lexical representation (Tong et al., 2017). Previous studies have shown that children used semantic radicals to infer the meanings of unfamiliar characters and words (McBride-Chang et al., 2003), indicating the analysis of meaning-bearing sublexical units rather than only visual features. In addition, Chinese has a high density of homophones (e.g., “唐” *Tang dynasty* and “糖” *candy* both pronounced /tong4/) and homographs (e.g., “花” /faa1/ meaning either *flower* or *to spend*), whereas English relies heavily on inflection (e.g., *cat* to *cats*) and derivation (e.g., *write*, *rewrite*, and *writing*). These structural contrasts highlight the need for language-specific approaches to assessing morphological awareness and for models that accommodate both language-general and language-specific morphological processes.

Several studies with Chinese-English bilinguals have examined the relationship between morphological awareness and reading comprehension in Chinese-English bilinguals, demonstrating both

within-language associations in both L1 Chinese (Zhang et al., 2014) and L2 English (Wang et al., 2006; Zhang et al., 2014), as well as cross-language transfer from L1 to L2 (Zhang et al., 2014; Zhang & Koda, 2014) and from L2 to L1 (Wang et al., 2006; Pasquarella et al., 2011). These effects generally hold even after controlling for relevant factors such as age, grade, vocabulary, and phonological awareness. In these studies, morphological awareness has typically measured with tasks tapping compounding, derivational morphology, and radical awareness, and relations with reading comprehension have been investigated primarily in children from Grade 2 to Grade 6.

Despite evidence of cross-language transfer in Chinese-English bilinguals, several important gaps remain in the literature. First, most studies have relied on either a single or very limited set of morphological awareness tasks (e.g., compounding and/or derivational morphology), providing only a partial view of morphological awareness in each language. Second, the focus on a specific age range has constrained our understanding of how the contribution of morphological awareness to reading comprehension change in different ages. Developmentally, as children move from “learning to read” to “reading to learn”, morphological awareness is expected to shift from supporting word reading in lower grades to supporting vocabulary growth in later grades. In Chinese, early morpheme-character mapping can make morphology especially predictive of word reading in young children, whereas in English, early effects are constrained by decoding and oral language, with strong vocabulary-mediated and direct effects emerging in upper grades. Consistent with this, studies with Chinese-speaking children suggest that morphological awareness may not remain a strong predictor of word reading in older primary-school students, as sensitivity to semantic units emerges as early as kindergarten (McBride-Chang et al., 2003; Li et al., 2012). In English-speaking children, morphological awareness tends to influence reading comprehension indirectly through word decoding in middle elementary grades but more directly in upper elementary grades (Deacon et al., 2014; Kieffer & Lesaux, 2012), indicating that early exposure to derivational and inflectional morphology facilitates word decoding, which in turn enhances reading comprehension. Third, even when multiple measures were included, their underlying dimensional structure has been rarely examined (e.g., Pasquarella et al., 2011). Recent research emphasizes that

morphological awareness is not a unitary construct but comprises distinct dimensions that differentially support bilingual reading development (Apel et al., 2013; Li et al., 2025).

Building on the multidimensional framework proposed by Li et al. (2025), we conceptualize bilingual morphological awareness as a set of correlated but separate dimensions defined by task modality (i.e., expressive versus receptive) and stimulus level (lexical versus sublexical). In this framework, Chinese-English bilingual children show modality-specific multidimensionality in L1 Chinese but a more unitary morphology factor in L2 English. Consistent with this framework, the current study samples each dimension in both languages using parallel tasks, allowing us to test dimension-specific pathways to reading comprehension.

The Present Study

To address the above limitations, the current study adopts a multidimensional framework (Li et al., 2025) and employed a comprehensive set of language-specific and language-general measures of morphological awareness in both L1 Chinese and L2 English. Using a cross-section design with Chinese-English bilingual children across multiple grade levels, we aim to uncover the development and role of morphological awareness in bilingual reading comprehension. Two specific research questions are addressed for within-language and cross-language pathways, respectively. First, to what extent does morphological awareness directly and indirectly contribute to reading comprehension within each language at different grade levels? We hypothesized that morphological awareness would significantly contribute to reading comprehension within both L1 Chinese and L2 English, either directly or indirectly via word reading and/or vocabulary (Deacon & Kirby, 2004; Kieffer & Box, 2013; Levesque et al., 2017). We further expected these pathways to vary by grade level: in lower grades, morphological awareness would support reading comprehension indirectly through word reading, whereas in upper grades, it would contribute more through vocabulary and may also exert a direct effect.

Second, to what extent does morphological awareness in one language directly and indirectly contribute to reading comprehension in different grade levels? We hypothesized bidirectional cross-language effects from L1 to L2 (Zhang et al., 2014; Zhang & Koda, 2014) and from L2 to L1 (Pasquarella

et al., 2011; Wang et al., 2006). We further anticipate that the effect of cross-language transfer may change by grade level in bilingual children, depending on the language proficiency and metalinguistic skills (Kim & Piper, 2019; Lee & Kim, 2025). In lower grades, morphological awareness supports word decoding (Colé et al., 2018; Cohen-Mimran et al., 2022), whereas in upper grades it contributes more through vocabulary and higher-level text integration (Liu et al., 2024).

Methods

Participants

A total of 467 Hong Kong Chinese-English bilingual children who were L1 Cantonese speakers learning English as L2 participated in the current study, including 150 students in Grade 2 (N = 76 female; mean age = 8.10 years \pm 7.28 months), 158 in Grade 5 (N = 83 female; mean age = 11.19 years \pm 7.95 months), and 159 in Grade 8 (N = 79 female; mean age = 13.79 years \pm 5.14 months), representing beginning, intermediate, and advanced stages of reading, respectively. All participants were typically developing without any cognitive, language, or learning impairments. They were recruited from local mainstream primary and secondary schools across three regions (Hong Kong Island, Kowloon, and the New Territories) in Hong Kong, in which Cantonese is the medium of instruction. Informed written consent was obtained from schools and parents before testing, and the study was approved by the ethics committee of the corresponding author's University. Table 1 presents parents' ratings of the participants' proficiency in Chinese and English. According to the parent-report Language and Social Background Questionnaire (Tong et al., 2015), all participants came from Cantonese-speaking families and learned English as L2. The L2 age of acquisition (AoA) was 4-6 years old for 46.6% of the children and before 3 years old for 48.0%. The socioeconomic status (SES) for most participants' families was medium- to high-income (The Hong Kong Census and Statistics Department, 2015). Parents also rated their children's ability for listening, speaking, reading, and writing in both languages on a five-point Likert scale (1 = very weak, 5 = excellent). As shown in Table 1, students in three grades received higher ratings on L1 Cantonese than L2 English across speaking, listening comprehension, and reading. Furthermore, students in Grade 2, 5, and 8 students received comparable parental ratings for L1 Cantonese speaking and

listening skills. In contrast, significant grade differences were observed in Cantonese reading, English speaking, English listening comprehension, and English reading, with Grade 8 students outperforming both Grades 2 and 5 students on all measures ($ps < .001$). These patterns indicate that our participants were more proficient in Cantonese than English in both spoken and written language, and that their L1 reading, as well as their L2 speaking, listening and reading skills improved significantly across grade levels.

<INSERT TABLE 1 ABOUT HERE>

Measures

The current study employed a comprehensive set of simultaneous measures assessing L1 Chinese and L2 English morphological awareness, vocabulary, word reading, and reading comprehension. A summary of all tasks, participants' grade-level performance, and Cronbach's alpha reliability (α) for each measure, is provided in Table 2.

<INSERT TABLE 2 ABOUT HERE>

Non-verbal intelligence

The Matrix Reasoning subtest from the Wechsler Intelligence Scale for Children Fourth Editions (WISC-IV UK; Wechsler, 2004) comprised three example items and 28 test items. For each item, participants were presented with an incomplete matrix and asked to choose one picture from five options to complete the matrix.

L1 Chinese Morphological Awareness

Morphological derivation. A 24-item task was used to assess children's ability to form novel words by adding the appropriate affix to real Chinese words. In each trial, participants were presented with the definition of a two- or three-character compound word containing the target affix, and were asked to generate a novel derived word using that affix. For example, 唔係自願叫[非自願]。唔係友好叫乜野? (答案: [非友好]) (*We describe not being voluntary as "non-voluntary"; what is it called for not being friendly?*) (Answer: "non-friendly").

Compounding awareness. A 24-item morphological compound task was adapted from previous studies (McBride-Chang et al., 2005a; Tong & McBride-Chang, 2010). To increase difficulty for advanced Chinese readers and reduce possible ceiling effects, nine items based on four-character idioms were added to the original set. For each item, a brief scenario was presented followed by a question, and participants were asked to produce a novel two-character word based on the new scenario. For example, 用膠造嘅袋叫膠袋。咁用鐵造嘅袋叫乜野? (*We call a bag made of plastic a “plastic-bag”. What do we call a bag made of iron?*) (Answer: “iron bag” 鐵袋). In the idiom items, participants analogically extended an existing four-character idiom to a new scenario. For instance, 扶住老人又拖住幼童叫扶老攜幼。咁扶住兄長又拖住細妹叫乜野? (*We describe helping an elderly person while holding a child’s hand as “helping the elderly while taking care of the child.” How do we describe helping one’s elder brother while holding hands one’s younger sister’s hand?*). The idioms were intended to be more challenging and to more sensitively assess understanding of compounding structure and the participant’s ability to manipulate morphemes.

Homophone awareness. A homophone identification and homophone production task were administered (Tong et al., 2011). The 24-item identification task assessed participant’s ability to recognize when homophones represent different morphemes. Each item consisted of three two-character words that belonged to the same grammatical category (noun, verb, or adjective). Within each item, the target homophone appeared in the same syllabic position across three stimuli (either syllable-initial or syllable-final). Participants first heard three words then were asked to identify the word in which the homophone character had a different meaning. For example, in 1. 藍天 /laam4 tin1/ (blue sky), 2. 藍圖 /laam4 tou4/ (blueprint), and 3. 籃球 /laam4 kau4/ (basketball), the first syllable /laam4/ is homophonous, but the third word uses a different morpheme. Therefore, participants should circle “3”. In some items, however, all three homophone characters had different meanings, for instance, for the syllable-final /joeng4/, e.g., 1. 太陽 /taai3 joeng4/ (*sun*), 2. 山羊 /sann1 joeng4/ (*goat*), 3. 海洋 /hoi2 joeng/ (*ocean*), each /joeng4/ carries different meaning, so participant should circle “X”. The homophone production task comprised 12

items that were two-character words containing the target homophone. Participants were provided with an example, e.g., 書 (包) /ʃy1pau1/ (*book bag*) with the target homophone syllable 書 /ʃy1/. Next, they were asked to produce real words that contained the same sound, such as 書本 /ʃy1pun2/ (*general books*) and 圖書 /t^hou4ʃy1/ (*library books*). Afterwards, participants were asked to produce real words that included another homophone of the target morpheme, e.g., 舒服 /ʃy1fok6/ (*comfort*).

Homograph awareness. A 30-item Chinese homograph discrimination task was adopted from a previous study (Tong & McBride-Chang, 2010). Each trial included four bimorphemic words that contained one homograph at the same syllable position. Participants heard each item and were asked to identify the homograph whose meaning differed from that of the other three. For example, 月光 /jyt6kwəŋ1/ (*moonlight*), 月球 /jyt6k^heu4/ (*the planet moon*), 月亮 /jyt6lœŋ6/ (*moon in the sky*), 月刊 /jyt6 hən1/ (*monthly magazine*) all contained the same written form 月, but the fourth one had a different meaning.

Semantic radical awareness. A 36-item task adapted from Tong and McBride (2010) was used to assess participants' understanding of meaning-related cuing function of semantic radicals. Each item consisted of a line drawing of a simple concept or object, two pseudo-characters and two non-characters. Pseudo-characters were formed using real semantic and phonetic radicals placed in legal positions (left-right, top-bottom, or enclosing). Non-characters violated positional regularity by reversing the positions of semantic and phonetic radicals. For example, the character for "rice", 飯 /fan6/, contains a semantic radical 食 (to eat) and a phonetic radical 反 /fan5/. The four corresponding stimuli were 𪗇 (correct semantic radical with correct position), 𪗈 (correct phonetic radical with correct position), 𪗉 (correct semantic radical with incorrect position), and 𪗊 (correct phonetic radical with incorrect position). Participants were asked to select which pseudo-character that best represented the meaning of the picture (i.e., 𪗇).

Chinese vocabulary

The 40-item vocabulary definition task, adopted from Tong et al. (2011), was used to assess expressive vocabulary depth for two-character Chinese words and four-character idioms. Two-character words were selected as they make up as much as 69.8% of modern Chinese high-frequency words as compared to monosyllabic words. Four-character idioms were included to avoid ceiling effect among eighth graders, as these words have a higher level of ambiguity than two-character Chinese words (Hodge & Louie, 1998). In each trial, participants heard an item and were asked to orally provide a definition. The task included 30 items designed for children aged 7 – 11 years (McBride-Chang et al., 2005a), and 10 new items chosen from local Chinese textbooks for children aged 12 or above (Chen et al., 2011). The 10 new words were rated with a difficulty level of 3 on a 5-point scale (1 = least difficult, 5 = most difficult). All items were presented in increasing order of difficulty to avoid discouragement from failing early items. Answers with a correct definition or a specific example were credited one point. Participants were prompted to explain their answers if they produced partially correct responses. Testing was discontinued after five consecutive zeros.

Chinese word reading

A 150-item Chinese character recognition task was used to assess participants' word reading accuracy and fluency. Among the stimuli, 70 two-character words were adopted from the Hong Kong Test of Specific Learning Difficulties in Reading and Writing (Ho et al., 2000), and the other 80 stimuli were selected from local Chinese textbooks for Secondary students. Participants were asked to read aloud each word as quickly and accurately as possible.

Chinese reading comprehension

The York Assessment of Reading Comprehension Passage Reading (YARC; Snowling et al., 2009) and the York Assessment of Reading Comprehension Passage Reading Secondary Test were translated and adapted into Chinese to assess Chinese reading comprehension. Three passages, designed for ages 5 to 12 years, were administered to Grades 2 and 5. These were expository and narrative texts targeting same level, higher level, and lower level of difficulty, each accompanied by a set of eight

comprehension questions assessing both literal and inferential comprehension skills. Reading errors were coded, and no discontinuation rule was applied. Grade 8 students completed two passages (one fiction and one non-fiction) suitable for students aged 12 – 18 years. Each passage was followed by 13 comprehension questions, assessing literal, inferential, and evaluative comprehension skills.

L2 English Morphological Awareness

Inflectional awareness. An English inflection analogy and English inflection judgment task were administered (James et al., 2021), each containing 24 items. In the analogy task, each trial included two pairs of real words. Participants were presented with the first pair (e.g., *lake: lakes*) followed by the first word of the second pair (e.g., *lemon: ____*) and were asked to provide the missing word. Stimuli were presented in both oral and written forms for Grades 2 and 5, who were asked to provide oral responses¹. Grade 8 students were asked to provide written responses. In the judgment task, participants were presented with a word stem together with an indicator of its word class (*to, the, or it is*) and were asked to complete a sentence by choosing one of the three choices (e.g., *To walk. Sophie is walking/walks/walked to school*). Items were presented in both oral and written forms for Grades 2 and 5. All children circled their answers in a response booklet.

English derivational awareness. An English derivational analogy and English derivational judgment task were administered (James et al., 2021), each comprising 20 items. In the analogy task, each trial comprised two word pairs that were either real words or non-words. For example, participants were presented with the first pair (e.g., *kind: kindness*) and the first word of the second pair (e.g., *prist: ____*) and were asked to provide the missing word. Stimuli were presented in both oral and written forms to Grades 2 and 5, who were asked to provide oral responses. Grade 8 students provided written responses instead. In the judgment task, participants were given a word stem and an indicator of its word class, and were asked to complete a sentence by choosing one of the three choices (e.g., *To farm. I want to be a*

¹ For phonological shifts in oral production, such as saying /z/ instead of /s/ in “lakes,” no points were deducted because the task aims to assess knowledge of inflection, not allomorphs.

farmist/farming/farmer). Stimuli were read aloud to Grades 2 and 5 students. All students circled their answers in a response booklet.

English compounding awareness. A compounding analogy and compounding judgment task were administered, each containing 24 test items (James et al., 2021). In the analogy task, participants were presented with a scenario that defined a real compound word and were asked to create a novel compounding word following the same pattern, e.g., *to step to the side is called to side-step. What is the name for when you skip to the side?* (Answer: *side-skip*). Grades 2 and 5 students provided oral responses, while Grade 8 students provided written responses. In the judgment task, participants were given a description and asked to choose which novel compound best described it, e.g., *a leaf that you chew: leaf chewing/chewing leaf* (Answer: *chewing leaf*). All participants circled their answers in response booklets. Stimuli were read aloud to children in Grades 2 and 5.

English vocabulary

Receptive vocabulary was measured by adapting the British Picture Vocabulary Scale Third Edition (BPVS-3; Dunn & Dunn, 2009) for group administration (James et al., 2021). Children were shown 36 age-appropriate items (four pictures per item) and were asked to circle the number (1 – 4) corresponding to the picture that best depicted the meaning of each word read aloud.

English word reading

Word reading accuracy and fluency were assessed using both the Sight Word Efficiency and Phonemic Decoding Efficiency subtests from the Test of Word Reading Efficiency Second Edition (TOWRE-2; Torgesen et al., 2012). Participants were presented with 108 real words and 66 non-words of increasing difficulty, and were asked to read as many words as accurately and quickly as possible within 45 seconds.

English reading comprehension

The YARC and the YARC Secondary Test (Snowling et al., 2009) were administered to assess English reading comprehension. Two passages (i.e., expository and narrative) were administered to participants, starting from the passage level that corresponded to their grade. The passages for students in

Grades 2 and 5 were designed for ages 5 to 12 years were each followed by a set of eight comprehension questions assessing both literal and inferential comprehension skills. The passages for Grade 8 students targeted students aged 12 – 18 years and included one fiction and one non-fiction passage. Each passage was followed by 13 comprehension questions, assessing literal, inferential, and evaluative comprehension skills. Students in Grades 2 and 5 students were asked to read the passage aloud as their reading errors were marked. Depending on whether they reached the benchmark or not, either a higher- or a lower-level passage was additionally administered.

Procedures

Testing was conducted in quiet classrooms at the participants' schools by well-trained Cantonese-English bilingual research assistants. Both individual and small-group formats was used. Tasks requiring verbal responses, including Chinese character recognition, Chinese vocabulary definition, Chinese morphological derivation, lexical compounding, homophone production were administered individually to all students. English inflection analogy, English derivational analogy, and English compounding analogy, were administered individually for Grades 2 and 5 students. All remaining measures were administered in small groups. The whole test battery lasted approximately 2 – 2.5 hours and was administered across multiple sessions during regular class periods, with short breaks as needed. Additional sessions scheduled for students who were absent. The order of Chinese and English tests was counterbalanced across students.

Data analysis

All data analyses were conducted in R version 4.2.3. We first conducted preliminary analysis to evaluate the overall distribution of morphological awareness, word reading, vocabulary, and reading comprehension tasks by checking the kurtosis and skewness (Table 2).

Next, we addressed our two research aims by conducting (1) correlational analysis among morphological awareness and reading comprehension tasks in L1 and L2 separately, and (2) structural equation modeling to examine the direct and indirect pathways from morphological awareness to reading comprehension both within-language and cross-language. The models in this study were estimated using

the grade-specific confirmatory factor analysis (CFA) models validated in the prior study (Li et al., 2025)². The complete model-fit indices can be found in Table 4 of the previous study. Consistent with developmental changes in morphological awareness, L1 Chinese showed a one-factor model in Grades 2 and 8 and two correlated factors in Grade 5 (expressive, receptive), while L2 English showed a single factor in Grades 2, 5, and 8. However, SEM diagnostics for Grade 5 models indicated severe multicollinearity between the two L1 morphological awareness factors, with variance inflation factors (VIFs) being larger than 10. Therefore, L1 morphological awareness in Grade 5 was modeled as a single latent factor for the main SEMs to obtain stable path estimates. The original two-factor SEMs and diagnostics are presented in the Supplementary Materials.

Models were constructed with multiple indicators: L1 morphological awareness (affixation, compounding awareness, homograph awareness, homophone production, homophone identification, semantic radical awareness), L2 morphological awareness (compounding analogy, compounding judgment, derivational analogy, derivational judgment, inflection analogy, inflection judgment), L1 vocabulary (Chinese Word Definition Task), L1 word reading (Chinese Word Identification Task), L2 vocabulary (British Picture Vocabulary Scale Third Edition), L2 word reading (Test of Word Reading Efficiency Second Edition), L1 reading comprehension (Chinese York Assessment of Reading Comprehension Passage Reading), and L2 reading comprehension (English York Assessment of Reading Comprehension Passage Reading). The average rate of missing data was 0.96%. Little's MCAR test was significant ($\chi^2 = 113$, $df = 87$, $p = .033$), indicating that the data were not fully consistent with missing completely at random. Follow-up diagnostics showed that missingness was concentrated in 15 of 467 participants and was concentrated in small blocks of variables, suggesting missed or incomplete task-administration sessions rather than sporadic item-level nonresponse. Given the very low overall missingness rate, models were estimated using full-information maximum likelihood under an MAR assumption.

² Task indicators and loadings can be found in Figures 1 and 2 in Li et al. (2025).

In the within-language models (Aim 1), we specified the model by including one direct pathway: from morphological awareness to reading comprehension, and two indirect pathways: (1) from morphological awareness to word reading to reading comprehension, and (2) from morphological awareness to vocabulary to reading comprehension. The L1 within-language models controlled for non-verbal intelligence, and the L2 within-language models controlled for L1 reading comprehension, word reading, and vocabulary in addition to non-verbal intelligence. The cross-language SEMs (Aim 2) included one direct pathway: from morphological awareness in one language to reading comprehension in the other language, and three indirect pathways via: (1) morphological awareness in the other language, (2) morphological awareness and word reading in the other language, and (3) morphological awareness and vocabulary in the other language. These models were constructed in both directions from L1 to L2 and from L2 to L1. All cross-language models controlled for non-verbal intelligence. The 95% bias-corrected bootstrap confidence intervals (CIs) for both direct and indirect effects were computed using 5000 bootstrap samples. We adopted a theory-driven approach. First, we estimated within-language models to establish language-internal relations. We then added a set of prespecified cross-language paths to test transfer effects, thereby aligning the model with the study's aims. Because language-specific measures are not necessarily commensurate, using separate measurement models avoids imposing unsupported assumptions of cross-language equivalence.

The goodness of model fit was examined by the following indices (Hu & Bentler, 1998): (1) the user model's chi-square and *p*-value ($> .05$), (2) Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) values ($> .90$), (3) Root Mean Square Error of Approximation (RMSEA) value ($< .08$), and (4) Standardized Root Mean Square Residual (SRMR) value ($< .08$). When the model had poor fit, covariances with the largest modification indices (MI) were added.

Results

All tasks demonstrated normal distributions in terms of skewness and kurtosis, except for the following: English compounding analogy (CMA), English inflection judgment (IFJ), Chinese affixation (AFF), Chinese word reading (CWID), and Chinese vocabulary (CWDT). To account for these non-

normal distributions, all SEMs were estimated using the maximum likelihood with robust standard errors (MLR). The mean, standard deviation, and range (minimum and maximum) for all measures are reported in Table 2.

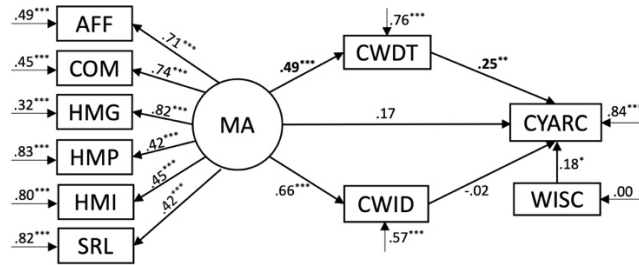
Table 3 displays the correlations between morphological awareness tasks and reading comprehension for each grade in both L1 and L2. According to Cohen's d (Cohen, 1977), all correlations for L1 Chinese in Grade 2 were small but significant, except for homophone identification ($r = .05$, $p > .05$) and semantic radical awareness ($r = .06$, $p > .05$). In Grade 5, correlations were weak to moderate and were significant. In Grade 8, correlations were generally small but remained significant. For L2 English, correlations in Grade 2 were small to moderate and significant, except for compounding judgment ($r = -.03$, $p > .05$). In Grade 5, all correlations were weak to small and significant, except for compounding judgment ($r = .13$, $p > .05$). In Grade 8, correlations were moderate to strong and significant, ranging from .42 to .70.

<INSERT TABLE 3 ABOUT HERE>

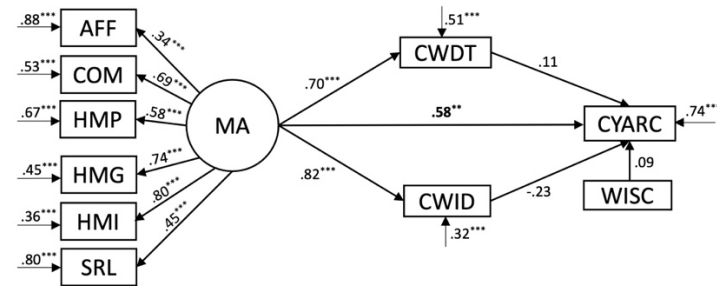
RQ1: Within-Language Contributions of Morphological Awareness to Reading Comprehension

Figures 1a-1c illustrate the within-language contributions of L1 morphological awareness to L1 reading comprehension in Grades 2, 5, and 8, respectively. In Grade 2, there was a significant indirect pathway from L1 morphological awareness to L1 vocabulary to L1 reading comprehension ($\beta = .12$, SE = .57, 95% CI [.32, 2.56]). In contrast, a significant direct pathway from L1 morphological awareness to L1 reading comprehension was found for both Grade 5 ($\beta = .58$, SE = 2.12, 95% CI [1.51, 9.84]) and Grade 8 ($\beta = .54$, SE = 2.59, 95% CI [2.78, 12.92]), indicating that morphological awareness directly contributed to reading comprehension in intermediate and older students.

(a) Grade 2



(b) Grade 5



(c) Grade 8

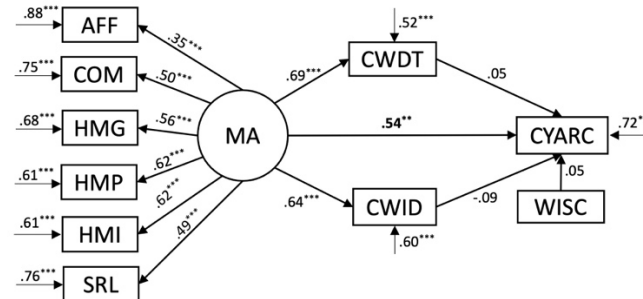


Fig.1 Within-language pathways from L1 Chinese morphological awareness to L1 Chinese reading comprehension in Grade 2 (a), Grade 5 (b), and Grade 8 (c). *Note:* Showing standardized regression coefficients. The oval shapes represent latent constructs of morphological awareness (MA). The rectangles represent observed variables of morphological derivation-affixation (AFF), compounding (COM), homograph awareness (HMG), homophone production (HMP), homophone identification (HMI), semantic radical awareness (SRL), Chinese Word Definition Task (CWDT), Chinese Word Recognition (CWID), Chinese York Assessment of Reading Comprehension Passage Reading (CYARC), and nonverbal intelligence (WISC). * $p < .05$; ** $p < .01$; *** $p < .001$.

Figures 2a-2c depict the within-language contributions from L2 English morphological awareness to L2 reading comprehension in Grades 2, 5, and 8, respectively. In Grade 2, three significant pathways were identified: (1) a direct pathway from L2 morphological awareness to L2 reading comprehension ($\beta = .48$, SE = 4.33, 95% CI [2.20, 19.15]), (2) an indirect pathway from L2 morphological awareness to L2 word reading to L2 reading comprehension ($\beta = .12$, SE = 1.05, 95% CI [.60, 4.72]), and (3) an indirect pathway from L2 morphological awareness to L2 vocabulary to L2 reading comprehension ($\beta = .11$, SE = .91, 95% CI [.67, 4.24]). These findings suggest that, after controlling for non-verbal intelligence and L1 literacy skills, L2 morphological awareness significantly contributed to L2 reading comprehension both directly and indirectly in younger readers. For Grade 5, a significant direct pathway was observed from L2 morphological awareness to L2 reading comprehension ($\beta = .50$, SE = 2.84, 95% CI [2.94, 14.05]), although the effect was negative. In Grade 8, a significant direct pathway ($\beta = .37$, SE = 2.41, 95% CI [4.36, 13.79]) and a significant indirect pathway through L2 vocabulary ($\beta = .14$, SE = 1.13, 95% CI [1.13, 5.56]) were found, suggesting that L2 morphological awareness contributed to L2 reading comprehension both directly and indirectly in advanced readers.

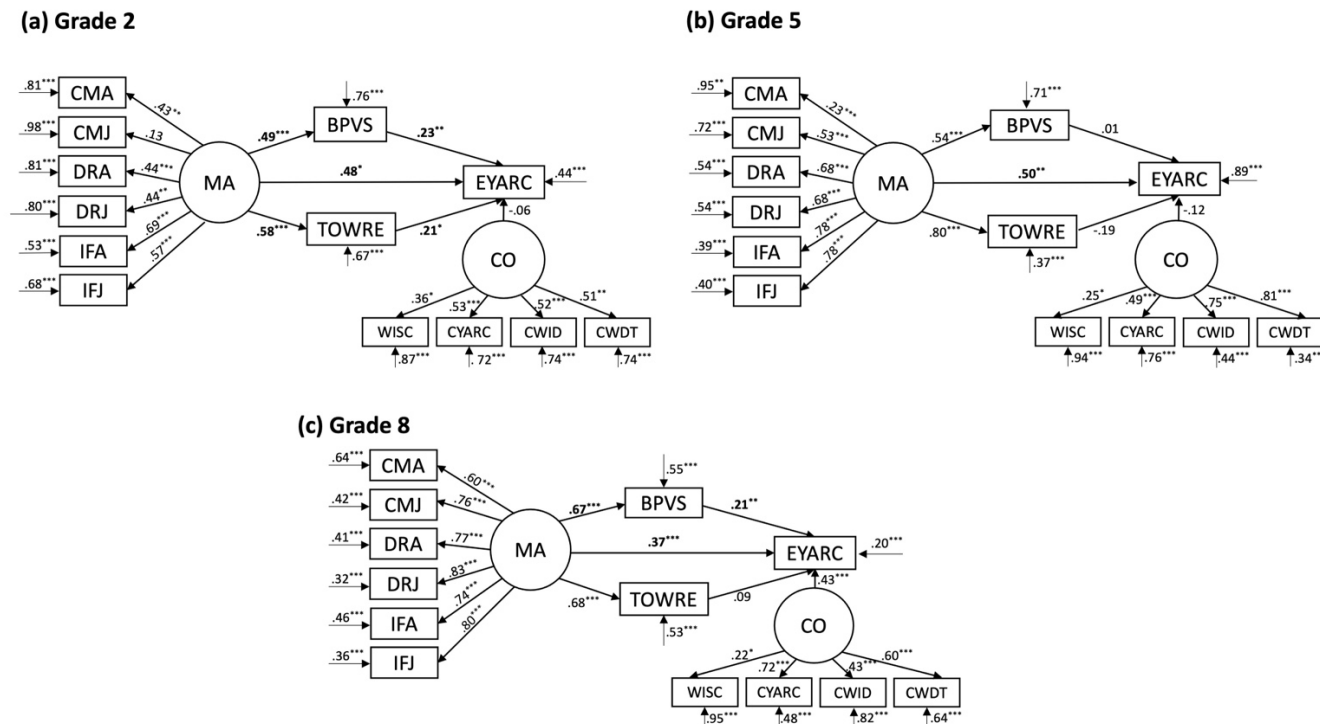


Fig.2 Within-language pathways from L2 English morphological awareness to L2 English reading comprehension in Grade 2 (a), Grade 5 (b), and Grade 8 (c). *Note:* Showing standardized regression coefficients. The oval shapes represent latent constructs of morphological awareness (MA) and control variable (CO). The rectangles represent observed variables of compounding analogy (CMA), compounding judgment (CMJ), derivational analogy (DRA), derivational judgment (DRJ), inflection analogy (IFA), inflection judgment (IFJ), English vocabulary task (BPVS), English word reading task (TOWRE); English York Assessment of Reading Comprehension Passage Reading (EYARC), Chinese Word Definition Task (CWDT), Chinese Word Recognition Task (CWID), and Chinese York Assessment of Reading Comprehension Passage Reading (CYARC), and nonverbal intelligence (WISC). * $p < .05$; ** $p < .01$; *** $p < .001$.

RQ2: Cross-Language Contributions of Morphological Awareness to Reading Comprehension

Figures 3a-3c demonstrate the cross-language contributions from L1 Chinese morphological awareness to L2 English reading comprehension in Grades 2, 5, and 8, respectively. In Grade 2, the model revealed three significant indirect pathways: (1) from L1 morphological awareness to L2 morphological awareness to L2 reading comprehension ($\beta = .21$, $SE = 2.19$, 95% CI [.34, 8.94]); (2) from L1 morphological awareness to L2 morphological awareness to L2 word reading to L2 reading comprehension ($\beta = .08$, $SE = .69$, 95% CI [.54, 3.23]), and (3) from L1 morphological awareness to L2 morphological awareness to L2 vocabulary to L2 reading comprehension ($\beta = .08$, $SE = .63$, 95% CI [.56, 3.02]). In Grade 5, there was a significant indirect pathway from L1 morphological awareness to L2 morphological awareness to L2 reading comprehension ($\beta = .24$, $SE = .11$, 95% CI [.02, .46]), suggesting that the effect of L1 morphological awareness on L2 reading comprehension was modulated by L2 morphological awareness in intermediate readers. For Grade 8, a significant indirect pathway was observed: from L1 morphological awareness to L2 morphological awareness to L2 reading comprehension ($\beta = .39$, $SE = 2.35$, 95% CI [4.99, 14.21]), indicating that L2 morphological awareness significantly mediated the relationship between L1 morphological awareness and L2 reading comprehension in advanced readers.

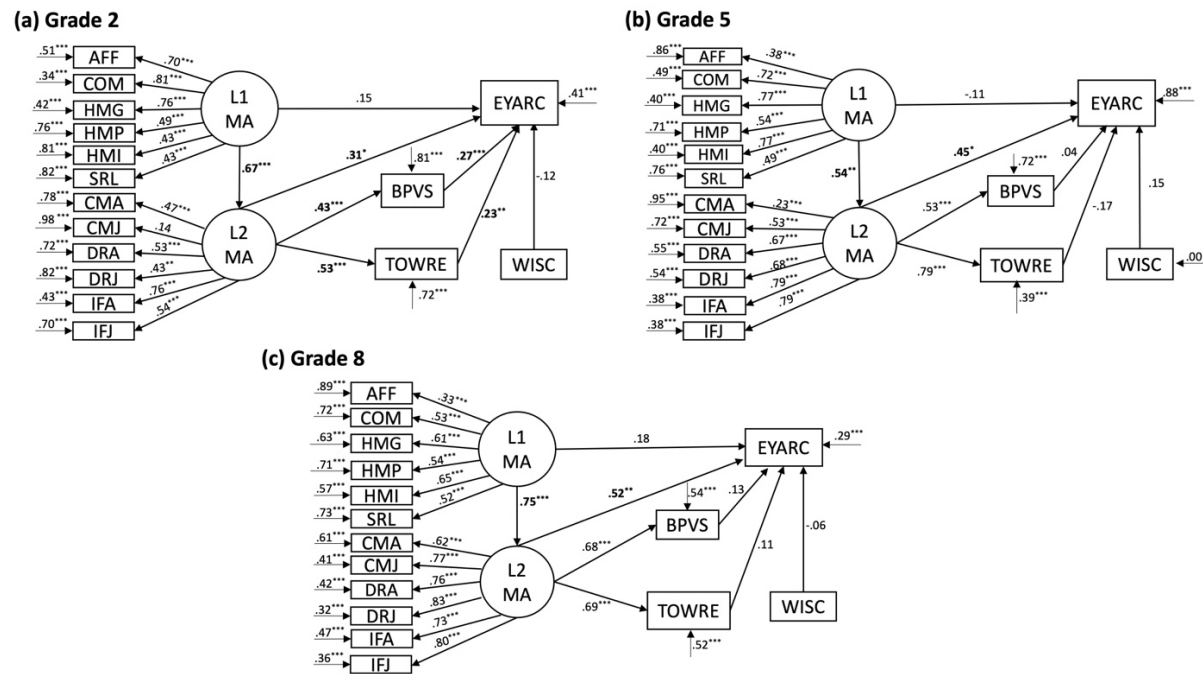


Fig.3 Cross-language pathways from L1 Chinese morphological awareness to L2 English reading comprehension in Grade 2 (a), Grade 5 (b), and Grade 8 (c). *Note:* Showing standardized regression coefficients. The oval shapes represent latent constructs of L1 Cantonese morphological awareness (L1 MA) and L2 English morphological awareness (L2 MA). The rectangles represent observed variables of morphological derivation-affixation (AFF), compounding (COM), homograph awareness (HMG), homophone production (HMP), homophone identification (HMI), semantic radical awareness (SRL), compounding analogy (CMA), compounding judgment (CMJ), derivational analogy (DRA), derivational judgment (DRJ), inflection analogy (IFA), inflection judgment (IFJ), English vocabulary task (BPVS), English word reading task (TOWRE), English York Assessment of Reading Comprehension Passage Reading (EYARC), and nonverbal intelligence (WISC). * $p < .05$; ** $p < .01$; *** $p < .001$.

Figures 4a-4c exhibit the cross-language contributions from L2 English morphological awareness to L1 Chinese reading comprehension in Grades 2, 5, and 8, respectively. In Grade 2, a significant indirect pathway was identified: from L2 morphological awareness to L1 morphological awareness to L1 vocabulary to L1 reading comprehension ($\beta = .08$, $SE = .40$, 95% CI [.14, 1.69]), suggesting that L1 vocabulary significantly mediated the effect of L2 morphological awareness on L1 reading comprehension in younger readers. In Grade 5, none of the direct or indirect pathways were significant. For Grade 8, a significant indirect pathway was found: from L2 morphological awareness to L1 morphological awareness to L1 reading comprehension ($\beta = .35$, $SE = 2.19$, 95% CI [.73, 9.30]), indicating that L1 morphological awareness significantly mediated the relationship between L2 morphological awareness and L1 reading comprehension in advanced readers.

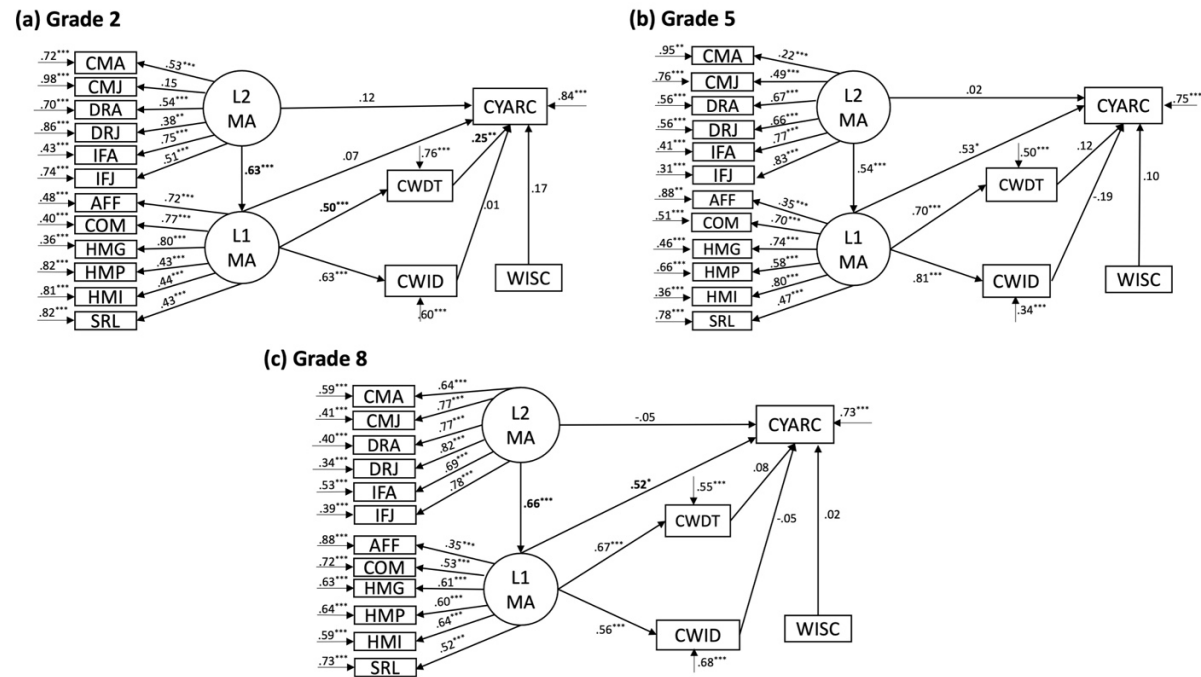


Fig.4 Cross-language pathways from L2 English morphological awareness to L1 Chinese reading comprehension in Grade 2 (a), Grade 5 (b), and Grade 8 (c). *Note:* Showing standardized regression coefficients. The oval shapes represent latent constructs of L1 Cantonese morphological awareness (L1 MA) and L2 English morphological awareness (L2 MA). The rectangles represent observed variables of morphological derivation-affixation (AFF), compounding (COM), homograph awareness (HMG), homophone production (HMP), homophone identification (HMI), semantic radical awareness (SRL), compounding analogy (CMA), compounding judgment (CMJ), derivational analogy (DRA), derivational judgment (DRJ), inflection analogy (IFA), inflection judgment (IFJ), Chinese Word Definition Task (CWDT), Chinese Word Recognition (CWID), Chinese York Assessment of Reading Comprehension Passage Reading (CYARC), and nonverbal intelligence (WISC). * $p < .05$; ** $p < .01$; *** $p < .001$.

Discussion

This study addressed a significant gap in our understanding by taking a developmental perspective of within- and across-language contributions of morphological awareness to reading comprehension. Specifically, we addressed two research questions: (1) to what extent does morphological awareness directly and indirectly contribute to *within-language* reading comprehension for each grade? and (2) to what extent does morphological awareness directly and indirectly contribute to *cross-language* reading comprehension for each grade? For within-language contribution in L1 Chinese, there was an indirect pathway via vocabulary for Grade 2 and a direct pathway for both Grade 5 and Grade 8. For L2 within-language contribution, we identified a direct pathway and two indirect pathways via word reading and vocabulary for Grade 2, a direct pathway for Grade 5, and both a direct pathway and an indirect pathway via vocabulary for Grade 8. For cross-language transfer from L1 morphological awareness to L2 reading comprehension, we found indirect pathways via L2 morphological awareness, L2 word reading, and L2 vocabulary for Grade 2, an indirect pathway through L2 morphological awareness for Grade 5, and an indirect pathway via L2 morphological awareness for Grade 8. For cross-language transfer from L2 morphological awareness to L1 reading comprehension, there was an indirect pathway via L1 morphological awareness and L1 vocabulary for Grade 2 and an indirect pathway via L1 morphological awareness for Grade 8. These findings support a dynamic role of morphological awareness in reading comprehension for bilingual children learning to read Chinese and English.

RQ1: Within-Language Contributions of Morphological Awareness to Reading Comprehension

In L1 Chinese, morphological awareness supports reading comprehension indirectly via vocabulary in Grade 2, corroborating the idea that younger readers rely on vocabulary knowledge for text comprehension (Wang et al., 2006). This finding is consistent with a morphological analysis account that children use knowledge of morphemes and word-formation patterns to analyze unfamiliar words, which builds vocabulary that, in turn, supports comprehension (Levesque et al., 2017). Early readers therefore show stronger mediation through vocabulary because they rely on analysis to infer and consolidate word meanings before those processes become automatized in text reading. This pathway is plausibly amplified

in Chinese, where characters map onto morphemes and semantic radicals cue meaning, facilitating analysis-based vocabulary growth and strengthening orthography-to-semantics links that aid reading comprehension. By Grade 5 and Grade 8, the mediating effect of vocabulary diminished alongside a direct relation between morphological awareness and reading comprehension, suggesting that sophisticated morphological awareness in L1 is integrated into the broader linguistic system and directly affects reading comprehension in advanced readers (Perfetti & Stafura, 2014).

In L2 English, the overlap among morphological awareness, word reading, vocabulary, and reading comprehension reflects a shared morphological-lexical mechanism: sensitivity to morphemes supports both decoding of morphological complex words and morpheme-based meaning inference, which boosts vocabulary growth and, in turn, facilitates comprehension (e.g., McBride-Chang et al., 2005b; Sparks & Deacon, 2015). Because L2 lexical representations are still consolidating, a more protracted lexical route is expected, with morphological awareness scaffolding vocabulary and decoding until lexical knowledge is robust enough to carry comprehension. Consistent with this account, Grade 2 showed both direct contributions and indirect effects via word reading and vocabulary—patterns observed when both skills mediate the relation between morphological awareness and reading comprehension in early readers (Carlisle, 2000). By Grade 5, the direct path between morphological awareness and reading comprehension became unstable when vocabulary and word reading were included together (McBride-Chang et al., 2005a), suggesting that these correlated mediators absorb most of the shared variance between morphological awareness and comprehension. By Grade 8, we observed not only an indirect effect through vocabulary but also a significant direct pathway. This residual direct link is consistent with evidence that morphological awareness can uniquely support online meaning construction—via morphological parsing and derivational knowledge—beyond what is captured by a single vocabulary score, especially as texts grow morphologically and conceptually dense in intermediate readers (Currie & Cain, 2023).

Taken together, these findings suggest a principled divergence: in the native language (Chinese), morphological awareness increasingly contributes directly to comprehension as readers mature; in the

second language (English), the impact of morphological awareness remains more dependent on vocabulary and word reading because lexical representations and morphological families are still being established in L2, making these skills central to comprehension in older bilinguals (Duke et al., 2021). This interpretation is consistent with evidence that morphological awareness supports reading across development, and that L2 status modulates how these relations unfold (Pasquarella et al., 2011; Wang et al., 2006; Zhang et al., 2014; Zhang & Koda, 2014).

RQ2: Cross-Language Contributions of Morphological Awareness to Reading Comprehension

Cross-language transfer from L1 morphological awareness to L2 reading comprehension was supported with various patterns across grades. In Grade 2, the effects were fully mediated by L2 morphological awareness and further channeled through L2 vocabulary and word reading. This pattern suggests that, for younger readers, the ability to analyze and manipulate morphemes in the first language facilitates the development of similar skills in the second language, which in turn enhances reading ability in L2. By Grade 5 and Grade 8, a strong indirect pathway emerged from L1 morphological awareness to L2 reading comprehension via L2 morphological awareness. These findings indicate that in intermediate and advanced readers, the transfer of morphological skills from L1 to L2 continues to play an important role, with L2 morphological awareness serving as the primary vehicle driving this cross-language influence (Chung et al., 2019). This developmental shift aligns with evidence that cross-language morphological awareness supports L2 reading comprehension and becomes a robust predictor of reading outcomes as L2 proficiency and metalinguistic sophistication increase (Lee & Kim, 2025). It also fits broader accounts in which L2 transfer and the salience of L2 morphology shape variability in morpheme acquisition and its downstream effects on comprehension (Wang et al., 2025).

Our findings also demonstrate cross-language transfer in the other direction, that is, from L2 morphological awareness to L1 reading comprehension, aligning with previous studies that have reported similar results (Pasquarella et al., 2011; Wang et al., 2006). However, the patterns of transfer appear to be dynamic across development, with the underlying mechanisms shifting across grade levels. In Grade 2, a significant indirect pathway through L1 morphological awareness and L1 vocabulary was observed. This

finding suggests that for younger readers, L2 morphological skills can support L1 reading comprehension, but the effect is mediated by the development of L1 linguistic and metalinguistic skills (Gottardo et al., 2021). In Grade 5, although no significant direct or indirect pathways were found, we found significant associations between L2 morphological awareness and L1 morphological awareness ($\beta = .57, SE = .16, 95\% CI [.38, 1.00]$), as well as between L1 morphological awareness and L1 reading comprehension ($\beta = .50, SE = .20, 95\% CI [.09, .87]$). These findings suggest that while L2 morphological awareness may strengthen its connection to L1 morphological awareness at this stage, this link alone may not be sufficient to significantly enhance L1 reading comprehension. By Grade 8, a significant indirect effect emerged via L1 morphological awareness, highlighting that for more advanced readers, the transfer of morphological skills from L2 is consolidated and operates primarily through strengthened L1 morphological awareness to support reading comprehension in the native language.

Taken together, the findings of cross-language transfer underscore the importance of fostering morphological awareness in both L1 and L2 in bilingual literacy development, as strengthening these skills may leverage learners' cross-language morphological knowledge, which eventually promotes cross-language transfer.

Theoretical and educational implications

Our study provides important theoretical and educational insights into bilingual literacy development. Theoretically, the results support the view that morphological awareness operates not only as a foundational skill within each language, but also as a key mechanism for cross-language transfer, with its mediating roles evolving across grade levels (and language and reading proficiency). The dynamic and bidirectional nature of transfer underscores how metalinguistic skills in one language can strengthen the same skills and advance reading comprehension in the other language. From the educational standpoint, these findings highlight the value of explicitly fostering morphological awareness in both languages. Early instruction should emphasize both linguistic and metalinguistic skills to maximize transfer effects, while later instruction can build on increasingly integrated metalinguistic skills to support advanced reading comprehension. Given that both Chinese and English are taught in parallel at

school in Hong Kong, educators should leverage cross-language connections to support more efficient and effective bilingual reading development.

Limitations and future directions

The current study has certain limitations that should be considered. First, it focused only on Chinese-English bilingual children from Grades 2, 5, and 8 in Hong Kong. This raises questions about the generalizability of the findings to bilinguals in other grade levels or those who speak other languages. Therefore, future research should extend the current study by including a broader range of bilingual populations with different language combinations and grade levels. Second, the cross-sectional design captures concurrent associations and cannot establish causal transfer between morphological awareness and reading comprehension. Directional effects should be tested in longitudinal designs that model stability and reciprocal influences over time. Third, the Chinese reading comprehension task, which was directly translated from the English task, yielded relatively low internal consistency. Future studies should develop tasks tailored for Chinese-speaking children. Fourth, the testing format differed for upper and lower graders, which was designed taking into account variations in their language and reading proficiency. It is crucial for future research to explore whether the testing format has any impact on task performance. Finally, our study included children with varying levels of reading comprehension. Future studies can categorize participants into good and poor comprehenders to investigate the role of morphological awareness in bilingual children with diverse reading levels. Work with monolinguals indicates that morphological awareness is associated with specific reading comprehension difficulties (Tong et al., 2011).

Conclusion

The current study evaluated the direct and indirect pathways from morphological awareness to reading comprehension in Chinese-English bilingual children in Grades 2, 5, and 8. Our findings demonstrate that morphological awareness contributes to reading comprehension within both L1 and L2, but the pathways differ by grade. Additionally, we identified both directions of cross-language transfer. Our findings suggest that younger readers rely more heavily on fundamental language skills, such as

vocabulary and word reading, for reading comprehension. As language and reading proficiencies increase, the link between L1 and L2 morphological awareness is strengthened, thereby facilitating reading comprehension across languages. These findings suggest that the pathways through which morphological awareness contributed to reading comprehension are influenced by both language-general and language-specific features of morphology and vary by grade level in bilingual children learning typologically different languages.

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Table 1

Means, standard deviations, and F tests for differences between children in Grade 2, Grade 5, and Grade 8 in parent ratings of Cantonese and English proficiency.

Proficiency	Grade 2		Grade 5		Grade 8		F-test	Pairwise Comparisons
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>		
Cantonese speaking	4.60	.66	4.63	.76	4.76	.51	2.57	
Cantonese listening comprehension	4.65	.56	4.67	.62	4.78	.46	2.76	
Cantonese reading	3.97	.83	4.25	.89	4.58	.62	22.80***	G2 < G5 < G8
English speaking	2.91	1.91	3.08	1.11	3.57	.80	9.97***	G2 < G8, G5 < G8
English listening comprehension	2.93	1.01	3.24	1.03	3.68	.77	24.16***	G2 < G5 < G8
English reading	2.76	1.01	3.29	1.09	3.79	.81	39.30***	G2 < G5 < G8

Note. ratings were provided on a 5-point Likert scale ranging from 1 (very weak) to 5 (*excellent*); *** $p < .001$.

Table 2

L1 Chinese and L2 English measures for Grade 2 (G2), Grade 5 (G5), and Grade 8 (G8) children.

	G2				G5				G8				Pairwise Comparisons	Skewness	Kurtosis	
	Mean	SD	Range	α	Mean	SD	Range	α	Mean	SD	Range	α				
<i>L1 Chinese tasks</i>																
AFF (/24)	16.43	3.96	4.00-24.00	.81	20.24	2.33	10.00-24.00	.63	21.35	1.41	17.00-24.00	.29	G2 < G5 < G8	-1.42	5.25	
COM (/24)	17.44	2.90	10.00-24.00	.73	19.97	2.65	10.00-24.00	.69	21.96	1.60	18.00-24.00	.43	G2 < G5 < G8	-.67	2.92	
HMG (/30)	16.34	5.00	3.00-26.00	.79	23.03	3.50	8.00-29.00	.72	25.68	2.56	13.00-30.00	.62	G2 < G5 < G8	-.98	3.43	
HMP (n/a)	8.54	4.85	0.00-27.00	.71	17.54	7.54	1.00-38.00	.80	25.99	8.84	9.00-53.00	.81	G2 < G5 < G8	.63	3.01	
HMI (/24)	8.13	3.39	0.00-19.00	.60	13.58	4.02	4.00-21.00	.72	16.94	3.26	5.00-23.00	.66	G2 < G5 < G8	-.18	2.04	
SRL (/36)	19.70	6.17	4.00-33.00	.84	24.72	6.00	6.00-34.00	.86	26.43	5.73	7.00-35.00	.87	G2 < G5 < G8	-.54	2.41	
CWID (/150)	73.60	15.80	44.00-132.00	.96	103.00	16.20	86.00-141.00	.95	122.00	10.50	86.00-141.00	.90	G2 < G5 < G8	-0.26	1.80	
CWDT (/40)	11.30	4.51	1.00-26.00	.81	20.20	7.81	0.00-35.00	.91	28.90	5.94	11.00-39.00	.87	G2 < G5 < G8	0.02	1.76	
YARC (/100)	81.20	12.20	41.70-100.00	.65	83.50	9.82	54.20-100.00	.57	69.50	14.50	38.50-100.00	.73	G8 < G2, G8 < G5	-0.46	2.95	
<i>L2 English tasks</i>																
CMA (/24)	21.90	2.60	14.00-24.00	.75	23.43	1.22	15.00-24.00	.65	21.14	4.65	0.00-24.00	.92	G2 < G5, G8 < G5	-3.69	20.79	
CMJ (/24)	14.16	3.68	5.00-22.00	.60	15.37	4.19	4.00-24.00	.72	19.03	4.05	7.00-24.00	.80	G2 < G5 < G8	-.26	2.26	
DRA (/20)	9.70	3.13	2.00-18.00	.71	11.99	2.82	3.00-18.00	.67	13.21	3.10	2.00-19.00	.71	G2 < G5 < G8	-.31	2.87	
DRJ (/20)	7.36	2.61	2.00-19.00	.36	9.58	3.31	0.00-19.00	.59	13.18	3.55	0.00-20.00	.72	G2 < G5 < G8	.22	2.22	
IFA (/24)	16.24	3.19	6.00-23.00	.71	19.26	3.30	9.00-24.00	.77	19.33	3.29	8.00-24.00	.75	G2 < G5, G2 < G8	-.57	2.98	
IFJ (/24)	10.36	3.77	3.00-22.00	.63	16.98	4.43	2.00-24.00	.82	20.16	3.97	6.00-24.00	.85	G2 < G5 < G8	-.34	1.78	
TOWRE (/174)	42.30	24.60	8.00-126.00	.98	70.40	29.60	14.00-156.00	.98	96.00	26.00	40.00-145.00	.98	G2 < G5 < G8	0.27	2.10	
BPVS (/36)	16.50	5.02	6.00-31.00	.74	13.60	5.44	5.00-33.00	.78	18.00	6.65	5.00-36.00	.87	G5 < G2, G5 < G8	0.66	2.98	

YARC (/100)	52.20	21.90	6.25- 100.00	.78	58.90	16.90	25.00- 93.80	.66	56.00	24.50	0.00- 100.00	.90	G2 < G5	-0.16	2.51
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Note. the maximum possible scores are in the parentheses; n/a: no maximum score. α : Cronbach's alpha reliability. AFF: affixation, COM: compounding, HMG: homograph awareness, HMP: homophone production, HMI: homophone identification, SRL: semantic radical awareness; CWID: Chinese Word Identification to assess word reading; CWDT: Chinese Word Definition Test to assess vocabulary; YARC: York Assessment of Reading Comprehension; CMA: compounding analogy, CMJ: compounding judgment, DRA: derivational analogy, DRJ: derivational judgment, IFA: inflection analogy, IFJ: inflection judgment; TOWRE: Test of Word Reading Efficiency; BPVS: British Picture Vocabulary Scale. Pairwise comparisons: significant difference between groups ($p < .05$).

Table 3

Correlation matrices between morphological awareness and reading comprehension tasks in L1 Chinese and L2 English in Grade 2, Grade 5, and Grade 8.

	Grade 2							Grade 5							Grade 8							
<i>L1</i>	HMI	HMG	SRL	AFF	COM	HMP	YARC	HMI	HMG	SRL	AFF	COM	HMP	YARC	HMI	HMG	SRL	AFF	COM	HMP	YARC	
HMI	-							-							-							
HMG	.39***	-						.63***	-						.39***	-						
SRL	.35***	.38***	-					.33***	.43***	-					.40***	.35***	-					
AFF	.26**	.60***	.27***	-				.30***	.26***	.27***	-				.22**	.19*	.16*	-				
COM	.34***	.58***	.31***	.55***	-			.51***	.54***	.34***	.32***	-			.24**	.31***	.25**	.18*	-			
HMP	.16	.38***	.07	.24**	.49***	-		.43***	.40***	.13	.13	.42***	-		.33***	.27***	.23**	.25**	.33***	-		
YARC	.05	.33***	.06	.28***	.25**	.24**	-	.34***	.38***	.21**	.17*	.40***	.34***	-	.28***	.35***	.25**	.13*	.25**	.37***	-	
<i>L2</i>	IFJ	DRJ	CMJ	IFA	DRA	CMA	YARC	IFJ	DRJ	CMJ	IFA	DRA	CMA	YARC	IFJ	DRJ	CMJ	IFA	DRA	CMA	YARC	
IFJ	-							-							-							
DRJ	.24**	-						.58***	-						.64***	-						
CMJ	.06	.21*	-					.40***	.43***	-					.61***	.64***	-					
IFA	.36***	.26**	.07	-				.64***	.45***	.33***	-				.71***	.54***	.54***	-				
DRA	.20*	.22**	.08	.48***	-			.55***	.39***	.35***	.55***	-			.59***	.65***	.57***	.60***	-			
CMA	.25***	.10	.08	.38***	.27***	-		.14	.13	.09	.24**	.16*	-		.55***	.52***	.45***	.44***	.47***	-		
YARC	.40***	.31***	-.03	.48***	.33***	.23**	-	.22**	.19*	.13	.24**	.23**	.18*	-	.60***	.70***	.63***	.57***	.61***	.42***	-	

Note. AFF: affixation, COM: compounding, HMG: homograph awareness, HMP: homophone production, HMI: homophone identification, SRL: semantic radical awareness; YARC: York Assessment of Reading Comprehension; CMA: compounding analogy, CMJ: compounding judgment, DRA: derivational analogy, DRJ: derivational judgment, IFA: inflection analogy, IFJ: inflection judgment; Weak association ($r = 0 - 0.19$); Small association ($r = 0.20 - 0.39$); Moderate association ($r = 0.40 - 0.59$); Strong association ($r = 0.60 - 1.00$); * $p < .05$, ** $p < .01$, *** $p < .001$.

Table 4

Goodness of model fit for within- and cross-language structural equation modeling predicting reading comprehension in Grade 2, Grade 5, and Grade 8.

	Grade 2					Grade 5					Grade 8				
	<i>Chi-square</i> (>.90)	<i>TLI</i> (>.90)	<i>CFI</i> (>.90)	<i>RMSEA</i> (<.08)	<i>SRMR</i> (<.08)	<i>Chi-square</i> (>.90)	<i>TLI</i> (>.90)	<i>CFI</i> (>.90)	<i>RMSEA</i> (<.08)	<i>SRMR</i> (<.08)	<i>Chi-square</i> (>.90)	<i>TLI</i> (>.90)	<i>CFI</i> (>.90)	<i>RMSEA</i> (<.08)	<i>SRMR</i> (<.08)
<i>Within-language</i>															
L1	65.74	.88	.91	.08	.10	89.55	.85	.89	.10	.10	50.96	.92	.94	.06	.09
L2	112.59	.83	.87	.08	.07	121.95	.87	.90	.08	.06	144.84	.89	.91	.09	.08
<i>Cross-language</i>															
L1 to L2	210.17	.80	.84	.09	.10	184.50	.87	.89	.08	.09	170.82	.92	.93	.07	.10
L2 to L1	169.47	.85	.88	.07	.09	175.44	.89	.91	.07	.09	168.73	.89	.91	.07	.10

Note. L1: Cantonese, L2: English; TLI: Tucker-Lewis Index; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; SRMR: Standardized Root Mean Square Residual.