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Exploring the reading–writing relationship in young Chinese language learners' sentence writing

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Abstract This study explored the concurrent and longitudinal relationships between reading and writing in young Chinese-as-a-second-language (CSL) learners' sentence writing, using structural equation modeling. The participants comprised 126 Hong Kong senior primary ethnic minority students, whose literacy skills were assessed at two time points over the course of a year. In grade 5 (Time-1), they were assessed with Chinese character reading and reading comprehension measures to evaluate their reading ability. In grade 6 (Time-2), their sentence reading, sentence writing, and literacy component skills of Chinese character writing fluency and written syntactic skills were assessed. The results demonstrated that students' reading and writing performances were substantially related both concurrently and longitudinally. Furthermore, (1) at Time-2, the component skills accounted for substantial portions of variance in sentence reading and writing skills, along with the relationship between them, while (2) Time-1 reading ability predicted Time-2 component skills and, through the mediation thereof, indirectly predicted sentence writing. Thus, in light of the linguistic characteristics of the Chinese language, literacy component skills are crucial component processes that connect reading and writing in CSL learners' sentence writing.

Keywords Chinese-as-a-second-language writing · Reading–writing relationship · Chinese character writing fluency · Written syntactic skill

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Introduction

To date, research concerning Chinese-as-a-second-language (CSL) literacy acquisition has primarily focused on Chinese character learning by adult learners (Guan, Perfetti, & Meng, 2015; Xu, Chang, & Perfetti, 2014; see also Shen, 2013), with comparatively few studies investigating CSL learners' reading and writing development beyond the beginning stage, particularly for young learners (Leong, Tse, Loh, & Ki, 2011; Wong, 2017a, b, c). This longitudinal study investigates the relationship between reading and writing (henceforth, the reading–writing relationship) in young Hong Kong ethnic minority students'[1] Chinese sentence writing, to illuminate the course of CSL literacy development. The reading–writing relationship has, to date, been supported by a sizable body of research, largely in relation to alphabetic languages. This research identified some shared linguistic knowledge and component skills at and across different linguistic levels (Berninger, Abbott, Abbott, Graham, & Richards, 2002; Fitzgerald & Shanahan, 2000; Kent & Wanzek, 2016). Among a range of linguistic processes, transcription and syntactic skills have been recognized as critical correlates to both writing (García, Crespo, & Bermudex, 2016; Kim & Schatschneider, 2017) and reading (Brimo, Apel, & Fountain, 2017; Graham & Hebert, 2011). Due to the characteristics of the Chinese language, transcription and syntactic skills have been found to play an even more crucial role in Chinese children's literacy development (Chan, Ho, Tsang, Lee, & Chung, 2006; Chik et al., 2012; Tan et al., 2005; Yeung, Ho, Chan, & Chung, 2013a, b, 2017). The Chinese writing system is complex and learners have to acquire good orthographic representations of Chinese characters for fluent reading and writing. Moreover, Chinese is non-inflectional and thus there is a heavy demand on word-order and other word-related knowledge to ensure syntactic understanding and sentence construction. These unique linguistic characteristics of Chinese have long been considered sources of difficulty for CSL learners (Everson, 1998; Li, 2003; Lü, 1980). Evaluating the concurrent and longitudinal relationships between reading and writing and their component skills in young CSL learners, this study will argue that: (1) character-writing fluency and written syntactic skills are critical for both CSL reading and writing, and (2) these component skills mediate learners' reading–writing relationship at the beginning writing stage.

The reading–writing relationship and its component skills

Previous researchers have explored the reading–writing relationship by evaluating shared linguistic knowledge and cognitive processes between the two literacy competences at and across different language levels (Fitzgerald & Shanahan, 2000; Kent & Wanzek, 2016; Shanahan, 2016). Specifically, correlations have been found between reading and writing at the sub-word (Goodrich, Farrington, & Lonigan, 2016), word (Pinto, Bigozzi, Tarchi, Gamannossi, & Canneti, 2015), sentence, and

[1] During their Chinese lessons, these ethnic minority students are taught the Cantonese and Traditional Chinese scripts that are the spoken and written forms of the Chinese language used in Hong Kong and different from those used in Mainland China (i.e., the Putonghua and simplified Chinese script).

text levels (Ahmed, Wagner, & Lopez, 2014; Lee & Schallert, 2016). Berninger et al. (2002) found that spelling and reading comprehension reciprocally influence each other across linguistic levels (i.e., word and text levels). Reviewing studies on the relationship between reading and writing, Fitzgerald and Shanahan (2000) and Shanahan (2016) found that they share some linguistic knowledge and skills in common, such as graphophonics, syntax, and text format. This study focuses on transcription and syntactic skills that previous research has found to be influential in both reading and writing.

In their meta-analysis of the component skills of writing, Kent and Wanzek (2016) identified transcription skills, including handwriting fluency and spelling, as the strongest predictors of writing performance. Their findings supported the view (Berninger et al., 2002; Juel, 1988; Juel, Griffith, & Gough, 1986) that proficiency in basic transcription skills frees up the cognitive load necessary for higher-order writing processes, and hence facilitates performance. This has been corroborated by recent studies (García et al., 2016; Harrison et al., 2016; Kim & Schatschneider, 2017) that children's transcription skills predict their writing performance. However, researchers have also found that transcription skills contribute to reading. In their meta-analysis, Graham and Hebert (2011) found that instruction on transcription skills that were hypothesized to consolidate letter-sound connections (Ehri, 2000), enhanced word reading and reading fluency. Pinto et al. (2015) found a reciprocal strengthening effect between word writing and word reading skills in Italian children, while Berninger et al. (2002) found that children's spelling skills are related to their reading comprehension skill beyond the word level.

Syntactic skills comprise knowledge of and the ability to use the grammatical structures of a language (Brimo et al., 2017; Gombert, 1992) and are requisites, among other cognitive and linguistic processes, in models demonstrating how readers construct meaning from text (Kintsch, 1998) and writers generate text from thoughts (Berninger & Swanson, 1994). Empirical studies indicate that syntactic knowledge and awareness are related to reading comprehension (Brimo et al., 2017; Cain, 2007; Cutting & Scarborough, 2006), and instruction in sentence construction skills improves reading fluency (Graham & Hebert, 2011). Moreover, grammatical knowledge plays a role in children's writing performance (Kim et al., 2011; Kim & Schatschneider, 2017), while interventions in sentence construction skills improve the sentence writing of students with learning difficulties (Datchuk & Kubina, 2013). It has also been found that L2 learners, more than their L1 counterparts, rely excessively on their L2 linguistic knowledge, including syntactic knowledge, and on their access speed to this knowledge while writing (Harrison et al., 2016; Schoonen, Gelderen, & Glopper, 2003).

Chinese reading and writing development: role of transcription and syntactic skills

Researchers have found that both transcription and syntactic skills play a critical role in Chinese reading and writing (McBride & Wang, 2015; Tong & McBride, 2017; Yeung et al., 2013a, b, 2017). Chinese is a morphosyllabic language (DeFrancis, 2002), with nearly 96% of characters composed of more than one

radical, and each character formed from clusters of strokes (Su, 2001). The majority of compound characters are ideo-phonetic, consisting of, in various positional configurations, a semantic radical that provides meaning cues and a phonetic radical that provides pronunciation cues (Kang, 1993; Li & Kang, 1993). For example, the character 媽 (*maa1*, mother)[2] is of left–right structure and consists of the radicals 女 (*neoi5*, female) and 馬 (*maa5*, horse), while 花 (*faa1*, flower) is of top-down structure and consists of the radicals ⺾ (indicating a plant-related meaning) and 化 (*faa3*, to melt). This sophisticated orthography influences Chinese children's literacy acquisition and development immensely.

Researchers have found that, due to its complex structural properties, Chinese word reading and writing are related and handwriting practices that strengthen visual-orthographic representations of characters enhance the acquisition of Chinese literacy in both native-speaking children (Chan et al., 2006; Tan et al., 2005) and Chinese L2 learners (Guan, Liu, Chan, Ye, & Perfetti, 2011; Guan et al., 2015). In particular, McBride et al. found that Chinese children's visual-orthographic copying skill of non-Chinese scripts (e.g., Korean) and Chinese characters are predictive of their Chinese word reading and writing (McBride-Chang, Chung, & Tong, 2011; Wang, McBride, & Chan, 2014; Wang, Yin, & McBride, 2015; see also McBride & Wang, 2015 for a summary of studies). In an intervention study, Wang and McBride (2017) found that Chinese kindergarteners who received a program combining copying and knowledge of compound characters' composition attained higher word reading and writing skills. Similarly, both Guan et al. (2011) and Guan et al. (2015) found that, with repeated character handwriting practice, adult CSL learners acquired better orthographic representations of characters that facilitated their Chinese word learning. Beyond word level, and consistent with the findings that transcription skills facilitate writing performance in alphabetic languages (Berninger et al., 2002), Guan, Ye, Wagner, and Meng (2013) identified handwriting fluency as a significant constituent of Chinese written composition performance among a group of Mandarin-speaking children, while Yeung et al. (2013a, b, 2017) found that, for Hong Kong's Cantonese-speaking children, handwriting and spelling skills were significant predictors of Chinese text writing ability throughout elementary grades.

Regarding syntactic skills, their importance is related to the fact that Chinese is non-inflectional and thus does not express grammatical relationships and meanings using morphological transformation. Instead, this information is conveyed by word order and the use of function words, such as the auxiliaries 的 (*dik1*, used as an adjective or possessive marker), 了 (*liu5*, used to indicate the completion of an action), and the preposition 把 (*baa2*, used to bring an object before its corresponding transitive verb) (Lü, 1980). For example, the sentence 我/打破了/媽媽的花瓶 (*ngo5/daa2po3liu5/maa5maa5dik1faa1ping4*) meaning 'I broke my mother's vase' (in which slashes indicate constituents) is of a typical subject-verb-object (SVO) structure, consisting of the subject 我 (ngo5, I), verb phrase 打破了

[2] Chinese characters in their traditional script forms are displayed alongside their Cantonese pronunciation and English glossary in parentheses. *Lexical Items with English Explanations for Fundamental Chinese Learning in Hong Kong Schools* (Chinese Language Education Section of the Hong Kong Education Bureau, 2008) was consulted regarding their Romanization and the translated English meanings.

(*daa2po3liu5*, have broken), and noun phrase 媽媽的花瓶 (*maa5maa5dik1faa1ping4*, mother's vase) as the object. The verb 打破 (/daa2po3/, 'to break') is combined with 了 to indicate that the action was completed in the past, while 媽媽 (/maa1maa1/, 'mother') is combined with 的 in the noun phrase to indicate its function as a possessive adjective for the head noun 花瓶 (/faa1ping4/, 'vase'). The sentence can be restructured as 我/把/媽媽的花瓶/打破了 (*ngo5*/*baa2*/*maa5maa5dik1faa1ping4*/*daa2po3liu5*) with the preposition 把 taking the object 媽媽的花瓶 before the verb phrase 打破了. Thus, Chinese learners require excellent syntactic skills, comprising word-related (including word-compounding) and sentence structure (word-order) knowledge, for syntactic understanding and sentence construction; skills that are considered difficult for CSL learners (Li, 2003).

A considerable amount of research with Hong Kong Cantonese-speaking students has found that syntactic skill plays a significant role in their reading comprehension skills (Chik et al., 2012; Chung, Ho, Chan, Tsang, & Lee, 2013; Siu, Ho, Chan, & Chung, 2016; Tong, Tong, Shu, Chan, & McBride-Chang, 2014; Yeung et al., 2011; Yeung, Ho, Chan, Chung, & Wong, 2013c). Specifically, the studies listed above have found both word-compounding and word-order knowledge to be predictive of students' reading comprehension throughout elementary grades (Chik et al., 2012; Siu et al., 2016; Tong et al., 2014; Yeung et al., 2013c), and junior high students with dyslexia (Chung et al., 2013). Tong and McBride (2017) further observed a reciprocal relationship between syntactic awareness and reading comprehension in senior elementary grade students. In their study in Hong Kong's elementary schools, Ho et al. (2012) identified syntactic skill teaching as a core component for effective reading instruction. In relation to writing, Yeung et al. (2013a, b, 2017) found that syntactic skills, assessed solely by a word order measure, were strong contributors to the text-writing development of elementary Chinese students from grades 1 to 4. Specifying a model of Chinese writing development throughout the elementary grade levels, these studies found that syntactic and transcription skills played an important role in Chinese text composition.

Guan, Ye, Wagner, Meng, and Leong (2014) and Tong and McBride (2016) explored the reading–writing relationship with regard to the influence of various component skills, including syntactic skills. While Guan et al. (2014) found that Chinese children's syntactic processing, along with working memory and morphological awareness, contributed uniquely to their written composition, Tong and McBride's (2016) longitudinal research further observed a reciprocal relationship between syntactic awareness and writing composition. Both studies found a strong reading–writing relationship, accounting for the contribution of syntactic skills to text composition; in other words, reading comprehension mediates the relationship between syntactic skills and writing. However, while these studies evaluated oral syntactic skills and their relationship with reading and writing, this study is concerned with CSL learners' written syntactic skills in using related written word and grammatical structure knowledge for sentence comprehension and composition. To this end, written word order measures, similar to those used in Yeung et al. (2013a, b, 2017) but without the provision of oral aid, were adopted in this study to assess the component skills. Analyses were then conducted to evaluate if the reading–writing relationship would account for the influence of literacy component skills.

Research questions

This study aimed to investigate the nature of the reading–writing relationship in CSL learners' writing, considering the roles played by character-writing fluency and written syntactic skill, at the sentence level. Given the findings of previous studies (described above) in relation to Chinese children (Guan et al., 2014; Tong & McBride, 2016), it was considered that a statistically significant reading–writing relationship would be observed. However, the focus here is on evaluating the predictive power of character-writing fluency and written syntactic skills on both reading and writing ability, as well as their influence on the reading–writing relationship. This study makes no claim regarding the directionality of this relationship but conducts the evaluation assuming that reading influences writing. For these investigations, two models were evaluated that influence the students' sentence writing, respectively, by concurrent sentence reading comprehension and prior reading ability (comprising Chinese character and text reading). Accordingly, these models were used to answer the following research questions:

1. How much variance in CSL learners' sentence reading and sentence writing skills can be accounted for by character-writing fluency and written syntactic skill? How does the influence of these component skills affect the relationship between sentence reading and writing? Finally, is the influence on writing mediated by sentence reading?
2. How much variance in CSL learners' character-writing fluency and written syntactic skill can be accounted for by prior reading comprehension? Do these two literacy component skills mediate the predictive effects of prior reading ability on sentence writing in a longitudinal model?

The mediating effect was evaluated according to the criteria established by Baron and Kenny (1986), and also used by Guan et al. (2014), whereby the function of a mediating variable is evaluated in relation to its strength in accounting for the relationship between an independent variable and its dependent variable with the following conditions: (1) it is predicted by the independent variable; (2) it in turn predicts the dependent variable; and (3) the direct influence from the independent to the dependent variable is substantially attenuated to not significant when the first two conditions are present.

Methods

Participants

The participants comprised 126 senior primary ethnic minority students (63 boys; 63 girls) in Hong Kong. The majority (95.24%) were South Asians (India, Pakistan, and Nepal), although most (78.57%) had been born in Hong Kong. They spoke their respective native languages at home and learned both Chinese and English as

second languages at school. At the time of the study, they were attending six government-subsidized schools wherein a substantial proportion of students were from ethnic minority backgrounds with low to moderate socioeconomic status. The limited linguistic, cultural, and economic resources of these students' families curtailed parental support and involvement in their education particularly Chinese learning (Tsung & Gao, 2012). Similar to schools in Hong Kong with a comparable ethnic minority student population (Shum, Gao, & Ki, 2016; Tsung, Zhang, & Cruickshank, 2010), English was the medium of instruction, except in Chinese classes, as students were more proficient in English; Chinese was taught as a core subject (at least 20% of class time) in Cantonese and Traditional Chinese scripts (the oral and written forms, respectively, of the Chinese language prevalent in Hong Kong). Due to the students' relative weakness in Chinese, all six schools developed school-based, customized Chinese curricula to meet their requirements with due emphasis placed on Chinese literacy acquisition, including character reading and writing, written vocabulary, and syntactic structure. As a comparatively simple writing task, sentence writing was considered an effective means to develop writing skills. At the time of the study, the students averaged 12.24 years old ($SD = .64$), had been living in Hong Kong for 11.39 years ($SD = 2.53$), and had been studying in their respective primary schools for 5.57 years ($SD = .98$).

Data collection and research procedures

Data were collected by the research team (comprising Postgraduate Diploma in Education Program students), with the assistance of respective school teachers, at two time points. At Time-1, 142 grade 5 students participated; they were assessed for reading comprehension skills, including Chinese character reading and Chinese reading comprehension tests, at both the sentence and passage levels. At Time-2, when they had entered Grade 6, 126 of the students were successfully assessed again, using a sentence reading comprehension test, character-writing fluency test, word order tests, and sentence picture writing tests. The tests were conducted from June to July, and took approximately 2 h at each school; group tests were hosted by the researcher, whereas the individual character reading test was conducted by research team members and monitored by the researcher. These tests served as either manifested variables or indicators for the latent variables representing five constructs: reading ability at Time-1 and sentence reading, sentence writing, character-writing fluency, and written syntactic skill at Time-2, as will be shown below.

Measures

All measures except for Chinese character reading and writing were adapted from a standardized test, the Hong Kong Attainment Test (HKAT), of grade-1 and grade-2 levels (Educational Research Section of the Hong Kong Education Department, 1989a, b, 1999a, b). The HKAT was used to assess students' Chinese language abilities from primary to junior secondary school. Due to the lower Chinese competence of the participating CSL learners compared to native Chinese-speaking

students, the HKATs used in this study were of a lower grade level than the students' grade at the time of the test.

Reading ability and sentence reading

A character reading test and reading comprehension test were used to assess Time-1 reading ability. The character reading test was developed for this study and comprised 100 items (50 single characters and 25 two-character words). Chinese characters suitable for junior primary level were selected after referring to Pan and Kang's (2003) study and the basic Chinese word list prepared for Hong Kong primary students by the local education department (Chinese Language Education Section of the Hong Kong Education Bureau, 2008). Students were required to read aloud, one by one, the characters indicated by a test administrator. One point was awarded for every correct pronunciation. The reading comprehension test was adapted from the 1989 HKAT and comprised items assessing students' understanding of literacy materials at either (1) the sentence level, by requiring them to fill in characters or words to complete sentences (in multiple-choice or cloze format), or (2) the passage level, by requiring them to answer questions concerning a short passage (in a multiple-choice or short-question format). The test comprised 31 items with a maximum score of 70.

At Time-2, the students' sentence reading comprehension was assessed using tests at the sentence level. The two tests comprised items adopted from the 1989 and 1990 HKATs, respectively. Sentence reading test 1 comprised 24 items (maximum score 48), while test 2 comprised 19 items (maximum score 38).

Chinese character-writing fluency

The character-writing fluency test was conducted at Time-2. The writing fluency test used in this study was developed with reference to Harrison et al. (2016), Kim et al. (2011), and Tan et al. (2005). Students were instructed to copy as many of the 51 presented Chinese characters as possible in 1 min. The test was developed following a pilot study with 20 students to evaluate the appropriate number of items and test reliability. On average, participants in the pilot test wrote 18 characters within the time limit; since the number of items in this test (51) far exceeded the student norm, the ceiling effect was avoided. The test–retest reliability, which was also evaluated during the pilot study, was good (Cronbach's $\alpha = .95$; see Table 1). Given that the test was novel for the students, practice items were first presented. Instructions were provided to clarify that: (1) it was not a speed test and students should write clearly and at their normal pace; (2) incorrect, unclear, or incomplete characters would not be scored.

Written syntactic skill

At Time-2, the students' written syntactic skill was assessed using two word-order tests. These were similar to those used by Yeung et al. (2013a, b), but the test items were not read out to students. This kind of written word order item is widely used in

Table 1 Alpha values and descriptive statistics for all measures used in the study (N = 126)

Measures	Alpha	Range	Mean	SD
Time 1				
Character reading	.98	1–99	32.79	25.00
Reading comprehension	.85	4–68	31.51	14.51
Time 2				
Sentence reading 1	.85	0–46	19.22	10.22
Sentence reading 2	.76	2–36	15.43	7.61
Character writing fluency	.95[a]	7–39	21.00	5.45
Word order 1	.65	0–6	3.10	2.04
Word order 2	.76	0–8	4.06	2.70
Picture writing 1	.84	0–19.67	10.93	5.59
Picture writing 2	.85	0–19.33	9.86	5.26

[a]Test–retest reliability evaluated during pilot study

Hong Kong primary schools for Chinese language tests, and all participating students were thus accustomed to the test format. Both tests 1 and 2 used items adopted from the 1989 and 1990 HKATs, respectively (test 1, three items, maximum score = 6; test 2, four items, maximum score = 8). For each item, the students were asked to combine four to five given words or phrases to create a proper sentence. They had to make use of both word-order and word-related knowledge, including function word knowledge, to complete the task. A sample item (Fig. 1) was provided below. Two marks were awarded per correct answer, and one mark for a partially correct answer in which at least the first two word segments had been ordered correctly.

Sentence writing

The students' sentence writing was assessed at Time-2 using two picture sentence-writing tests. Each test comprised two items with a maximum score of 20. Tests 1 and 2 comprised items adopted from the 1989 and 1990 HKATs, respectively. For each item, the students were presented with a picture and a target word and instructed to write sentence(s) using the target word, for example, 害怕 (*hoi6paa3*, frightened) to describe a picture of two children frightened by a mouse. The students were given 25 min to complete all four items. They were reminded of the task requirements and encouraged to describe the picture in detail with no restrictions on sentence length. The assessment criteria had two dimensions, both on a 5-point

(1) 勤勞地 (*kan4lou4dei6*, diligently; 地 is an auxiliary used to form an adverbial) / (2) 一群 (*jat1kwan4*, a swarm of) / (3) 花蜜 (*faa1mat6*, honey) / (4) 小蜜蜂 (*siu2mat6fung1*, little bee) / (5) 採 (*coi2*, gather)

The correct order is: (2) (4) (1) (5) (3)

Fig. 1 Sample item from the word-order test

scale: dimension (1) for correctness and accuracy in the use of the target word and sentence structure; dimension (2) for the elaboration of content for picture description. In the sample item illustrated above, for dimension (1), four to five marks were awarded for the correct use of the adjective "frightened" to describe the children, one to three mark(s) for the use of the adjective as a verb, and zero marks for its use to describe the mouse. The marking on dimension (1) was also affected by sentence structure. For dimension (2), higher marks were awarded for more detailed descriptions of the scene. As such, it was expected that sentence length, which in some way indicates the extent of elaborations given by students, would correlate with the marks awarded to a response, but that this relationship would be curtailed by the score ceiling. For each error in Chinese character-writing or punctuation, .1 mark was deducted but no further deduction was made beyond zero; the marking range for each item was from 0 to 10.

Three raters, who were first trained and engaged in pilot marking conferences, scored the writing tests. All were post-graduate students of a primary Chinese teacher certificate course and all had engaged in undergraduate Chinese-related study. Each rater marked all three papers and inter-rater reliability was then assessed using a two-way random, consistency, average-measures intra-class correlation (ICC) (Hallgren, 2012). A high degree of inter-rater agreement was found as the ICC was .88, with a 95% CI [.84, .92], $F\,(125, 250) = 8.60, p < .001$. The averages of the ratings were used for the analysis.

Analysis

First, confirmatory factor analysis was conducted to evaluate the measurement model of the four latent variables, namely Time-1 reading ability and Time-2 sentence reading, sentence writing, and written syntactic skill. The strengths of the reading–writing relationship were evaluated from the inter-factor correlations in the model and used as a baseline comparison for evaluations of the mediating effect in the subsequent analyses. Second, to address the research questions, two structural equation models of the reading–writing relationship, one concurrent and the other longitudinal, were constructed to investigate the nature of the reading–writing connection. In the first model with all Time-2 variables (specified with reference to Guan et al.'s (2014) model), the effects of character-writing fluency and written syntactic skill on sentence reading and sentence writing, as well as the effect of sentence reading on sentence writing, were specified. The model was also used to evaluate the mediating effect of sentence reading on the relationship between the component skills and sentence writing. In the second model, a longitudinal relationship between reading and writing was specified; the effect of Time-1 reading ability on Time-2 sentence writing was indicated, with the two component skills posited as mediators. Specifically, the effects of Time-1 reading ability on Time-2 component skills, and the mediating effects of the component skills on the longitudinal reading–writing relationship were evaluated. In addition to model Chi square (χ^2), the following approximate fit indexes, as recommended by Kline (2016), with the cutoff criteria as recommended by Hu and Bentler (1999), were used by this study: Comparative Fit Index (CFI) close to or greater than .95,

standardized root mean square residual (SRMR) close to or less than .08, and root mean square error of approximation (RMSEA) close to or less than .06.

Results

Descriptive statistics and correlations

The alpha values for internal consistency, descriptive statistics, and correlations of all measures are given in Tables 1 and 2. The measures were generally of high reliability, with alpha values of close to or over .70. All measures were correlated with statistically significant coefficients at $p < .05$ or less. Students' performances on the picture sentence-writing tests were further scrutinized to explore the relationship between the score (quality) and sentence length. As expected, they were positively related with a correlation coefficient at .61. The sentence lengths of responses were highly comparable across the four items, with means of 12.68 (*SD* 6.70), 11.75 (*SD* 5.18), 10.79 (*SD* 6.76), and 14.55 (*SD* 8.36) characters, respectively; in total, there were only 22 relatively lengthy sentences, those with the number of characters two *SD*s above the respective mean (4.36% of all responses).

Assessing the measurement model and inter-factor relationships

Confirmatory factor analysis (CFA) was conducted to evaluate the measurement model, with eight measures as indicators for four factors, and the inter-factor relationships. The model fit well with the data: $\chi^2(14) = 13.58$, $p = .48$, CFI = 1, SRMR = .02, RMSEA = .00, 90% CI [.00, .08], PCLOSE = .75. Table 3 presents the standardized factor loadings of the indicators to their respective factors, as well as the correlations among factors. All factor loadings were strong, with values

Table 2 Correlations among all measures in the study (N = 126)

Variables	1	2	3	4	5	6	7	8	9
1. CharRead	–								
2. ReadCom	.85**	–							
3. SenRead1	.83**	.82**	–						
4. SenRead2	.78**	.78**	.79**	–					
5. CharWrit	.32**	.36**	.33**	.26**	–				
6. WordOrd1	.63**	.68**	.66**	.61**	.21*	–			
7. WordOrd2	.67**	.72**	.69**	.61**	.20*	.76**	–		
8. PicWrit1	.52**	.59**	.56**	.45**	.36**	.58**	.63**	–	
9. PicWrit2	.59**	.61**	.56**	.50**	.29**	.58**	.65**	.82**	–

CharRead character reading, *ReadCom* reading comprehension, *SenRead1, 2* sentence reading 1 and 2, *CharWrit* character writing fluency, *WordOrd1, 2* word order 1 and 2, *PicWrit 1, 2* picture writing 1 and 2

**$p < .01$; *$p < .05$

Table 3 Standardized factor loading and inter-factor correlations from confirmatory factor analysis (N = 126)

Measure	Factor			
	T1 RC	T2 SR	T2 WS	T2 SW
Character reading	.91			
Reading comprehension	.93			
Sentence reading 1		.92		
Sentence reading 2		.86		
Word order 1			.84	
Word order 2			.90	
Picture writing 1				.89
Picture writing 2				.92
Inter-factor correlations				
T2 sentence reading	.98	–		
T2 written syntactic skill	.84	.83	–	
T2 sentence writing	.70	.65	.78	–

T1 Time 1, *T2* Time 2, *RC* reading comprehension, *SR* sentence reading, *WS* written syntactic skill, *SW* sentence writing

$^{**}p < .01$; $^{*}p < .05$

ranging from .84 to .93. Time-1 reading ability was highly related to sentence reading a year later (correlation value of .98). A substantial reading–writing connection was observed as the correlations between Time-2 sentence writing and Time-2 sentence reading (.65) and Time-1 reading ability (.70) were both considerable. Strong relationships were also observed between written syntactic skill and reading and writing, with correlation values ranging from .78 to .84. Subsequent structural equation modeling analyses, evaluating the concurrent and longitudinal reading–writing relationships to address the research questions were conducted with these four latent variables and the manifested variable of character-writing fluency.

Concurrent relationship between sentence writing and sentence reading comprehension

A structural model (Fig. 2) was specified with the Time-2 sentence reading and sentence writing being predicted by both character-writing fluency and written syntactic skill. The path from reading to writing was also specified, reflecting the assumption that writing depends on reading. The model fit well with the data: $\chi^2(9) = 6.66$, $p = .67$, CFI = 1, SRMR = .02, RMSEA = .00, 90% CI [.00, .080], PCLOSE = .84. The model also showed that the two component skills accounted for substantial variances in both sentence reading (70%) and writing (64%). The contributions of written syntactic skill to both sentence reading (β-value of .79) and writing (β-value of .81) were much more sizable than those of character-writing fluency (β-value to reading was .16 and to writing was .20). Moreover, the influence of sentence reading on sentence writing had been attenuated to nearly zero (with a statistically non-significant β-value of − .09) with the presence of the two component skills; sentence reading did not mediate the regression effects of these component skills to sentence writing.

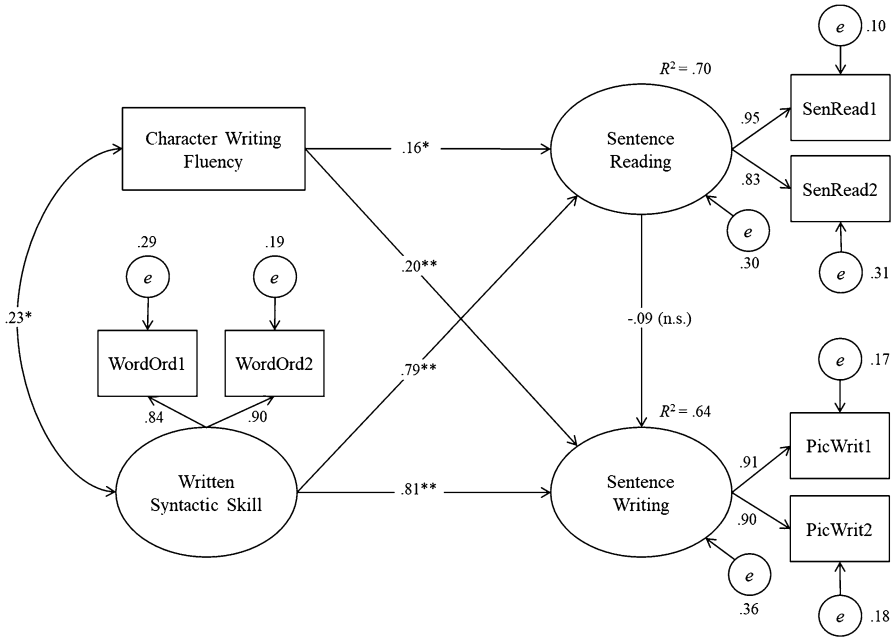

Fig. 2 Structural equation model of the effects of character writing fluency and written syntactic skill on sentence reading, sentence writing, and their relationship at Time 2. Note: *SenRead1, 2* sentence reading 1 and 2, *WordOrd1, 2* word order 1 and 2, *PicWrit 1, 2* picture writing 1 and 2, *e* error, $^{**}p < .01$; $^{*}p < .05$, *n.s.* not significant

Longitudinal relationship between sentence writing and reading ability

A structural model of the longitudinal reading–writing connection in sentence writing, with character-writing fluency and written syntactic skill as mediating variables was specified (Fig. 3). First, sentence writing was specified as influenced by the two componential processes of Chinese character-writing fluency and written syntactic skill. Second, all these literacy skills at Time-2 were specified as influenced by reading ability at Time-1. The model fit well with the data: $\chi^2(10) = 9.37$, $p = .50$, SRMR = .02, CFI = 1, RMSEA = .00, 90% CI [.00, .09], PCLOSE = .72. It also showed that substantial variances of character-writing fluency (13% as with a β-value at .36) and written syntactic skill (70% as with a β-value at .83) were predicted by Time-1 reading ability, while these two variables in tandem, with β-values of .16 and .71 respectively, accounted for 64% of variance in sentence writing. The two variables accounted for the entire relationship between reading and writing such that the β-value between the two was reduced to nearly zero (with a statistically non-significant β-value of .03). The results demonstrated that the two componential skills fully mediated the regression effect of Time-1 reading ability on Time-2 sentence writing: the indirect effect of Time-1 reading ability on sentence writing was predominantly through written syntactic skill (91%), as against character-writing fluency (9%).

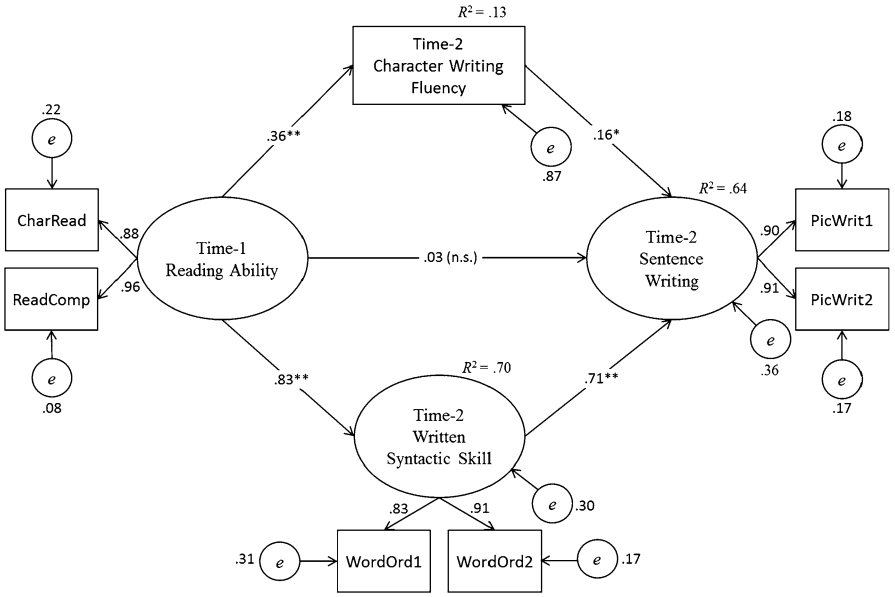

Fig. 3 Structural equation model of the longitudinal relationship between Time-1 reading ability on Time-2 sentence writing with Time-2 character writing fluency and written syntactic skill as mediators. Note: *CharRead* character reading, *ReadCom* reading comprehension, *WordOrd1, 2* word order 1 and 2, *PicWrit 1, 2* picture writing 1 and 2, *e* error, $^{**}p < .01$; $^{*}p < .05$, *n.s.* not significant

Discussion

This study explored the nature of the reading–writing relationship in young CSL learners' sentence writing. As expected, a strong relationship was observed between reading and writing, as the learners' sentence writing was related to both their concurrent sentence reading and prior reading ability a year previously (inter-factor correlations of .65 and .70 respectively). Further investigations were conducted considering the learners' character-writing fluency and written syntactic skill that were found to contribute to sentence reading and sentence writing respectively; moreover, both the concurrent and longitudinal models showed that they were mediators of the reading–writing relationship in the learners' sentence writing. In the concurrent model (Fig. 2), the relationship between learners' reading and writing at the sentence level was reduced to a statistically non-significant β-value of − .09 with the presence of character-writing fluency and written syntactic skill. Similarly, as in the longitudinal model (Fig. 3), the influence of Time-1 reading ability on Time-2 sentence writing was fully mediated, with the direct influence attenuated to near zero (β-value of .03), through the literacy component skills.

These results indicate the importance of character-writing fluency and written syntactic skill on both CSL reading and writing, as well as clarifying their relationship: the two component skills explained the significant variance in both sentence reading (70%) and sentence writing (64%), as shown in the concurrent and longitudinal models (Figs. 2, 3). The results are consistent with the findings of

previous studies on alphabetic-language learners (Graham & Hebert, 2011; Kent & Wanzek, 2016), and, as emphasized in previous sections, are related to the linguistic characteristics of the Chinese language. First, due to its complexity, the Chinese writing system is considerably difficult to learn. One of the pre-requisites for CSL learners to become proficient readers and writers is a good orthographic representation to support fluent character reading and writing; otherwise, excessive attention will be diverted to low-level decoding/transcription, thus making it difficult to achieve higher level literary comprehension or production. In this sense, Chinese character fluency that serves as an indicator of learners' orthographic quality, contributes to both sentence reading and writing, with β-values of .16 and .20 respectively, as shown in the concurrent model. This result also supports previous research findings (Chan et al., 2006; Guan et al., 2015) that character copying is an effective method to develop a better orthographic representation in Chinese learning.

Written syntactic skills were found to be a dominant predictor of students' sentence reading and writing, with β-values of .79 and .81 respectively, as shown in the concurrent model. These high correlations are, first, related to Chinese, as a non-inflectional language, placing heavy demand on word order and word-related knowledge especially regarding function words for sentence comprehension and composition. Written syntactic skills are important for CSL students' sentence parsing and construction. This is consistent with studies on the relationship between syntactic skills and reading and writing respectively in native Chinese-speaking children (Yeung et al., 2011; Yeung et al., 2013a, b, c). Second, written syntactic skill is related to reading and writing; the word order measures required participants to access their written word and sentence-structure knowledge, which may also explain why written syntactic skill along with character-writing fluency did not mediate from reading to writing as was the case with oral syntactic skill in studies like Guan et al. (2014) and Tong and McBride (2016). Instead, the two literacy component skills mediated the longitudinal reading–writing relationship.

The mediating effects of character-writing fluency and written syntactic skill on the reading–writing relationship were shown in the longitudinal model (Fig. 3): Time-1 reading ability could only influence Time-2 sentence writing indirectly through the mediation of character-writing fluency and written syntactic skill. The complete mediation implied that these two literacy component skills might account for learners' CSL reading–writing relationship at the sentence level; their sentence writing was largely influenced by the Chinese orthographic representation and written syntactic knowledge they had acquired and developed through reading. Moreover, it is as important to recognize that Time-1 reading ability was, in turn, a predictor for Time-2 character-writing fluency and written syntactic skill, thus explaining a substantial portion of the variance of both: 13% in the former and 70% in the latter. Supporting the findings of reciprocal relationships between word writing, morphological awareness, syntactic awareness, and reading among Chinese-speaking children (Chan et al., 2006; Cheng, Zhang, Wu, Liu, & Li, 2016; Tong & McBride, 2017), the results reveal that reading ability, comprising both character reading and reading comprehension, supports the acquisition of orthographic representation, word-related, and syntactic knowledge for fluent

character writing and excellent written syntactic skill in CSL learners as well. It is also highly probable that, although not evaluated in this study, the learners may develop these component skills better in writing than reading, as writing provides them direct practice in writing characters and constructing sentences. Overall, the findings support the reciprocal relationship between reading and writing, on the one hand, and literacy component skills on the other. By discerning that these component skills account for the connection between reading and writing, we may better understand the nature of the reading–writing relationship in CSL learners' literacy development.

Educational implications

The findings suggest a close relationship between reading and writing, related to certain literacy component skills in CSL learning. This may facilitate learners' literacy development by heightening their awareness of the linguistic features in literacy instruction. For example, during reading instruction, learners' attention may be directed to the configuration of a given character, complemented by an appropriate number of copying exercises. Similarly, the practice of character writing would be beneficial to reading. Another example relates to the teaching of sentence structure in both reading and writing instruction: learners would substantially benefit from explicit instruction regarding sentence structure to improve their sentence comprehension and construction.

Limitations and further studies

Focusing on CSL learners' writing at the sentence level, this study naturally limits its consideration of linguistic knowledge and skills at this level, of which the component skills under investigation, i.e., handwriting fluency and written syntactic skill, play important roles. Hence, the findings in relation to the CSL reading–writing relationship may not be applicable at higher levels, for example, the paragraph and text/discourse levels. It is recognized that the linguistic and cognitive demands required for writing beyond the sentence level would be much more sophisticated, for example, in consideration of content structure, and intra- and inter-paragraph cohesion, and would place a much higher demand on effective use of working memory to conduct the complicated executive functions for text composition. Further studies may be conducted at these levels to investigate the interplay of higher linguistic/cognitive processes. Regarding written syntactic skill, the measure used by this study that assessed participants' word-order and word-related (particularly function word) knowledge, may not capture the full range of students' variability in the skill whereby responses with minor errors reflecting a developing ability are not totally represented. More studies on CSL learners' syntactic skill development are required. Moreover, this study was solely concerned with literacy-related skills, and hence no consideration was given to the role of oral language competence. The relationships between CSL learners' various oral skills, for example, phonological, morphological, or syntactic, and their interactions and relationships with their literacy development are of significant interest, and, as far as

I know, empirical research on such is lacking. Furthermore, the spoken and written forms of the Chinese language learned by the participating students are Cantonese and the traditional script respectively that are different from those used in Mainland China and may influence the students' CSL literacy development. Lastly, these students were learning both Chinese and English as second languages in school, while speaking their native language at home. Interpretations of the findings should consider this, and further studies could pursue the effects of students' multilingual learning/exposure experiences on their CSL literacy acquisition.

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