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ORIGINAL ARTICLE

Cognitive-linguistic skills and vocabulary knowledge breadth and depth in children's L1 Chinese and L2 English

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Abstract
This study examined the correlates of different aspects of vocabulary knowledge in L1 Chinese and L2 English in Hong Kong bilingual children ($N = 481$, age = 6–12 years old). Their nonverbal IQ, cognitive-linguistic skills, receptive and expressive vocabulary knowledge breadth, and vocabulary knowledge depth in Chinese and English were measured. Results demonstrated that morphological awareness was uniquely correlated with different aspects of vocabulary knowledge across Chinese and English. Phonological processing skills played different roles in vocabulary knowledge in L1 and L2. In addition, receptive vocabulary breadth uniquely contributed to expressive vocabulary breadth across languages. Moreover, both receptive and expressive vocabulary breadth contributed to vocabulary knowledge depth in L1 Chinese and L2 English. The findings highlight some shared and unique aspects of different vocabulary constructs across languages.

Keywords: receptive vocabulary breadth; expressive vocabulary breadth; vocabulary knowledge depth; Chinese; English

How are various cognitive-linguistic skills and facets of vocabulary knowledge associated in children's first and second language learning? Clarity on this question might have important implications for both testing of skills and prediction of vocabulary knowledge, as well as for vocabulary training.

Although vocabulary knowledge has been recognized as an important ability for language acquisition and academic success (Biemiller, 2006; Scarborough, 2005; Storch & Whitehurst, 2002); however, there is still no clear consensus concerning the nature of vocabulary knowledge across languages (Read, 2013; Schmitt, 2014). To some extent, this is because vocabulary knowledge remains an extremely complicated construct that resists any single explanation (Schmitt, 2014, 2019). Researchers have explored the nature of vocabulary knowledge and investigated how to assess and teach vocabulary knowledge efficiently (e.g., Pearson et al., 2007; Read, 2013; Schmitt, 2019). The two facets of vocabulary knowledge, namely, receptive and expressive vocabulary knowledge, have been identified in some previous work (Schmitt, 2019). Two further dimensions, namely, vocabulary knowledge breadth and depth, are often proposed to capture different levels of vocabulary knowledge (Anderson & Freebody, 1981; Qian, 1999; Schmitt, 2014).

Previous research investigating the associations between vocabulary knowledge and other language-related skills have often conceptualized the nature of vocabulary knowledge in different ways. Many have included only a single measure of vocabulary knowledge when examining its associations with other literacy and language skills; they have minimally addressed its multidimensional nature (Kieffer & Lesaux, 2008). However, a few studies have found that different aspects of vocabulary knowledge, namely receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth, are intercorrelated but also distinct as they may play different roles in facilitating different reading skills (Li & Kirby, 2015; Ouellette, 2006). The current study aimed to unpack the associations of different aspects of vocabulary knowledge in L1 Chinese and L2 English among Hong Kong bilingual children, by using comparable measures to test their vocabulary knowledge in Chinese and English within a single study.

In addition, we also investigated the associations of different aspects of vocabulary knowledge with different cognitive-linguistic skills, namely phonological awareness, morphological awareness, and rapid automatized digit naming (RAN). Children's knowledge of phonology, morphology, and speed of access to the lexicon have been established as important correlates of vocabulary learning across languages (e.g., Liu et al., 2017; McBride-Chang et al., 2005a, 2005b, 2008; Pan et al., 2011; Ramirez et al., 2013; Sparks & Deacon, 2015). However, it is not clear whether these cognitive-linguistic skills play similarly important roles in different aspects of vocabulary knowledge. In the current study, we focused on systematically investigating these associations across two typologically distant languages within the same children. Exploring these associations can help to identify both shared and unique knowledge and processes required for different aspects of vocabulary knowledge across languages. Understanding these associations can potentially be useful both for vocabulary testing and training.

The differences and associations between vocabulary knowledge breadth and depth

Vocabulary knowledge breadth refers to the quantity of words one knows (Nation, 2001; Qian, 1999). In general, receptive vocabulary breadth is measured by asking participants to select (usually by pointing) which of several presented pictures matches an auditorily presented word; expressive vocabulary breadth is typically tested by requiring the subjects to name the picture using a word that best describes

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it (Ouellette, 2006). In contrast, vocabulary knowledge depth generally refers to the understanding of various aspects of a given word and their applications across contexts (Nation, 2001; Qian, 1999). Vocabulary knowledge depth is often assessed by asking participants to describe or define a given word (Ouellette, 2006), a task of production.

Although vocabulary breadth and depth are two facets of vocabulary knowledge, they are closely associated with one another. In previous studies of children, the correlations of breadth and depth of vocabulary knowledge were found to be between .70 and .85 (Qian, 1999, 2002; Vermeer, 2001). This high correlation is consistent with the conceptualization of these constructs as two intercorrelated but distinct dimensions of vocabulary knowledge that facilitate each other.

The breadth and depth of vocabulary knowledge are distinct. This is not just because their developmental trajectories are not the same but also because of a theoretically fundamental distinction: knowing how many words are stored in a child's lexicon cannot represent how much detail the child has acquired about the precise meanings of a given word, nor the other way around (Ouellette, 2006). Children may learn a new word and store it in the lexicon, facilitating their receptive vocabulary breadth, without fully acquiring the meaning of that word (Lahey, 1988). With increasing learning experience, word meanings are gradually refined, contributing to children's depth of vocabulary knowledge. The differences between vocabulary knowledge breadth and depth underline the need to view these facets as distinct. Therefore, in language learning and education, attention should be paid to these different constructs of oral vocabulary. However, too little is known about the correlations and distinctions of these aspects of vocabulary knowledge.

Children typically learn some new vocabulary words in their daily lives and refine their understandings of the meanings of these words in different contexts. Vocabulary knowledge breadth is likely to facilitate the development of vocabulary depth. The more words one knows, the more refined one's understanding of concepts can be by making use of different words. Moreover, vocabulary knowledge across languages generally develops from receptive to productive mastery (Schmitt, 2019). This is especially the case for young language learners. For typically developing children, learning most words at the level of receptive mastery is relatively easy; it is more challenging to enhance the knowledge in productive mastery (Schmitt, 2019). From this perspective, receptive vocabulary knowledge is likely to be the foundation for expressive vocabulary knowledge. The current study explored this issue across languages.

The importance of receptive and expressive vocabulary breadth in vocabulary knowledge depth across languages

The depth of vocabulary knowledge mainly refers to the quality of one's understanding of word meanings (Anderson & Freebody, 1981; Li & Kirby, 2015). Previous research has used different approaches in conceptualizing and measuring vocabulary knowledge depth. Nonetheless, researchers view vocabulary knowledge depth as involving at least precision and multiplicity of word meaning, the relations between any given vocabulary words, and morphological knowledge about the word

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(Li & Kirby, 2015; Ouellette, 2006; Tannenbaum et al., 2006). Therefore, the growth of vocabulary knowledge depth is possibly driven by the lexicon and the quality of lexical representations. Children who store more words in their lexicon, enlarging their receptive and expressive vocabulary breadth, are likely to enrich the depth of their vocabulary knowledge. Therefore, children's receptive and expressive vocabulary breadth may be important correlates of vocabulary knowledge depth in young children.

Cognitive-linguistic skills and receptive vocabulary breadth in Chinese and English

Receptive vocabulary knowledge breadth encompasses knowledge of the spoken word identification, its basic uses, and its surface meanings (Li & Kirby, 2015; Nation, 2001). One important step in learning a word is storing its phonological form in memory, along with representations of its meaning. The development of vocabulary knowledge breadth is likely to be driven by cognitive-linguistic and perceptual phonological factors. The lexical restructuring hypothesis postulates a strong link between the development of vocabulary growth and phonological skills, as spoken word representations evolve from a holistic to a segmental-based identification through development (Metsala & Walley, 1998). This seems to be universal across languages, with evidence from previous studies in Chinese and English, two typologically different languages: receptive vocabulary breadth was uniquely explained by phonological awareness in previous studies of Hong Kong bilingual children's L1 Chinese and L2 English (McBride-Chang et al., 2006) and native English-speaking children (Metsala, 1999; Sparks & Deacon, 2015). Children's phonological sensitivity to phoneme onset and syllable units was significantly associated with receptive vocabulary knowledge breadth in L1 Chinese and L2 English, and the finer phonological discriminations were found to be more important for developing English receptive vocabulary knowledge (McBride-Chang et al., 2006). The present study used a relatively comprehensive phonological awareness measure (including both syllable deletion and onset deletion) to explore the role of phonological awareness in receptive vocabulary breadth across languages. We also included the cognitive-linguistic skills of morphological awareness and rapid digit automatized naming.

Morphological awareness, defined as the ability to recognize morphemes and manipulate morphological structures in the words (Carlisle, 1995), is associated with the acquisition of vocabulary knowledge across languages (Chen et al., 2009; Ku & Anderson, 2003; McBride-Chang et al., 2008; Ramirez et al., 2013). In both Chinese and English, a majority of words are morphologically complex; their meanings can potentially be inferred based on the meanings of their parts. Knowing more morphemes and understanding the morphological structure is important in extracting the meanings of new/unfamiliar words (Kuo & Anderson, 2006). Therefore, morphological awareness is likely to facilitate vocabulary breadth. The unique importance of morphological awareness in receptive vocabulary breadth in Chinese has been reported in a previous study of Hong Kong children (McBride-Chang et al., 2006). Similarly, another study in English demonstrated that morphological awareness uniquely predicted receptive vocabulary breadth beyond other cognitive-linguistic skills in native English-speaking children (Sparks & Deacon, 2015). It seems that morphological awareness is particularly important for the acquisition of receptive vocabulary breadth, although the aspects of morphological awareness (i.e., inflectional and derivational morphology, and lexical compounding) that may be integral to the development of receptive vocabulary knowledge may differ across Chinese and English, given the different language features of both languages. For example, inflectional (e.g., adding *-s* to indicate plural) and derivational morphology (e.g., adding suffix -er to change a verb to a noun) are common in English but almost nonexistent in Chinese. On the other hand, lexical compounding is more common in Chinese than in English. The current study explored the extent to which tasks of morphological awareness, designed to tap unique morpheme knowledge in each language separately, would each explain unique variance in vocabulary learning in the same participants who speak Chinese as a native language and English as a second language.

Moreover, RAN, the ability to access the names of highly familiar stimuli such as digits, letters, colors, and objects (Denckla & Rudel, 1976), has been shown to be significantly associated with expressive vocabulary knowledge in both Chinese and English in some studies (e.g., McBride-Chang, et al., 2005b; Pan et al., 2011; Xie et al., 2020). RAN typically involves speeded retrieval of phonological representations from long-term memory and fluency of access to the lexicon (Wagner & Torgesen, 1987). RAN may represent quick phonological and semantic access to relatively well-learned vocabulary words, which is likely to be important for developing receptive vocabulary breadth across languages. Given ideas that RAN in part reflects the speed with which individuals taps into their mental vocabulary (Wagner & Torgesen, 1987), we hypothesized that RAN would be associated with receptive vocabulary breadth. However, few studies have focused on the role of RAN in children's receptive vocabulary knowledge. Thus, RAN was also included to examine its association with receptive vocabulary breadth in both L1 Chinese and L2 English.

The roles of receptive vocabulary breadth and cognitive-linguistic skills in expressive vocabulary breadth across languages

Receptive vocabulary breadth may facilitate the growth of expressive vocabulary breadth (Li & Kirby, 2015). In general, our receptive vocabulary breadth is larger than our expressive vocabulary breadth as we are able to understand more words through listening than we produce in speech production. This phenomenon occurs not only because language comprehension normally precedes production, but also because additional cues to the words are available in receptive language activities, but not in production (Pearson et al., 2007). This should be universal in learning different languages. In the present study, we tested whether receptive vocabulary breadth was a unique correlate of expressive vocabulary breadth in L1 Chinese and L2 English.

Previous research on vocabulary breadth has focused more on receptive vocabulary breadth rather than expressive vocabulary breadth. However, recent studies have found that these two aspects of vocabulary breadth are different (Li &

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Kirby, 2015; Ouellette, 2006). Oral production of words requires more complicated lexical and extra articulation processes, which are likely to require more precise phonological processing (Liu et al., 2017; Ouellette, 2006). Given the importance of phonological precision (e.g., Metsala, 1999), phonological awareness may be integral to the development of expressive vocabulary breadth. Existing studies of Hong Kong Chinese-English bilingual children have found that their L2 English expressive vocabulary breadth was uniquely associated with their phonological awareness (Liu et al., 2017; Yeung & Chan, 2013). However, a unique association of phonological awareness and expressive vocabulary breadth was not found in previous research on Chinese children when their age, nonverbal IQ, RAN, and morphological awareness were statistically controlled (Chen et al., 2009). This may be because of the difference in language features, given that homophones and homographs are more prevalent in Chinese than English (Liu & McBride-Chang, 2010). For pronouncing Chinese words, phonological awareness tends to be less integral in distinguishing one word from another as compared to morphological awareness. Indeed, lexical compounding is helpful for children in distinguishing both the syllables and the morphemes in words simultaneously. In Chinese, but not in English, a morpheme and a syllable are typically the same unit of speech. More research is required to address this issue across L1 Chinese and L2 English.

Oral production of words also requires efficient retrieval of meaning and word form across Chinese and English. In Chinese, expressive vocabulary may particularly depend on morphological awareness, as compared to phonological processing skills, among primary school children. Research on Chinese learning has repeatedly emphasized the important role of morphological processing, particularly given that phonological cues in Chinese are often unreliable (e.g., Shu et al., 2003; Yeung et al., 2011). Understanding and identification of morphemes in homophones, words that may sound the same but have different meanings (e.g., 園/jyun4/ *garden* and 員 /jyun4/ *member*, are crucial for Chinese word recognition. For example, in a study of Chinese primary school children, Chinese expressive vocabulary breadth was significantly correlated with phonological awareness, RAN, and morphological awareness (Chen et al., 2009). However, when these cognitive-linguistic skills were all included in the same model, only morphological awareness uniquely explain children's expressive vocabulary breadth in Chinese. The authors argued that the contribution made by morphological awareness to Chinese expressive vocabulary breadth is much larger than the contribution made by phonological processing skills. Similarly, morphological awareness has been strongly linked to English expressive vocabulary breadth in native English-speaking children (McBride-Chang et al., 2005b). Therefore, we expected that morphological awareness would uniquely explain variance in expressive vocabulary breadth in both L1 Chinese and L2 English in Hong Kong bilingual children.

Apart from phonological and morphological awareness, we tested the association of RAN to expressive vocabulary breadth in the present study. Both the RAN and the expressive vocabulary breadth tasks require children to name visual stimuli. RAN tasks require that these stimuli be named as quickly and efficiently as possible. The ease of lexical access to familiar stimuli might be important for vocabulary acquisition as well. Expressive vocabulary breadth was associated with RAN in native Chinese and English primary schoolers in previous studies (Chen et al., 2009; McBride-Chang et al., 2005b). However, these studies also found that RAN was not among the unique correlates of expressive vocabulary breadth when other cognitive-linguistic skills were statistically controlled. Nevertheless, there have been relatively few studies of expressive vocabulary breadth in relation to RAN thus far, so the present study included RAN tasks in order to further test this association in Hong Kong children's L1 Chinese and L2 English.

Cognitive-linguistic skills and vocabulary depth in L1 Chinese and L2 English

Vocabulary knowledge depth, as measured with tasks of oral definition, was significantly correlated with other cognitive-linguistic skills in Chinese and English in previous studies (e.g., Choi et al., 2019; McBride-Chang et al., 2005a, 2008; Pan et al., 2011; Tong et al., 2018; Xie et al., 2020). Vocabulary knowledge depth involves using various linguistic structures to express accurate information, represent the core meanings of linguistic items, and thus explain or define words (Benelli et al., 2006). Vocabulary depth may require a higher quality of lexical representations of a given word, compared to vocabulary breadth. Therefore, those cognitive-linguistic skills that are important for the development of vocabulary breadth may also be helpful in facilitating vocabulary knowledge depth. Phonological awareness has been shown to be associated with vocabulary knowledge depth in several previous studies on Chinese children's L1 Chinese and their L2 English (e.g., Choi et al., 2019; McBride-Chang et al., 2008; Pan et al., 2011; Song et al., 2015). In addition, the importance of morphemes for vocabulary learning has been highlighted in previous work in both Chinese (McBride-Chang et al., 2008; Xie et al., 2020) and English (Nagy & Anderson, 1984; Sparks & Deacon, 2015). Morphological awareness was uniquely associated with vocabulary knowledge depth in Hong Kong children's L1 Chinese and L2 English (e.g., Tong et al., 2017, 2018). The bidirectional relationship between the development of morphological awareness and vocabulary knowledge depth in Chinese was underscored by a longitudinal study carried out by McBride-Chang et al. (2008). RAN has been less of a focus in previous work, but because it represents the speed of lexical access, it may also play an important role in vocabulary acquisition: quick access to both word labels and additional information about a given word, that is, depth and breadth, respectively, is likely to be important for vocabulary learning.

Current study

To better understand the shared and unique variances of different facets of vocabulary knowledge, the current study explored the associations of different cognitive-linguistic skills to vocabulary breadth and depth and the inter-correlations among different aspects of vocabulary knowledge. A systematic examination of the shared and unique variances of these variables across languages in the same participants can facilitate the understanding of the nature of vocabulary knowledge.

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We measured children's phonological awareness in Chinese and morphological awareness, RAN, receptive and expressive vocabulary breadth, as well as expressive vocabulary depth in both Chinese and English. In addition, we also measured children's nonverbal IQ, given that it was significantly associated with children's vocabulary knowledge beyond their age in some previous work (Liu et al., 2017; McBride-Chang et al., 2008).

In the current study, our first hypothesis was that the correlations among the cognitive-linguistic skills and different aspects of vocabulary knowledge would be significant in both L1 Chinese and L2 English. However, due to the typological differences between both languages (i.e., phonology has a greater impact on English as compared to Chinese), we expected that the prediction strength of the cognitive-linguistic skills in different facets of vocabulary knowledge might vary in both L1 and L2. Second, as reviewed above, across L1 Chinese and L2 English, receptive vocabulary breadth was expected to predict children's expressive vocabulary breadth. Both receptive and expressive vocabulary breadth were hypothesized to contribute to vocabulary knowledge depth.

Methods

Participants and procedure

The present study is a part of an ongoing longitudinal twin project in Hong Kong involving reading and mathematics (Wong et al., 2017). All children in this project were typically developing children without any special education needs (as reported by their parents). The sample size of the present study was 481 Hong Kong primary school children (age $M = 7.86$ years, 234 boys). They were recruited from different schools located in various districts in Hong Kong. All children were native Cantonese speakers. Hong Kong children start to learn English as a second language from the first year of kindergarten (age 3.5 years). When they go to primary schools, both English and Chinese are taught as language subjects (Education Bureau of the Hong Kong Special Administrative Region, 2004). They also learn Mandarin (another oral Chinese language) in primary school. The sample includes 98 nontwin children and 383 twin children. In order to ensure the independence of the sample, we selected only one child from each twin pair for inclusion in the present study. This was done by randomly selecting data from one child from each pair of twins for analysis, ensuring a representative sample that conforms to the independent sampling assumption in regression analyses.

Ethics approval was granted from the Survey and Behavioral Research Ethics Committee of the Chinese University of Hong Kong for our longitudinal project. Written consent was obtained from children's parents before testing. Children were required to complete a systematic battery of cognitive- and literacy-related tests, some in Chinese and others in English. The tasks included in the analyses for the present study were part of this battery and are described below. All tests were administered by professional research assistants who were Cantonese-English bilinguals. They used Cantonese as the main language in which to instruct children to finish the tasks, while in some English tests, they presented the items in English.

It took approximately 2 hours for the entire testing session. Short breaks were arranged following every half-hour.

Measures

The below testing materials and the data set used in the present study are available at https://osf.io/6svbn/.

Nonverbal IQ

The Raven's Standard Progressive Matrices test (Raven, 1976) was used as a standardized test to measure children's nonverbal IQ. The test contained five sets with 12 items each. In this study, children who were 8.5 years old or older were asked to finish the full test, while children who were younger than 8.5 years old were asked to complete the short form including Sets A, B, and C. For each item, children were presented with a visual matrix with a missing part. They were asked to select the best matching piece to complete the visual matrix from among six to eight alternatives. Standard scores were calculated based on the local norm established by the former Hong Kong Education Department in 1986. The reliability within the current sample was .97.

Phonological awareness (Chinese)

This measure was adopted from a published study (Chung et al., 2008). It consisted of 41 items presented in ascending difficulty. The first 19 syllable-deletion items included 5 real and 14 pseudo three-syllable words. It required children to verbally repeat a three-syllable word first, and then the experimenter would ask them to delete one syllable and say the new phrase aloud. For example, children were required to say aloud /ning4/ /mung 4/ /caa4/ (檸檬茶, lemon tea) without /caa4/ (茶, tea). The correct answer would be /ning4/ /mung4/. The next 22 onset-deletion items consisted of 10 real and 12 pseudo one-syllable words. These items required children to repeat a one-syllable word first in its entirety and then without the first sound (consonant). For example, children were asked to say aloud /po4/ <婆> without the initial sound. The correct response would be /o4/ <哦>. Four practice items (two real and two pseudo words) were provided for the children before the formal testing. One point was marked for each correct answer. The reliability for the current sample was .98.

Morphological awareness (Chinese)

This measure was adopted from McBride-Chang et al. (2003) and Liu and McBride-Chang (2010). It included two practice items and 46 testing items. In each item, a scenario was presented orally to the children in one or two sentences. They were asked to construct a novel compound word from known morphemes to depict the object or concept based on that scenario. For example, one story was "早上既時候日頭出嚟,我地會叫佢做日出/yat6 ceot1/；咁夜晚既時候月亮出嚟,我哋會點叫佢啊? (The sun rising in the morning is called a sunrise. What would we call the moon that when it rises?)." The correct answer in this example is

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"月出 /yuet6 ceot1/ (moon rise)." One point was marked for each corrected answer. The reliability with the current sample was .97.

Morphological awareness (English)

This task was adapted from an English morphological awareness test used in previous studies (McBride-Chang et al., 2005a, 2005b). It consisted of 20 test items, presented in ascending order of difficulty. For the first 11 test items, children were required to create a new word based on a given compound word example (e.g., *A trap that is used to catch a mouse is called a mousetrap. What do we call a trap that is used to catch a bug*?) The correct answer is *bugtrap*. Children were presented with a picture and a sentence both orally and in written form in the next four items. They were also asked to present the answer both orally and in written form. These items were created referring to the *wugs* examples from Berko (1958). For example, *this boy knows how to RICK. What is he doing? He is* ____. The correct answer was *ricking*. One point was given to each correct response for these 15 items. For the remaining five test items, children were required to construct an English word that best represented the newly created object described in a scenario with no hints on the morphological structure provided. For example, *what do we call a house which is made of corn*? The model answer was *corn-house*. Children's response was rated on a 0- to 4-point scale based on the rationale given in the study of Liu and McBride-Chang (2010). The reliabilities with the current sample were .84.

Rapid automatized digit naming (Chinese and English)

The RAN task in Chinese, adjusted from the RAN tasks used in Denckla and Rudel (1976), was used to measure children's rapid naming performance (Ho et al., 2017). The task visually presents eight rows of five digits (e.g., 2, 3, 6, 8, and 9) to the children. These digits were arranged in different orders for each row. The children were asked to name the digits as quickly and accurately as possible. The RAN task in English was exactly the same as the Chinese one in test materials and procedures in addition to asking the children to name the digits in English. Two trials were conducted in each task, and the average time in seconds was marked. The correlations between the two trials were .93 (in both Chinese and English).

Vocabulary knowledge (Chinese and English)

A test battery was administered to measure children's breadth and depth of vocabulary knowledge in Chinese and English. This test battery was adopted from Tong et al. (2018) who developed them earlier by using a subsample from the current project. Items in the receptive and expressive vocabulary breadth tests were selected from the Peabody Picture Vocabulary Test – Third Edition (PPVT-III) (Dunn & Dunn, 1997), and those in the vocabulary knowledge depth test were chosen from a book listing words that showed frequently in local primary school textbooks (Zhuang, 2000). These items include noun, verb, quantifier, and adjective. The test items in each test were presented in an order of increasing difficulty. The original tests were adjusted by discarding some items that were too difficult or too easy for the children aged from 6 to 11 years old and including those items that demonstrated optimal discriminating power (Tong et al., 2018). This test battery has been used in previous studies with good overall internal consistency reliabilities for receptive and expressive vocabulary breadth, and vocabulary depth reported for Chinese and English (e.g., Tong et al., 2018; Wong et al., 2020). The internal consistency reliability of this overall test battery for the current sample was .88 for Chinese and .94 for English.

Receptive vocabulary breadth. The receptive vocabulary breadth tests included 10 items for Chinese and 15 items for English. In each item, the research assistant orally presented a word. The children were asked to point to one of four pictures that best represented the word they heard. One point was given for each correct answer. Reliabilities in the current sample were .44 (Chinese) and .83 (English), respectively.

Expressive vocabulary breadth. There were 12 and 15 items to measure Chinese and English expressive vocabulary breadth, respectively. Each item required the children to name the presented picture by using a single word that best described it. One point was marked for each correct response. Reliabilities in the current study were .68 (Chinese) and .87 (English).

Vocabulary knowledge depth. There were 26 Chinese and 15 English words used in the vocabulary definition tasks. Test procedure and scoring method were modeled after the vocabulary subscale of the Stanford–Binet Intelligence Scale (Thorndike et al.,1986). The children were required to explain the word they heard. Their answers were rated by two trained research assistants according to the rationales determined through pilot testing and a previous study (see McBride-Chang et al., 2008). Two points were marked if the answer completely describes the meaning of the word, one point was given if an answer just partially conveys the meaning of the word, and zero scores were marked for irrelevant answers. For example, in the Chinese version, when children were asked to define the word *廚房* (*kitchen*), a 2-point answer for this word would be "*a place for cooking*," whereas a 1-point answer would be "*a place at home*." In the English version, when children were asked to define the word *traveling*, a 2-point answer for this word would be "to *go somewhere else to see the sights*," whereas a 1-point answer would be "to *go by airplane*." A zero score was marked for other irrelevant answers in both versions. Reliabilities for the current sample were .86 (Chinese) and .87 (English).

Results

Table 1 shows the means, standard deviations (*SD*), and ranges of each measure. Generally, all measures had a good range. The distributional properties of all measures were appropriate, as demonstrated by the skewness values.

Table 2 shows the correlations among all variables. The partial correlations of most variables were significant with age and nonverbal IQ statistically controlled. Receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth were significantly associated with each other in both Chinese ($ps < .001$) and English ($ps < .001$). In addition, in Chinese, vocabulary knowledge depth was significantly associated with phonological awareness ($p < .001$),

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Table 1. Descriptive statistics of the variables

Measures (*Max*)	Mean	SD	Range	Skewness
Age (11.99)	7.86	1.25	6–12	.54
IQ (135)	108.72	14.30	65–135	−.03
Phonological awareness (41)	26.89	9.11	4–41	−.14
Chinese morphological awareness (46)	21.62	6.71	0–41	.03
Chinese RAN (-)	21.77	7.06	7.96–56.08	1.18
English morphological awareness (35)	15.48	6.36	0–32	−.19
English RAN (-)	33.12	12.68	8.66–81.11	1.13
Chinese receptive vocabulary breadth (10)	8.88	1.25	3–10	−1.23
Chinese expressive vocabulary breadth (12)	8.26	2.30	2–12	−.45
Chinese vocabulary knowledge depth (52)	15.68	8.00	0–39	.56
English receptive vocabulary breadth (15)	10.10	3.65	1–15	−.51
English expressive vocabulary breadth (15)	6.59	3.60	0–15	.31
English vocabulary knowledge depth (30)	7.74	5.97	0–27.5	.91

Note. $N = 481$. RAN = rapid automatized digit naming.

morphological awareness ($p < .001$), and RAN ($p = .007$); expressive vocabulary breadth was significantly correlated with morphological awareness ($p < .001$) and RAN ($p = .02$) but not with phonological awareness ($p = .17$); receptive vocabulary breadth was only associated significantly with morphological awareness ($p < .001$).

In English, the correlations of receptive vocabulary breadth with phonological awareness ($p < .001$), English morphological awareness ($p < .001$), and RAN ($p < .001$) were all significant. Expressive vocabulary breadth was also significantly correlated with phonological awareness ($p < .001$), English morphological awareness ($p < .001$), and RAN ($p < .001$). Similarly, vocabulary knowledge depth was also significantly associated with these three cognitive-linguistics skills ($ps < .001$).

Linear mixed model analyses: Explaining receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in L1 Chinese

A stepwise regression analysis with linear mixed model (LMM) method was used to examine the relative contributions of age, nonverbal IQ, phonological awareness, morphological awareness, and RAN for explaining variance in receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in L1 Chinese. The LMM analyses were conducted using the lmer program of the lme4 package in R 4.1.2 (R Core Team, 2020). The significance of the fixed effects was assessed using the lmerTest package. The LMM analysis allowed random effects to be considered simultaneously with fixed effects of interest. In the following models, the random effects of children's age on their performance in receptive and expressive vocabulary breadth or depth were considered.

Table 2. Partial correlations among the variables in Chinese and English beyond age and IQ

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Chinese phonological awareness	1										
2. Chinese morphological awareness	.34***	1									
3. English morphological awareness	.50***	.44***	1								
4. Chinese RAN	−.29***	−.16***	−.30***	1							
5. English RAN	−.32***	−.15**	−.35***	.55***	1						
6. Chinese receptive vocabulary breadth	.06	.22***	.15**	−.03	−.06	1					
7. Chinese expressive vocabulary breadth	.07	.23***	.26***	−.10*	.02	.33***	1				
8. Chinese vocabulary knowledge depth	.22***	.30***	.27***	−.12**	−.08	.19***	.27***	1			
9. English receptive vocabulary breadth	.43***	.07	.46***	−.17***	−.47***	.08	−.01	.09*	1		
10. English expressive vocabulary breadth	.48***	.16**	.55***	−.19***	−.49***	.04	.003	.13**	.74***	1	
11. English vocabulary knowledge depth	.48***	.16**	.52***	−.18***	−.46***	.05	−.03	.21***	.68***	.77***	1

Note. $N = 481$.
*$p < .05$.
**$p < .01$.
***$p < .001$.
RAN = rapid digit automatized naming.

Table 3. Linear mixed model estimates of fixed effects for receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in Chinese

	Receptive vocabulary breadth				Expressive vocabulary breadth				Vocabulary knowledge depth			
Fixed effects	Beta	***SE***	***z***	***p***	Beta	***SE***	***z***	***p***	Beta	***SE***	***z***	***p***
Age	.72	.34	5.96	<**.001**	.49	.13	3.90	<**.001**	.48	.09	5.52	<**.001**
IQ	.18	.12	2.87	**.004**	.16	.06	2.74	**.006**	−.01	.02	−.49	.622
Chinese phonological awareness	−.03	.06	−.48	.633	−.04	.06	−.66	.511	.05	.02	2.54	**.011**
Chinese morphological awareness	.40	.07	5.53	<**.001**	.27	.07	3.92	<**.001**	.08	.02	3.55	<**.001**
Chinese RAN	.02	.06	.34	.738	−.10	.06	−1.63	.103	−.02	.02	−1.13	.259
Chinese receptive vocabulary breadth	–	–	–	–	.29	.05	6.24	<**.001**	.07	.02	3.01	**.003**
Chinese expressive vocabulary breadth	–	–	–	–	–	–	–	–	.12	.03	5.21	<**.001**

Note. $N = 481$. RAN = rapid automatized digit naming.

Table 3 specifically shows the estimated fixed effects of different variables on different aspects of vocabulary knowledge in Chinese. In explaining receptive vocabulary knowledge breadth, only the main effects of age ($p < .001$), IQ ($p = .004$), and Chinese morphological awareness ($p < .001$) were significant. The main effects of phonological awareness and Chinese RAN on receptive vocabulary breadth were not significant ($ps \geq .633$). For expressive vocabulary breadth, the main effects of age ($p < .001$), IQ ($p = .006$), Chinese morphological awareness ($p < .001$), and receptive vocabulary breadth ($p < .001$) were all significant. However, the effects of phonological awareness and RAN were not significant ($ps > .103$). In explaining vocabulary knowledge depth, age ($p < .001$), phonological awareness ($p = .011$), Chinese morphological awareness ($p < .001$), receptive vocabulary breadth ($p = .003$), and expressive vocabulary breadth ($p < .001$) were all significant predictors. In contrast, the effects of IQ and Chinese RAN were not significant ($ps \geq .259$).

Linear mixed model analyses: Explaining receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in L2 English

Similar LMM analyses methods were used to examine the unique correlates of receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in L2 English. Table 4 specifically demonstrates the estimated fixed effects of different variables on different aspects of vocabulary knowledge

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Table 4. Linear mixed model estimates of fixed effects for receptive vocabulary breadth, expressive vocabulary breadth, and vocabulary knowledge depth in English

	Receptive vocabulary breadth				Expressive vocabulary breadth				Vocabulary knowledge depth			
Fixed effects	Beta	***SE***	***z***	***p***	Beta	***SE***	***z***	***p***	Beta	***SE***	***z***	***p***
Age	−.20	.10	−1.97	**.049**	−.08	.14	−.57	.571	.26	.09	3.03	**.002**
IQ	.11	.08	1.41	.157	.05	.08	.66	.509	−.01	.03	−.39	.694
Chinese phonological awareness	.43	.08	5.11	<**.001**	.26	.09	2.86	**.004**	.05	.03	1.57	.116
English morphological awareness	.49	.09	5.45	<**.001**	.64	.10	6.11	<**.001**	.13	.03	3.86	<**.001**
English RAN	−.59	.08	−7.64	<**.001**	−.46	.09	−4.95	<**.001**	−.11	.03	−3.35	<**.001**
English receptive vocabulary breadth	–	–	–	–	1.47	.10	14.93	<**.001**	.27	.04	6.69	<**.001**
English expressive vocabulary breadth	–	–	–	–	–	–	–	–	.29	.04	7.42	<**.001**
Age x English morphological awareness	–	–	–	–	.21	.09	2.23	**.021**	–	–	–	–
Age x English RAN	–	–	–	–	−.32	.10	−3.34	<**.001**	–	–	–	–

Note. $N = 481$. RAN = rapid automatized digit naming.

in English. In explaining receptive vocabulary knowledge breadth, only the main effect of IQ was not significant ($p = .157$). The main effects of age ($p = .049$), phonological awareness ($p < .001$), English morphological awareness ($p < .001$), and English RAN ($p < .001$) were all significant. For expressive vocabulary breadth, the main effects of phonological awareness ($p = .004$), English morphological awareness ($p < .001$), RAN ($p < .001$), and receptive vocabulary breadth ($p < .001$) were all significant. However, the effects of age and IQ were not significant (*ps* ≥ .509). The interaction between age and English morphological awareness ($p = .021$) and between age and English RAN ($p < .001$) were also significant. In explaining vocabulary knowledge depth, age ($p = .002$), English morphological awareness ($p < .001$), RAN ($p < .001$), receptive vocabulary breadth ($p < .001$), and expressive vocabulary breadth ($p < .001$) were all significant predictors. In contrast, the effects of IQ and phonological awareness were not significant (*ps* ≥ .116).

Discussion

The present study investigated the unique correlates of different aspects of vocabulary knowledge across L1 Chinese and L2 English in Hong Kong bilingual children. The results demonstrated some commonalities and differences in the nature of vocabulary knowledge across Chinese and English, two typologically distant languages. Several key findings emerged in the present study. First, phonological

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awareness was uniquely associated with English receptive and expressive vocabulary breadth, and with vocabulary knowledge depth in Chinese, but it was not uniquely associated with vocabulary breadth in Chinese nor vocabulary depth in English. Second, morphological awareness was universally associated with all three aspects of vocabulary knowledge in both Chinese and English. Third, RAN was consistently associated with all three aspects of vocabulary knowledge in English, but not in Chinese. Finally, across L1 Chinese and L2 English, receptive vocabulary breadth contributed to expressive vocabulary breadth beyond other cognitive-linguistic skills; both receptive and expressive vocabulary breadth contributed to vocabulary knowledge depth. These findings are discussed in more detail below.

Phonological awareness plays different roles in different aspects of vocabulary knowledge in L1 Chinese and L2 English

Phonological awareness was associated with Chinese and English vocabulary knowledge differently in the present study. It was significantly associated with English vocabulary knowledge breadth, consistent with findings from previous studies in Hong Kong children's L2 English (Liu et al., 2017; McBride-Chang et al., 2006; Yeung & Chan, 2013) and similarly to their English native-speaking counterparts (Sparks & Deacon, 2015). These results suggest that sensitivity to phonology is helpful in facilitating vocabulary breadth in English as an alphabetic language.

However, this was not the case in Chinese in the present study. The associations of phonological awareness with Chinese receptive or expressive vocabulary breadth were not significant after controlling for age, nonverbal IQ, morphological awareness, and RAN. This was in line with previous findings (e.g., Chen et al., 2009) on Chinese primary school children. Children's vocabulary breadth is typically indicated by their performance in the recognition or oral production of single-word vocabulary. As there are a large number of homophones present in Chinese as compared to English, phonological awareness may be relatively less important in promoting the breadth of receptive or expressive vocabulary in Chinese. However, importantly, phonological awareness was uniquely associated with Chinese vocabulary knowledge depth, similar to findings in previous studies of Chinese children (Hulme et al., 2019; McBride-Chang et al., 2008; Pan et al., 2011; Song et al., 2015). To some extent, these findings support the hypothesis that vocabulary knowledge depth is different from vocabulary knowledge breadth in Chinese. On the one hand, Chinese vocabulary depth may require more detailed lexical representations in phonology to fully understand the different aspects of a given word. On the other hand, phonological awareness is also likely to be important for orally producing a clear definition of the word. Previous research has suggested that the development of expressive vocabulary depth is related to the quality of lexicon representation, which is related to phonological skills (e.g., van Goch et al., 2019). However, one should note that such differential contributions of phonological awareness to different facets of vocabulary knowledge across languages in Hong Kong children could be a reflection of a slower phase in vocabulary acquisition of their L2 English as compared to their L1 Chinese ability or that it may be consequentially due to the presence of greater variability of vocabulary learning in L2 English in this group.

Morphological awareness is significantly associated with different aspects of vocabulary knowledge in L1 Chinese and L2 English

Our findings demonstrated that morphological awareness was uniquely associated with vocabulary breadth and depth in L1 Chinese and L2 English. These are consistent with previous findings in monolingual Chinese-speaking children and Hong Kong Chinese-English bilingual children (e.g., Chen et al., 2009; Liu & McBride-Chang, 2010; McBride-Chang et al., 2008; Song et al., 2015). Similar findings on the importance of morphological awareness in English vocabulary knowledge were also reported in Spanish-speaking children learning English as a foreign language (Ramirez et al., 2013) and monolingual English-speaking children (e.g., McBride-Chang et al., 2005b; Sparks & Deacon, 2015). However, these studies have tended to have only measured one or two aspects of vocabulary knowledge. Our findings, with relatively comprehensive measures of vocabulary knowledge, highlighted the consistent importance of morphological awareness across all three aspects of L1 Chinese and L2 English vocabulary knowledge.

Morphological awareness facilitates vocabulary breadth across Chinese and English. Children vary in their acquisition of morphemes and morphological structures in a given language, resulting in different performances in receptive and expressive vocabulary breadth in that language (Kuo & Anderson, 2006). Previous studies have repeatedly emphasized the importance of morphological awareness across both Chinese and English (e.g., McBride-Chang et al., 2006; Sparks & Deacon, 2015). Children with better morphological awareness may be more efficient in expanding vocabulary breadth with their abilities to infer the meanings of new vocabulary words. For example, children with well-developed morphological awareness may be more able to extract the meanings of novel words such as *sunny*, *similarity*, and *methodological* by connecting their meanings with those words they have already acquired previously, such as *sun*, *similar*, and *method*, thereby broadening their vocabulary breadth. This is similar in Chinese since most Chinese words share the same morpheme (e.g., 花 (*flower*) and 工 (*job*)) and morphological compounding structures (e.g., 菊花 (*Chrysanthemum*), 鲜花 (*fresh flower*), and玫瑰花 (*rose*); 工人 (*worker*), 工作 (*job*), and 工位 (*station*)).

Morphological awareness also promotes the development of vocabulary knowledge depth across languages. Knowing more morphemes and how they could be legally combined helps a learner to understand various aspects of a given word and their applications across contexts. For example, when encountering the novel word *bedroom*, children with better morphological awareness may be able to understand both the morphemes of *bed* and *room* separately; this knowledge can facilitate learners to fully understand this word and to use it in an appropriate context. In addition, children may know that the word *harness* is not processed in the same way as the word *sadness*, because only the latter one can be divided into two morphemes. Morphological awareness also helps to discriminate and provide the exact definitions of vocabulary words that share the same morphemes but with different morphological structures such as *cake pan* and *pancake* in English, and 奬金 (*bonus*) and 金奖 (*gold award*) in Chinese. Overall, across Chinese and English, morphological awareness appears universally to facilitate the full acquisition of a word's meanings and usage, especially those that are morphological complex or have many homophones or homographs, and thus facilitate expressive vocabulary depth.

RAN plays different roles in Chinese and English vocabulary knowledge

RAN was found to be less strongly associated with vocabulary knowledge in Chinese than in English. RAN was not significantly associated with receptive vocabulary in Chinese even in the simple correlation matrix. Its associations with Chinese expressive vocabulary breadth and depth were small. Further, it no longer explained any aspect of Chinese vocabulary knowledge when other variables were statistically controlled in the LMMs. Thus, RAN, which tends to involve the speeded retrieval of phonological representation in long-term memory, does not appear to be among the dominant cognitive-linguistic skills that facilitate the acquisition of vocabulary breadth or depth in Chinese. This is in line with previous findings in Chinese primary school children (Chen et al., 2009). In contrast, English RAN was consistently and significantly correlated with all English vocabulary measures. This pattern was clear and consistent. English RAN may serve as a broad measure of relative automatic access to the L2 English lexicon overall. It would be especially important in future research to test this association in L1 and L2 speakers across languages. It is not clear whether this finding is related more to the phonological distinctness of various English words relative to Chinese words or, rather, whether RAN's unique association with vocabulary knowledge in the present study for English only reflects greater variability in automaticity of English learning in L2 learners.

Another notable finding in the present study is that the interactions between age and English morphological awareness and between age and RAN were significant in explaining English expressive vocabulary breadth. This finding implies that the facilitating effects of morphological awareness and RAN on expressive vocabulary breadth in L2 English may have increased from younger to older Hong Kong children. Similar interaction effects were not found in other models in explaining English receptive vocabulary breath and expressive vocabulary depth, or different aspects of Chinese vocabulary knowledge. This may be because Hong Kong children's L2 English skills (especially in terms of morphological awareness, RAN, and expressive vocabulary knowledge) develop at a relatively slow pace as compared to their L1 Chinese ability. In addition, learning most English words at the level of receptive mastery is easier than enhancing the knowledge in productive mastery (Schmitt, 2019). Therefore, the current sample, aged from 6 to 12 years, may be at a critical period in developing their morphological awareness, RAN, and expressive vocabulary breadth in English. With increasing learning experiences from younger to older children, children's morphological awareness and RAN are gradually improved, contributing more and more to their expressive vocabulary depth. In contrast, phonological awareness may play a consistently important role in expressive vocabulary breadth across ages. A similar developmental trajectory was not found in the model of expressive vocabulary breadth. This is likely because children in the sample were still at the very beginning developmental stage of English expressive vocabulary depth. Compared to younger children, older children did not perform significantly better in integrating newly acquired morphological knowledge and quicker RAN skills into enhancing their expressive vocabulary depth in L2 English. Future studies, preferably longitudinal, should explore further the developmental changes of different cognitive-linguistic skills vis-a-vis different aspects of vocabulary knowledge in Hong Kong children's L1 Chinese and L2 English.

Vocabulary knowledge breadth is important for vocabulary knowledge depth across languages

The other finding of interest was the fact that vocabulary knowledge breadth was uniquely predictive of vocabulary knowledge depth across L1 Chinese and L2 English. Perhaps children who have a larger vocabulary size also learn more oral and written words via linkages between different lexical items and possibly develop more extensive lexical networks to facilitate their vocabulary depth (Li & Kirby, 2015). This is similar for vocabulary learning in different languages. For example, when required to provide definitions of the word *cat*, children with a smaller vocabulary size may describe it simply as *an animal*; however, those who have a larger vocabulary size may provide more detailed and precise definitions of it. The definition can be that *a cat is an animal that has a tail but is distinct from a dog or a tiger; it is as meek as a lamb and can be kept as a pet.* Children who know more words will highlight the relations among words in the same category such as *cat*, *dog*, and *tiger*, or the words sharing the same morpheme (e.g., *graph*, *photograph*, and *graphic* in English, or 中國 (*China*), 美國 (*American*), and 國家 (*country*), in Chinese). Therefore, vocabulary breadth can facilitate vocabulary depth in either Chinese or English.

In addition, in the present study, expressive vocabulary breadth was more strongly associated with vocabulary depth than receptive vocabulary breadth in both Chinese and English, probably because the expressive measures reflect deeper and more specific lexical representations than the receptive ones. Moreover, repetitive vocabulary breadth consistently played a unique role in expressive vocabulary breadth in Chinese and English. These results support the notion that children's vocabulary knowledge may develop from receptive to expressive mastery (Schmitt, 2019). Overall, these findings highlight the universal importance of vocabulary breadth for vocabulary depth and the foundational role of receptive vocabulary knowledge in expressive vocabulary knowledge across languages. To some extent, these association patterns among different aspects of vocabulary knowledge may reflect children's similar vocabulary learning practices in different languages. They are likely to be found in children learning any language. However, it is also possible that there are some unique features of Cantonese and English speaking, as well as differences in learning to speak in L1 vs. L2. Future research on vocabulary development beyond the Chinese-English bilingual context of the present study can help to clarify these issues.

Limitations and future directions

An important limitation of the present study was that this was a correlational and concurrent one. The findings did not allow us to make any causal conclusions. Future studies should examine such associations longitudinally. Although the current study has suggested a unique role of age in the acquisition of vocabulary knowledge, longitudinal studies across different time points on the same group of children would reveal important information about the developmental trajectories of L1 and L2 vocabulary knowledge improvement with more stringent control. A longitudinal design would also allow an exploration of the potential bidirectional relations among different aspects of vocabulary knowledge and various cognitive-linguistic skills, as proposed in previous studies (e.g., McBride-Chang et al., 2008; Sparks & Deacon, 2015). Furthermore, skills of phonological awareness in the present study were only tested in Chinese but not in English. Despite that, due to the potential transfer of phonological skills, our current result showed that English vocabulary knowledge correlated significantly with L1 Chinese phonological skills beyond age and IQ. Previous research has, with evidence, referred to the potential generalizability of L1 phonological skills in explaining both L1 and L2 literacy learning in Hong Kong bilingual children (e.g., McBride-Chang & Ho, 2005). In other studies, too, language performance in L1 and L2 was approximately equally explained by phonological processing in the native language (Gottardo et al., 2001). Hence, there may be little to no additional benefit in measuring L2 phonological skills, at least for most aspects of prediction (an exception is that "invented spelling" in English—arguably tapping phoneme knowledge in English may predict some additional variance in word reading in English for Hong Kong young children, e.g., McBride-Chang & Ho, 2005)). We included only Chinese phonological awareness in the present study for practical reasons as well since we had limited testing time. In addition, the receptive vocabulary measure in Chinese had relatively low reliability. We have observed that forced-choice measures often have lower reliabilities as compared to measures where the answer must be produced by the child. Moreover, the mean of this measure was almost 9 out of 10 possible. Thus, the receptive vocabulary measure in the children's native language was likely a bit too easy for the children at this level. Perhaps better receptive vocabulary measures could be created in future work.

Conclusion

Despite the limitations mentioned above, the present study has expanded our understanding of the nature of L1 Chinese and L2 English vocabulary knowledge in Hong Kong bilingual children. The results suggest that different aspects of vocabulary knowledge are intercorrelated but also distinct. Collectively, our findings also highlight the importance of morphological awareness for vocabulary building in both L1 and L2, the particular utility of phonological awareness for L1 vocabulary depth and L2 vocabulary breadth, and the apparently unique but important role of L2 RAN for vocabulary variability. All of these findings have implications for early testing of language learning and may suggest potential avenues for effective training to promote optimal vocabulary acquisition. Theoretically, we have also demonstrated how vocabulary depth might potentially build upon vocabulary breadth in both L1 Chinese and L2 English. Perhaps educators may consider teaching with the goal of building good vocabulary breadth in children before focusing on vocabulary depth. Research in Chinese and English in the same participants contributes to an ultimate understanding of universalities and specificities in learning across different languages.

Replication Package. Replication data and materials for this article can be found at https://osf.io/6svbn/.

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