Full title: The Dimensionality of Morphological Awareness: Evidence from Hong Kong Chinese-English Bilingual Children

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Abstract

Morphological awareness is essential for language and literacy development, yet its underlying structure remains unclear, especially in Chinese-English bilinguals at different ages. This study tested 467 Hong Kong bilingual children in Grades 2, 5, and 8 on their morphological awareness in both Chinese and English. Confirmatory factor analysis was conducted to examine whether morphological awareness in each language is a unidimensional structure, a multi-dimensional structure by task modality (i.e., receptive vs. expressive), or a multi-dimensional structure by stimulus level (i.e., Chinese: word, character, radical; English: free vs. bound morpheme). The results indicated that for L1 Chinese, morphological awareness was unidimensional in Grade 2, multi-dimensional by task modality in Grade 5, and unidimensional in Grade 8. L2 English maintained a unidimensional structure across all grades. These findings underscore how the dimensionality of morphological awareness is shaped by language-specific features and developmental changes.

Keywords: bilingualism, morphological awareness, dimensionality, cross-language similarities

Background

Morphology organizes the morphemic subunits of words across diverse languages (Rastle, 2019). A key aspect of this is morphological awareness, the ability to identify morphemes (e.g., "*teacher"* = "*teach"* + "*er"*) and understand their compositional structure to form words, which is vital for reading development (e.g., Verhoeven & Perfetti, 2011). However, the dimensionality of morphological awareness at different grade levels of children, particularly those learning morphologically distinct languages, such as Chinese and English, remains unexplored. To address this gap, the current study utilized comprehensive measures in both first language (L1) Chinese and second language (L2) English to explore the dimensionality of morphological awareness among Hong Kong Chinese-English bilingual children in Grades 2, 5, and 8.

Morphological awareness between Chinese and English: Similarities and differences

Morphology plays a universal role in bridging between spoken and written language through meaning. A morpheme is defined as the smallest unit of meaning that indicates spelling and pronunciation (Carlisle, 2003). Nevertheless, since different languages exhibit various morphological structures, it is necessary for cross-linguistic studies to incorporate measures that capture both the common (language-general) and unique (language-specific) aspects of morphology (Rastle, 2019).

The distinct linguistic context of Hong Kong Chinese-English bilingual children provides a valuable opportunity to explore morphological awareness given the shared and distinct characteristics of Chinese and English morphology. One prominent similarity is the presence of compound words at the lexical level in both languages. Chinese heavily utilizes lexical compounding to form new words (Kuo & Anderson, 2006). For example, *夜 (night)* + *市 (market) = night market*, in which the right morpheme carries the categorical information (*i.e.,* *market*) and the left morpheme refines this information (*i.e., night*). Similarly, English features compound words, such as *black* + *board* = *blackboard*, although they are less prevalent compared to Chinese.

At the sublexical level, both Chinese and English use written forms that provide meaning-related cues. In English, derivational morphemes modify word meanings and enable new word formation (e.g., *un-, -ness*). Similarly, Chinese characters often contain semantic radicals that convey meaning (McBride-Chang et al., 2003; Tong et al., 2017). Most characters are semantic-phonetic compounds, combining a meaning-bearing radical (e.g., 口 "mouth" in 吃 /jaak3/ "*to eat*") with a phonetic component (e.g., 乞 /hat1/) (Shu et al., 2006). The role of semantic radicals has been debated, as some lack independent pronunciation (e.g., 犭 *"animal-related"*). However, previous research has argued that they function like English derivational morphemes for three reasons (McBride-Chang et al., 2003; Tong et al., 2017). First, some radicals integrate orthographical, phonological, and semantic information (e.g., 木 /muk6/ "*wood"*). Second, their positional flexibility determines function. For example, 木 acts as a semantic radical in 板 *"board"* but as a phonetic radical in 沐 /muk6/ *"to bathe."* Third, they combine with other characters to form semantically related words (e.g., 木 in 松 *"pine"* and 树 *"tree"*). Psycholinguistic research has suggested that semantic radicals entail a distinct level of representation in the mental lexicon (Tong et al., 2017), necessitating its inclusion in morphological measures.

Despite some similarities, Chinese and English exhibit distinct morphological structures. Chinese is a morphosyllabic language, featuring numerous homophones (e.g., *藍* /lam4/ "*blue*" vs. *籃* /lam4/ *"basket"*) and homographs (e.g., *月* /jyt6/ meaning either *"month"* or *"moon"*).

English also has homophones (e.g., *fair* vs. *fare*) and homographs (e.g., *bow* meaning either to bend or a knot tied with loops), but primarily relies on inflection (e.g., *cat* → *cats*) and derivation (e.g., *write* → *rewrite*). These differences raise a crucial question: what is the underlying structure of morphological awareness in Chinese-English bilingual children's L1 and L2?

The dimensional structure of morphological awareness: Unidimensional or multi-dimensional

Morphemes encode phonological, orthographic, syntactic, and semantic information (Perfetti, 2007), suggesting that morphological awareness is not a single skill but a constellation of related yet distinct abilities (Carlisle, 2000; Kuo & Anderson, 2006). The Morphological Pathways Framework further supports this multidimensionality through its two word-identification pathways (Levesque et al., 2021): form-based morphological decoding and meaning-based morphological analysis. Nevertheless, inconsistent measurement across studies has imposed challenges to know whether morphological awareness represents a unified construct or multiple dimensions (see Deacon et al., 2008 for a review). Existing research has focused primarily on alphabetic languages (Kristensen et al., 2023; Levesque et al., 2017), leaving open questions about how both language-general and language-specific features of Chinese and English morphology influence the structure of morphological awareness.

Some studies support a unidimensional structure of morphological awareness (e.g., James et al., 2021; Spencer et al., 2015), indicating that task performance reflects a general sensitivity to morphology. Spencer et al. (2015) administered nine English morphological tasks to fourth-grade English speakers, which varied in response format (i.e., oral response vs. multi-choice) and administration mode (i.e., oral vs. written). When comparing unidimensional and two-factor models by response format and administration mode, the unidimensional model demonstrated superior fit, suggesting morphological awareness functions as a unitary construct.

Meanwhile, growing evidence indicates that morphological awareness is multi-dimensional, with performance shaped by distinct yet interrelated dimensions. One fundamental dimension is task modality, which distinguishes between receptive (e.g., identifying correct inflections) and expressive (e.g., orally producing derived forms) demands. These modality differences reflect distinct cognitive processes: receptive tasks primarily involve recognition and comprehension of morphological patterns, while expressive tasks impose higher cognitive loads by requiring active retrieval and semantic-syntactic integration (Carlisle, 2000; Deacon et al., 2008). For instance, Apel et al. (2013) assessed morphological awareness in kindergarteners using three tasks: (1) production of multi-morphemic words and words with inflection or derivation; (2) identification of affixes in non-English words; and (3) semantic judgment of words, and found that expressive tasks (i.e., word production and semantic judgment) predicted reading performance more strongly than receptive tasks. These findings underscore task modality as a critical dimension, indicating the need for tailored instruction that balances input-based (receptive) and output-based (expressive) approaches.

An equally critical dimension is stimulus level, which differentiates between lexical and sublexical processing (Tong et al., 2017). This distinction reveals both cross-linguistic similarities and differences in Chinese and English, offering insights into bilingual morphological development. While both languages demonstrate morphological structures at the lexical and sublexical levels, their manifestations differ markedly. In Chinese, lexical-level stimuli encompass whole-word forms, including single- or multi-character words (McBride-Chang et al., 2003), while sublexical processing involves extracting meaning cues from semantic radicals within semantic-phonetic characters (Shu & Anderson, 1997). In contrast, English organizes morphology through *free morphemes*, i.e., stand-alone words (e.g., *fly, sun*, *keyboard*), and *bound morphemes*, i.e., prefixes (e.g., *pre-* in *preclude*), suffixes (e.g., *-able* in *movable*), or bases (e.g., *mort* in *mortal*), which derive meaning only when attached to other morphemes. These language-specific patterns suggest bilinguals employ distinct cognitive strategies when processing different stimulus levels—a crucial consideration for assessment and instruction tailored to morphological awareness in both languages.

Our study investigated these two theoretically grounded dimensions—task modality and stimulus level—through separate models. This approach enabled us to empirically validate the receptive-expressive modality distinction, which reflects fundamental differences in cognitive processing demands. It also facilitated an examination of the lexical-sublexical distinction, which captures essential linguistic variation between Chinese and English. By analyzing these dimensions independently, we provide a methodological framework for future research to investigate their interactive effects on bilingual morphological development.

The growth of morphological awareness in Chinese-English bilingual children

Morphological awareness develops alongside reading skills, yet its structural progression in Chinese-English bilingual children remains unclear. Chinese is a morphosyllabic language that emphasizes orthography-semantic connections (Li et al., 2012; McBride-Chang et al., 2003). In Hong Kong, from as early as Grade 1, children are explicitly taught structures and meanings of Chinese characters, including phonetic radicals, semantic radicals, and homophones (Hong Kong Education Bureau, 2023). This early focus reinforces Chinese morphology as a transparent and cohesive system for young learners.

On the other hand, English is a morpho-phonemic language, in which its orthography reflects a mix of both phonological and morphological cues of a word. Research on English-speaking children has found the strongest morphological growth during the early stage of reading, i.e., Grades 1 – 3 (Treiman & Cassar, 1996), with continued development through childhood (Berninger et al., 2010). In Hong Kong, the English curriculum progresses from basic inflections (e.g., plural *-s*, progressive tense *-ing*) in Grades 1 – 3 to complex derivations (e.g., comparatives *-er*, verb participles *-en*) from Grade 3 onward (Hong Kong Education Bureau, 2023). Early skills are also consolidated through targeted exercises in morphological decomposition and word formation (VanPatten & Cadierno, 1993), enhancing students' metalinguistic abilities. By advanced stages of reading, students have already developed a comprehensive language system in which morphological awareness becomes an integral part of it. Given the distinct developmental trajectories between L1 and L2, we examined how language-specific features and proficiency influence morphological awareness in Chinese-English bilingual children across grade levels.

The present study

Two research questions were addressed in this study. First, what is the structure of morphological awareness in L1 Chinese for Hong Kong Chinese-English bilingual children at different grade levels: single or multi-component, or both? Second, what is the structure of morphological awareness in L2 English for Hong Kong Chinese-English bilingual children at different grade levels: single or multi-component or both? To address these questions, this study employed both language-general and language-specific measures of L1 Chinese and L2 English morphology. These tasks required response in either expressive (i.e., oral or written production) or receptive (i.e., identification) format targeting different linguistic levels of stimuli. Based on previous studies (Apel et al., 2013; James et al., 2021; Spencer et al., 2015), we proposed three model structures to investigate the underlying construct of morphological awareness in both L1 Chinese and L2 English: 1) a uni-dimensional model that includes all morphological awareness constructs of the assessed language; 2) a multi-dimensional model determined by task modality, i.e., whether a task required an expressive or receptive format of response; and 3) a multi-dimensional model determined by the stimulus level of the assessed language, i.e., word vs. character vs. radical levels in Chinese, and free vs. bound morphemes in English.

We hypothesized that the dimensionality of morphological awareness would vary between L1 Chinese and L2 English, reflecting the unique morphological structures of each language, and would also vary across different grades. If morphological awareness is unidimensional, this would indicate a universal underlying cognitive process underpinning various types of measures. Alternatively, if a multi-dimensional model based on task modality is supported, it would imply that distinct cognitive processes would be at play between distinct task modalities. Moreover, if a multi-dimensional model based on stimulus level is validated, it would suggest that the underlying constructs of morphological awareness change across different linguistic levels.

Methods

Participants

Participants were 467 Hong Kong Chinese-English bilingual children who were L1 Chinese (Cantonese) speakers learning English as L2. There were 150 students in Grade 2 (N = 76 female; mean age = 8.10 years ± 7.28 months), 158 in Grade 5 (N = 83 female; mean age = 11.19 years ± 7.95 months), and 159 in Grade 8 (N = 79 female; mean age = 13.79 years ± 5.14 months), representing early, intermediate, and advanced stages of reading, respectively. Based on parent reports, all children were typically developing without any history of cognitive, language, or learning disorders. Most participants came from medium- to high-income families (The Hong Kong Census and Statistics Department, 2015). Students were recruited from local mainstream primary and secondary schools located in Hong Kong, in which Cantonese is the primary medium of instruction, with daily English classes focusing on basic literacy and spoken language skills. Explicit teaching of Chinese morphology begins early in Grade 1, whereas English derivational morphology is introduced systematically later after Grade 3. Written consent was obtained from schools and participants' parents before testing.

Parents filled out the Language and Social Background Questionnaires before testing (Tong et al., 2015). They reported children's L2 English age of acquisition (AoA), and rated on a five-point Likert scale (1 = poor, 5 = excellent) on children's language exposure and use at home, and proficiency in different aspects of Cantonese and English. According to the results, the L2 AoA was 4-6 years old for 46.6% of the participants and before 3 years old for 48.0%. Children were more proficient in L1 Chinese than L2 English in both spoken and written language (Table 1).

<INSERT TABLE 1 ABOUT HERE>

Measures

Students completed a series of L1 Cantonese and L2 English morphological awareness tasks as detailed below. All tasks were administered in their respective languages.

Chinese affix awareness

A newly developed 24-item task was used to assess children's ability to form novel words by adding the appropriate affix to real characters. In each trial, participants were orally presented with the definition of a two- or three-character compound word including the target affix, then asked to create a novel affixed word based on its expression. For example, 年長既人叫長者。奇怪既人叫乜野？(答案: 怪者) (*We call people who are old as "old people"; what is* *the name for people who are strange?*) (Answer: “strange people”). All participants responded orally in this task.

Chinese compounding awareness

The lexical compounding task tapped students’ awareness of Chinese morphological construction rules (Tong & McBride-Chang, 2010a). Students were asked to form novel compound phrases after listening to a scenario that was orally presented to children. A total of 24 items were included with an increasing level of difficulty. For example, 由一隻蜘蛛織成嘅網叫蜘蛛網。咁由一隻螞蟻織成嘅網叫乜野？(答案: 螞蟻網) (*We describe a web formed by a spider as a spider-web. How do we describe a web which is formed by an ant?*) (Answer: *ant-web*). For advanced-level students (i.e., relatively good performance in the testing items), nine 4-character idioms were added as more challenging items to assess students’ understanding of the compounding structure. For example, 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？(答案: 扶兄攜妹) (*We describe the action of lending a helping hand to an elderly person while holding hands with a child as “helping the elderly while taking care of the child.” How do we describe the action of lending a helping hand to our elder brother and holding hands with our younger sister?*) (Answer: helping our brother while taking care of our sister). Although Chinese idioms are fixed expressions, they often follow a [2 + 2] morphemic structure, mirroring the structure of compound words. This structural similarity allows idioms to function as viable stimuli for assessing compounding awareness. The inclusion of these expressions thus provided a higher-level measure of children’s ability to recognize and manipulate morphemes within a challenging linguistic context.

Chinese homophone awareness

A homophone identification and homophone production task were administered to assess students' awareness of Chinese homophones (Tong et al., 2011). In the identification task, a total of 24 items were included comprising 2-character words containing a homophone. The homophone syllable was at either the initial or final position of a word. Participants first heard three words from the same grammatical category, i.e., noun, verb, or adjective, e.g., 1. 藍天 (*blue sky*), 2. 藍圖 (*blueprint*), and 3. 籃球 (*basketball* – target). Then they judged whether all three characters were the same or different. If different, they circled the item number corresponding to the odd-one-out on their answer sheets.

The production task aimed to assess students' ability to distinguish homophones (i.e., same pronunciation, different meanings) in Cantonese. It included 12 items that were 2-character words containing the target homophone. Participants first heard an example, e.g., 書 (包) /ʃy1pau1/ (*book bag*) with the target morpheme 書 /ʃy1/. They were asked to produce real words that contained the same morpheme as quickly as possible, such as 書本 /ʃy1pun2/ (*general books*) and 圖書 /t^{h}ou4ʃy1/ (*library books*). They were then asked to produce words containing homophonic and semantically distinct morphemes, e.g., 舒服 /ʃy1fʊk6/ (*comfort*) and 輸入 /ʃy1jɐp6/ (*import*). This second step aimed to test their ability to suppress semantic interference while accessing phonological representations, the key component of homophone awareness. Without this step, this task would only measure morpheme productivity, not homophonic discrimination.

Chinese homograph awareness

A 30-item Chinese homograph discrimination task was used to assess children's homograph awareness (Tong & McBride-Chang, 2010a). Each trial included four bimorphemic compound words that contained one homograph at the same position, either syllabic-initial or syllabic-final, which were orally presented to the participants. Children were asked to identify the homograph that had a different meaning than the others. For example, 月光 /jyt6kwɔŋ1/ (*moonlight*), 月球 /jyt6kʰɐu4/ (*the planet moon*), 月亮 /jyt6lœŋ6/ (*moon in the sky*), 月刊 /jyt6 hɔn1/ (*monthly magazine*) all contained the same written form 月. The first three homographs had the same meaning of “moon”, while the fourth homograph had the meaning of “monthly.”

Chinese semantic radical awareness

The 36-item task tapped students’ ability to encode positional, phonological and semantic information of Chinese radicals, which was used by Tong and McBride (2010a) to assess student awareness of the functional and structural information of Chinese radicals. For each item, participants saw a line drawing of a simple concept or object, two pseudo-characters and two non-characters. The pseudo-characters are not real Chinese characters formed by real semantic and phonetic radicals following the positional regularity in left-right, top-bottom or enclosing Chinese characters[1]. The non-characters violated the rule of positional regularity by reversing the positions of semantic and phonetic radicals. For instance, for the picture showing 飯 (rice), the pseudo-character stimuli were 食支 (correct semantic radical correct position), 言反 (correct phonetic radical correct position), 支食 (correct semantic radical incorrect position), and 反言 (correct phonetic radical incorrect position). Participants needed to select which novel symbol best represented the meaning of the picture, i.e., correct semantic radical with correct position.

English inflection awareness

An analogy and judgment task were used to assess English inflection awareness on plural nouns, singular present tense, and singular past tense. Each task consisted of 24 items. In the

[1] Some radicals may occur in either position in Chinese, but we assessed radicals in the position where they occur most frequently in Chinese characters, e.g., left-sided for semantic radicals, right-sided for phonetic radicals.

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 (target: *lemons*). Stimuli were presented in both oral and written formats for Grades 2 and 5, who were asked to provide oral responses. Grade 8 students were provided with a testing booklet and asked to provide written responses instead.

In the judgment task, participants were presented with a word stem together with an indicator of its word class (*to, the, or it is*). Then they were asked to complete a sentence by choosing one of the three choices that had the same root (e.g., e.g., *To walk. Sophie is walking/walks/walked to school*). All children completed this task by circling answers in a testing booklet. Items were presented orally, as well as in written form to children in Grades 2 and 5.

English derivational awareness

An English derivational analogy and judgment task were used to assess awareness of suffixes forming nouns, verbs, and adjectives, each comprising 20 test items. In the analogy task, each trial comprised two word pairs that were either real words or non-words. Participants were presented with the first pair (e.g., *kind*: *kindness*) and the first word of the second pair (e.g., *happy*: ___), and were asked to provide the missing word (target: *happiness*). Stimuli were presented in both oral and written formats for Grades 2 and 5, and oral responses were acquired. Grade 8 children were given a testing booklet to provide written responses.

In the judgment task, children were given a stem and an indicator of its word class. They were asked to complete a sentence by choosing one of the three choices that shared the same stem with different variations (e.g., *To farm. I want to be a farmist/farming/farmer*). All children completed this task by circling the answers in a testing booklet. Stimuli were additionally read aloud to Grades 2 and 5.

English compounding awareness

A compounding analogy and judgment task were administered to assess awareness of English compounds. Each task comprised 24 test items, all of which were novel words created by changing the modifier or head of existing compound words. Participants heard a scenario that defined a real compound word and were then asked to create a novel compound 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*). Children in Grades 2 and 5 were tested individually and asked to provide oral responses. Grade 8 students were given a testing booklet and asked to provide written responses.

Similarly, the stimuli in the judgment task were all novel compound words. Participants heard a description and were asked to choose which novel compound best described it (e.g., *a leaf that you chew: leaf chewing/chewing leaf*). All participants provided written responses by circling in the testing booklets. Stimuli were also read aloud to children in Grades 2 and 5.

Scoring and procedure

For all the Chinese and English morphological awareness tasks, one point was awarded for each correct response. For tasks that required written responses in Grade 8, i.e., English inflectional analogy, derivational analogy, and compounding analogy, both oral and written responses were scored as 0 for inaccurate and 1 for accurate. Responses that were partially accurate due to phonological errors or misspelling (e.g., 'walking' → 'walkeng', 'happiness' → 'happines', 'side-skip' → 'site-skip') were scored as 0.

Testing was conducted in quiet classrooms at the participants' schools by Chinese-English bilingual research assistants. Chinese compounding and Chinese affixation were administered individually to all students; English inflection analogy, English derivational analogy, and English compounding analogy were administered individually for students in Grades 2 and 5 students; All other measures were administered in small groups. The whole testing lasted approximately 2 – 2.5 hours and was completed across separate sessions.

Data Analysis

All data analyses were conducted in R version 4.2.1 (R Studio, 2022). We first conducted preliminary analysis to evaluate the overall distribution of all the morphological awareness tasks by checking the kurtosis and skewness. We then examined the effect of grade on each morphological awareness task using two sets of simple linear regressions for L1 and L2, respectively. In the first set of models, the raw score on each L1 Chinese task was the dependent variable, and the grade level was the independent variable. In the second set of models, the raw score on each L2 task was the dependent measure with the grade level being the independent variable. Pairwise comparisons were conducted using the Tukey method.

Next, we addressed our two core research questions concerning dimensionality by conducting 1) correlational analyses among morphological awareness tasks in L1 and L2 separately, and 2) confirmatory factor analyses (CFA) to test the models specified for L1 and L2. The threshold of statistical significance was set at $p < .05$.

Three CFA models were conducted for each language by the grade level: 1) a one-factor uni-dimensional model (i.e., all morphological awareness tasks were explained by one single latent variable), 2) a multi-dimensional model by task modality (i.e., expressive vs. receptive), and 3) a multi-dimensional model by stimulus level (i.e., Chinese: word, character, radical; English: free vs. bound morpheme). All CFA models were fit using the *lavaan package* in R. To estimate all the factor loadings, a loading for each factor was fixed to be one using the variance standardization method. To determine good model fit, the following standards were applied (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 larger than 0.90, and (3) Root Mean Square Error of Approximation (RMSEA) value less than 0.08. In the case where the model had poor fit, the largest covariances between morphological awareness tasks based on modification indices (MI) were added and confirmed with the literature. Model comparisons were conducted every time when a parameter was added to determine if it significantly improved the model fit. Finally, to select the best fitting model, the least restricted uni-dimensional model served as a baseline model for model comparisons. Chi-square difference tests were performed to compare the other two models (i.e., multi-dimensional by response modality, multi-dimensional by stimulus level) against the baseline uni-dimensional model.

Supplementary Table 1 provides the classification of both L1 Chinese and L2 English task dimensionality, i.e., unidimensional, multi-dimensional by task modality, and multi-dimensional by stimulus level. To estimate the one-factor uni-dimensional model, morphological awareness was conceptualized as one single factor, in which all morphological awareness tasks were observed indicators (i.e., L1: affixation, homophone production, compounding, homophone identification, semantic radical awareness, homograph awareness; L2: compounding analogy, compounding judgment, derivational analogy, derivational judgment, inflection analogy, inflection judgment). In the multi-dimensional model by task modality, morphological awareness was composed of two distinct dimensions, i.e., *expressive* vs. *receptive* modality. The *expressive* modality factor included three indicators (i.e., L1: affixation, homophone production, compounding; L2: compounding, derivation, and inflection analogy) and the *receptive* modality factor contained three indicators (i.e., L1: homophone identification, semantic radical awareness, homograph awareness; L2: compounding, derivation, and inflection judgment). In the multi-dimensional model by stimulus level, morphological awareness encompassed three distinct dimensions for L1 (i.e., *word, character*, and *radical* levels). The *word* factor was consisted of two indicators (i.e., affixation, compounding), the *character* factor contained three indicators (i.e., homophone identification, homophone production, homograph awareness), and the *radical* factor included one indicator (i.e., semantic radical awareness). This model contained two dimensions for L2 (i.e., *free* vs. *bound* morpheme). The *free* morpheme factor included two tasks (i.e., compounding analogy and judgment), whereas the *bound* morpheme factor contained four tasks (i.e., inflection analogy, inflection judgment, derivational analogy, derivational judgment).

Results

Preliminary analyses

Table 2 shows the skewness, kurtosis, mean, standard deviation, range, and Cronbach's alpha for each task. All tasks showed normal distribution except for: English compounding analogy, Chinese affixation, Chinese compounding, Chinese homograph awareness, and Chinese homophone production. Hence, the CFA models were conducted using the maximum likelihood with robust standard errors (MLR) estimator (Rosseel, 2017), which accommodates non-normal distributions.

<INSERT TABLE 2 ABOUT HERE>

Grade differences in Chinese and English morphological awareness tasks

The effect of grade was significant in all Chinese and English tasks (ps < .05). Pairwise comparisons with Tukey method showed that for L1 Chinese, Grade 5 significantly outperformed Grade 2 (ps < .01), and Grade 8 significantly outperformed both Grades 2 (ps < .01) and 5 (ps < .05) in all tasks. For L2 English, Grade 5 showed significantly superior performance than Grade 2 in all tasks (ps < .05). Grade 8 obtained significantly higher scores than Grade 2 in all tasks except for compounding analogy (*p* = .090). Grade 8 also significantly outperformed Grade 5 in all tasks with the exception of compounding analogy (*p* < .01).

Correlational analysis

Table 3 illustrates the correlations among morphological awareness tasks by grade in Chinese and English. For the Chinese tasks, the correlations in Grade 2 were small to strong, except between homophone production and homophone identification (*r* = .16), and between homophone production and semantic radical awareness (*r* = .07). All tasks in Grade 5 showed small to strong correlations, except for homophone production with affixation (*r* = .13) and semantic radical awareness (*r* = .13). The correlations in Grade 8 were small to moderate, except between affixation and homograph awareness (*r* = .19), and between affixation and compounding (*r* = .18)

<INSERT TABLE 3 ABOUT HERE>

For the English tasks, the correlations in Grade 2 were small to moderate, except between compounding judgment and inflection judgment (*r* = .06), compounding analogy and derivational judgment (*r* = .10), inflection analogy and compounding judgment (*r* = .07), derivational analogy and compounding judgment (*r* = .08), and compounding analogy and compounding judgment (*r* = .08). The correlations in Grade 5 were small to strong, except between compounding analogy and inflection judgment (*r* = .14), derivational judgment (*r* = .13), compounding judgment (*r* = .09), and derivational analogy (*r* = .16). All tasks in Grade 8 demonstrated moderate to strong associations.

CFA models

Chinese models. The best fitting model was unidimensional for Grade 2 (Table 4). Chi-square difference test did not show a significant difference between unidimensional models and multi-dimensional models by response modality (p = .18) or multi-dimensional models by stimulus level (p = .10). For Grade 5, the multi-dimensional model by response modality fit significantly better than the unidimensional model ($\Delta\chi^2$ = 4.30, p < .05), in support of multidimensionality of Chinese morphological awareness in this grade. For Grade 8, all three models exhibited over-fitting (TLIs > 1, RMSEAs = 0), likely due to high item correlations or sample size limitations. Hence, we prioritized Bayesian Information Criterion (BIC) to balance fit and parsimony, selecting the model with the lowest BIC value (Vrieze, 2012). Figure 1 demonstrates the best fitting models for Grades 2, 5, and 8. Factor loadings in all three models were significant (ps < .001).

<INSERT TABLE 4 ABOUT HERE>

<INSERT FIGURE 1 ABOUT HERE>

English models. A uni-dimensional model was the best fitting model for Grades 2, 5, and 8 (Table 4). Chi-square difference tests did not reveal any significant differences between uni-dimensional models and multi-dimensional models by response modality (Grade 2: p = .14; Grade 5: p = .052; Grade 8: p = .22) or multi-dimensional models by stimulus level (Grade 2: p = .78; Grade 5: p = .65; Grade 8: p = .46). Figure 2 illustrates the best fitting models for Grades 2, 5, and 8. In the model for Grade 2, all factor loadings were significant except for compounding judgment (p = .29). In the models for Grades 5 and 8, all factor loadings were significant (ps < .001).

<INSERT FIGURE 2 ABOUT HERE>

Discussion

By employing both language-general and language-specific measures for L1 Chinese and L2 English, this study investigated the underlying construct of morphological awareness among

Hong Kong Chinese-English bilingual children at Grades 2, 5, and 8. Our findings demonstrated, for the first time, that the dimensionality of morphological awareness varied not only between languages but also across grade levels. These findings were discussed in terms of the interplay between linguistic context and developmental stages in L1 and L2 morphological acquisition.

The dimensionality of L1 Chinese morphological awareness evolves developmentally. Early readers tend to adopt holistic strategies to process Chinese morphology, influenced by the early emphasis on using semantic units to acquire Chinese characters (Li et al., 2012; McBride-Chang et al., 2003), and the focus on rote memorization prevalent in early education. Such a universal approach to morphological structures reflects the initial learning strategies employed by early readers to navigate the complexities of the Chinese writing system.

By Grade 5, the instructional focus shifts towards a more explicit analysis of Chinese morphology (Tong & McBride-Chang, 2010b; VanPatten & Cadierno, 1993). At this stage, performance may vary by the task complexity or demand, with expressive tasks posing greater cognitive challenges compared to receptive tasks (Carlisle, 2000). The emergence of this multidimensionality in Grade 5 suggests that the cognitive demands underlying tasks represent distinct yet related facets of L1 Chinese morphological awareness.

By Grade 8, continued explicit instruction coupled with advanced linguistic abilities promote refined and automatic application of morphological knowledge, allowing morphological awareness to manifest as an integrated construct that aids in morphological processing. This aligns with findings that children process meanings holistically after they have acquired sufficient knowledge of Chinese morphemic structure (Shu et al., 2006). However, the results of Grade 5 should be interpreted with caution since model fit was based on BIC values.

Additionally, models in Grade 8 were just-fitted, potentially due to lower reliabilities in some L1 Chinese measures (factor loadings < 0.4).

In contrast, L2 English exhibits consistent unidimensionality across grades, aligning with findings from English monolinguals (e.g., James et al., 2021). According to the phase model (Ehri, 1995), once children progress from the full-alphabetic phase (i.e., Grades 1 – 4) to the consolidated-alphabetic phase (i.e., Grades 4 and above), they systematically apply morphemic knowledge for decoding and meaning retrieval. This consistency reflects an integrated skill where compounding, derivation, and inflection contribute to a unified construct. While some studies reported multidimensionality (e.g., Apel et al., 2022), methodological differences might explain the discrepancy. First, these studies focused on a limited range of tasks, whereas we assessed inflectional, derivational and compounding awareness, providing a more comprehensive evaluation of English morphological awareness. Second, other studies administered tasks in either receptive or expressive modality, whereas we incorporated both modalities. Third, prior studies examined high-proficiency monolinguals, who may demonstrate finer differentiation of morphological skills. These findings collectively suggest that the construct of morphological awareness depends on both assessment approach and language proficiency.

Our Chinese measures included homophone and homograph awareness tasks, which are critical due to the logographic nature and high degree of homophony in Chinese. In contrast, while English also has homophones and homographs (e.g., "*bear*" vs. "*bare*"), they are less central to English morphology. This difference may explain why Chinese morphological awareness exhibited multidimensionality in Grade 5, where expressive and receptive tasks diverged. Specifically, homophone awareness might play a significant role in such divergence, as homophone production required retrieval and production of morphemes from long-term memory and assembly of morphemes to form new words, while homophone identification relied more on judging morpheme relationships and identifying homophone meanings. Future research could examine whether incorporating homophone and homograph awareness tasks in English would introduce similar dimensionality shifts.

Our findings of different constructs between Chinese and English are likely attributed to both bilingual language proficiency and language-specific morphological features. Children across all grade levels demonstrated relatively lower language proficiency in L2 English than L1 Chinese in reading, speaking, and listening (Table 1), thus may lead to differences in task performance between languages. Moreover, the unique morphological system in each language plays a crucial role in the underlying dimensionality (Kuo & Anderson, 2006). The evolution of the dimension for L1 Chinese reflects the complexities of Chinese morphology given its morpho-syllabic nature. In contrast, the unidimensionality for L2 English indicates a linear nature of English morphology, as the ortho-phonological link may make it easier for learners to apply consistent strategies for morphological processing (Carlisle, 2000).

These findings carry significant implications for morphology assessment and instruction in bilingual education. Assessments should adapt to developmental differences across grades: while unidimensional measures may be sufficient for early and advanced readers in both L1 Chinese and L2 English, intermediate readers require multidimensional assessments targeting both receptive and expressive modalities in Chinese. Instruction should similarly address both modalities in Grade 5 Chinese while maintaining a comprehensive focus on English across all grades. Educators should therefore design language- and grade-specific materials that align with these distinct learning trajectories.

Limitations and future directions

The study has several limitations. First, it focuses solely on school-age Chinese-English bilinguals, without the inclusion of preschoolers and L1 English-L2 Chinese groups. This restricts generalizability to other age groups and language pairs and prevents direct comparisons with monolingual readers. Future studies should include these populations to better understand when morphological awareness differences emerge.

A second limitation concerns morphological measures. Since Chinese and English exhibit distinct structures, the tasks in both languages were not fully parallel. For example, English assessed both receptive and expressive abilities, while Chinese did not; Some features like inflection or derivation in Chinese and homophones or homographs in English were not tested. Additionally, many tasks were newly developed, lacking baseline data or stopping rules, and some may have been confounded by other skills, such as vocabulary knowledge in Chinese compounding tasks. Future research should refine these measures for better cross-linguistic comparisons.

Finally, the analytical approach could be expanded. The current CFA models examined task modality and stimulus level, but future research should incorporate additional factors, such as orthographic input, to clarify language-specific effects. Differentiating between tacit (automatic) and strategic (metalinguistic) processing in tasks may also improve frameworks. Moreover, the cross-sectional design limits causal inferences. Future longitudinal studies are needed to address these issues.

Conclusion

The current study investigated the underlying dimensionality of both L1 Chinese and L2 English morphological awareness in Hong Kong Chinese-English bilingual children at Grades 2, 5, and 8. Our findings showed that L1 Chinese morphological awareness developed from a unidimensional construct in early readers to a multi-dimensional construct by task modality (i.e., expressive vs. receptive) in intermediate readers, and to a unidimensional consolidated construct in advanced readers. In comparison, the best fitting model for L2 English was a unidimensional model across all grades. These findings reflect how language-specific morphological structures and bilingual language proficiency shape the development of morphological awareness. Future research should elucidate the underlying construct of morphological awareness in different bilingual populations.

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Table 1

Parent-report language Cantonese and English proficiency for children in Grade 2, Grade 5, and Grade 8.

Proficiency	**Grade 2**		**Grade 5**		**Grade 8**	
	Mean	***SD***	***Mean***	***SD***	***Mean***	***SD***
Cantonese listening comprehension	4.65	.56	4.67	.62	4.78	.46
Cantonese speaking	4.60	.66	4.63	.76	4.76	.51
Cantonese reading	3.97	.83	4.25	.89	4.58	.62
English listening comprehension	2.93	1.01	3.24	1.03	3.68	.77
English speaking	2.91	1.91	3.08	1.11	3.57	.80
English reading	2.76	1.01	3.29	1.09	3.79	.81

Note. ratings were provided on a 5-point Likert scale ranging from 1 (*poor*) to 5 (*excellent*).

Table 2

Grade-level performance and skewness/kurtosis in L1 Chinese and L2 English morphological awareness tasks.

	Grade 2					Grade 5					Grade 8					Pairwise Comparisons	Skew ness	Kurt osis
	M	*SD*	*Min.*	*Max.*	*α*	*M*	*SD*	*Min.*	*Max.*	*α*	*M*	*SD*	*Min.*	*Max.*	*α*			
L1 Tasks																		
AFF	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	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
HMI	8.13	3.39	.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
HMP	8.54	4.85	.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
HMG	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
SRL	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
L2 Tasks																		
IFA	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	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
DRA	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	7.36	2.61	2.00	19.00	.36	9.58	3.31	.00	19.00	.59	13.18	3.55	.00	20.00	.72	G2 < G5 < G8	.22	2.22
CMA	21.90	2.60	14.00	24.00	.75	23.43	1.22	15.00	24.00	.65	21.14	4.65	.00	24.00	.92	G2 < G5, G5 > G8	-3.69	20.79
CMJ	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

Note. α: Cronbach's alpha reliability. AFF: affixation (/24), COM: compounding (/24), HMI: homophone identification (/24), HMP: homophone production (no max. score), HMG: homograph awareness (/30), SRL: semantic radical awareness (/36); IFA: inflection analogy (/24), IFJ: inflection judgment (/24), DRA: derivational analogy (/20), DRJ: derivational judgment (/20), CMA: compounding analogy (/24), CMJ: compounding judgment (/24).

Table 3

Correlation matrices among L1 Chinese and L2 English morphological awareness tasks in Grades 2, 5, and 8.

	Grade 2						**Grade 5**						**Grade 8**					
L1	AFF	COM	HMI	HMP	HMG	SRL	AFF	COM	HMI	HMP	HMG	SRL	AFF	COM	HMI	HMP	HMG	SRL
AFF	1.00						1.00						1.00					
COM	.55***	1.00					.32***	1.00					.18*	1.00				
HMI	.26**	.34***	1.00				.30***	.51***	1.00				.22**	.24**	1.00			
HMP	.24**	.49***	.16	1.00			.13	.42***	.43***	1.00			.25**	.33***	.33***	1.00		
HMG	.60***	.58***	.39***	.38***	1.00		.26***	.54***	.63***	.40***	1.00		.19*	.31***	.39***	.27***	1.00	
SRL	.27***	.31***	.35***	.07	.38***	1.00	.27***	.34***	.33***	.13	.43***	1.00	.16*	.25**	.40***	.23**	.35***	1.00
L2	IFA	IFJ	DRA	DRJ	CMA	CMJ	IFA	IFJ	DRA	DRJ	CMA	CMJ	IFJ	DRJ	CMJ	IFA	DRA	CMA
IFA	1.00						1.00						1.00					
IFJ	.36***	1.00					.64***	1.00					.71***	1.00				
DRA	.48***	.20*	1.00				.55***	.55***	1.00				.60***	.59***	1.00			
DRJ	.26**	.24**	.22**	1.00			.45***	.58***	.39***	1.00			.54***	.64***	.65***	1.00		
CMA	.38***	.25**	.27***	.19	1.00		.24**	.14	.16*	.13	1.00		.44***	.55***	.47***	.52***	1.00	
CMJ	.07	.06	.08	.21*	.08	1.00	.33***	.40***	.35***	.43***	.09	1.00	.54***	.61***	.57***	.64***	.45***	1.00

Note. AFF: affixation, COM: compounding, HMG: homograph awareness, HMP: homophone production, HMI: homophone identification, SRL: semantic radical awareness; 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

Model fit parameters.

	Grade 2						**Grade 5**						**Grade 8**					
	Chi-square	***TLI (> .9)***	***CFI (> .9)***	***RMSEA (< .08)***	***BIC***	$\Delta\chi^2$	***Chi-square***	***TLI (> .9)***	***CFI (> .9)***	***RMSEA (< .08)***	***BIC***	$\Delta\chi^2$	***Chi-square***	***TLI (> .9)***	***CFI (> .9)***	***RMSEA (< .08)***	***BIC***[a]	$\Delta\chi^2$
L1 Chinese																		
Uni-dimensional	10.51	0.97	0.99	0.06	4814.16	-	14.24	0.96	0.98	0.06	4962.89	-	4.55	1.07	1.00	0.00	4709.98	-
Multi-dimensional by response modality	8.41	0.97	0.99	0.05	4816.94	2.01	10.89	0.98	0.99	0.05	4965.08	4.30*	2.87	1.09	1.00	0.00	4713.39	1.93
Multi-dimensional by stimulus type	6.06	0.99	1.00	0.04	4822.38	1.91	12.21	0.95	0.98	0.07	4970.85	2.08	3.47	1.06	1.00	0.00	4724.26	0.98
L2 English																		
Uni-dimensional	10.30	0.98	0.99	0.03	4436.73	-	12.26	0.98	0.99	0.05	4413.37	-	11.94	.98	.99	.06	4728.51	-
Multi-dimensional by response modality	7.66	1.01	1.00	0.00	4439.01	2.16	8.17	1.00	1.00	0.01	4414.03	3.75	10.63	.98	.99	.06	4732.56	1.22
Multi-dimensional by stimulus type	10.10	0.96	0.98	0.04	4441.64	0.08	9.10	0.98	0.99	0.04	4420.65	3.29	11.62	.97	.99	.07	4733.53	0.04

Note. [a] Grade 8 model selection prioritized BIC due to saturated fit (TLIs > 1.00) across competing models. TLI: Tucker-Lewis Index; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; BIC: Bayesian Information Criterion; $\Delta\chi^2$: Chi-square difference test between 1) uni-dimensional and multi-dimensional by response modality, and between 2) uni-dimensional and multi-dimensional by stimulus type.

*: $p < .05$.