Differential Contribution of Psycholinguistic and Cognitive Skills to

Written Composition in Chinese as a Second Language

Abstract

This study examined the contribution of the constructs of orthographic processing (orthographic choice and orthographic choice in context), syntactic processing (grammaticality and sentence integrity), and verbal working memory (two reading span indicators) to written Chinese composition (narration, explanation, and argumentation) in 129 fifteen-year-old L2 learners. A matrix task was also administered as a control task to tap cognitive flexibility. Structural Equation Modeling (SEM) analysis with written composition as a latent variable revealed orthographic processing and working memory as two significant, independent contributors, whereas the unique contribution of syntactic processing was not significant. Subsequent SEM analysis with narration, explanation, and argumentation as separate endogenous variables found varied patterns of the contribution of each latent predictor to written composition in different genres. These patterns are discussed in light of the importance of attention to learners' developmental stage and genre-sensitive measures to capture the psycholinguistic and cognitive underpinnings of written composition in L2 Chinese.

Keywords: Written composition; Chinese as a Second Language; working memory; orthographic processing; sentence processing.

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Written composition performance depends on the execution and coordination of several important processes, including planning, translating, and reviewing (Hayes, 1996; Hayes & Flower, 1980). During the translation stage, writers not only need to formulate ideas (i.e., text generation) but also to make sure ideas are subsequently transcribed on paper with automaticity, grammaticality, and coherence (i.e., transcription) (Berninger & Swanson, 1994; Olive, 2014). To make their writing clear and explicit, students need to orchestrate a number of skills, such as hand writing and spelling skills and linguistic knowledge (e.g., lexical and syntactic knowledge) (Abbott, Berninger, & Fayol, 2010; Berninger, Abbott, Abbott, Graham, & Richards, 2002; Graham & Hebert, 2011). In addition, given that writers need to "juggle and integrate the multiple constraints of their knowledge, their plans, and their text into the production of each new sentence" (Flower & Hayes, 1981, p. 371), writing is arguably a cognitively demanding process, working under limited mental resources. Thus, unsurprisingly writers' cognitive skills like working memory have been noted to play an important function in composition and been found to predict students' writing development (Berninger & Swanson, 1994; McCutchen, 1996, 2000; Olive, 2012).

While the foregoing insights have been largely established on the basis of studies on English writing, the psycholinguistic and cognitive underpinnings of written composition have recently also received increasing attention in Chinese, a language that is notably different from English not only in its writing system but also syntactic structures (Li & Thompson, 1989). Researchers have examined, for example, whether the factor structure of English writing-related skills would hold in developing Chinese writers (Guan, Ye, Wagner, & Meng, 2012), reading-

writing connection in Chinese (Authors blinded for review, 2014; Tong & McBride, 2016), and the simple view of writing in Chinese (Yeung, Ho, Chan, & Chung, 2016), among other issues (Yeung, Ho, Chan, & Chung, 2013a, 2013b; Yan et al., 2012). Nevertheless, notable gaps exist.

On the one hand, existing studies have paid little attention to students' writing in different genres, which have been noted to place different levels of demands on the writer and eventually could have an impact on how different skills are orchestrated during the writing process (Beers & Nagy, 2011). On the other hand, previous modeling on how subskills work in tandem in influencing written composition focused almost exclusively on native-speaking children with little attention to second language (L2) writers of Chinese. Compared to their L1 counterparts, L2 learners' limited oral language and literacy experiences with the target language constrain the development of not only composition ability itself but also skills that underpin the composition process (e.g., orthographic and syntactic processing). Consequently, writing could be a more demanding task for L2 writers (Kormos, 2012; Manchón, 2013). This may be particularly true of L2 writers whose L1 is typologically distant from Chinese (Taylor & Taylor, 2014). While recently there has been some understanding about L1 versus L2 readers of Chinese (Authors blinded for review, 2011; Author blinded for review, 2017; Authors blinded for review, 2018), little research has addressed L2 writers of Chinese (see Wong, 2018 for an exception).

Within a Structural Equation Modeling (SEM) methodological framework, the present study thus attempts to add to the literature by exploring the effects of orthographic and sentence processing ability and reading span memory capacity on the quality of Chinese composition written by young non-native writers. To address how the concurrent contribution of these psycholinguistic and cognitive skills to written composition may be the same in or differ between different genres, we examined three types of writing: narration, explanation, and argumentation.

Psycholinguistic and Cognitive Underpinnings of Writing Chinese

Orthography and Syntactic System in Modern Chinese

Chinese is a morphosyllabic language based on syllable-to-morpheme/character mapping in that each character (*zi* 字) represents a syllable and typically a morpheme. While a significant number of Chinese characters are of a single unit, most of them are compounds consisting of two orthographic units named *radicals*: the semantic radical provides clue to the overall meaning of its host character, whereas the phonetic radical indicates the sound of the character. While many characters would themselves be words (*ci* 詞), most Chinese words are formed through compounding and represented in print as a string of two or more characters. To give an example, 游泳 (*swim, swimming*) is a compound word composed of two constituent morphemes/characters: 游 and 泳. In both characters, the semantic radical is the left component of the character (i.e., 氵), which refers to *water* or *liquid*; and the orthographic component on the right of each character is the phonetic radical. Another notable characteristic of Chinese at the morphemic or lexical level is that there are many homophones (i.e., morphemes that have the same sound but differ in meaning). This is because of the fact that the large number of Chinese characters are represented by a restricted number of valid tone syllables (Taylor & Taylor, 2014). For example, 游 shares the same sound with 由 (*reason*), 油 (*oil*), and 猶(*hesitant*); and 泳 with 永(*forever*), 勇(*brave*), and 湧(*gust*).

At the syntactic level, there are also some notable characteristics of modern Chinese. For example, word order is the "single most important syntactic device for sentence interpretation" and occupies "a pivotal position in Chinese syntax" (Chang, 1992, pp. 279-280). While Chinese sentences are basically of the subject-verb-object (SVO) type, they also allow for other

arrangements such as SOV and OSV. The notion of topic and comment is another syntactic characteristic of Chinese sentences. Chao (1968) and Li and Thompson (1989) have argued that the grammatical meaning of subject and predicate in Chinese sentences should be treated as topic and comment, rather than as agent and action, while agent and action may be a special case of topic and comment. Chinese is also known as a pro-drop language where the subject or topic in a sentence may not always be expressed (i.e., zero spell-out of pronouns). These syntactic features, among many others, could pose a challenge to L2 learners of Chinese, particularly those whose first language (L1) is typologically distant from Chinese (e.g., Jiang, 2009; Jin, 1994; Polio, 1995).

Studies on Chinese Writing

The complexity in the aforementioned (sub-) lexical and syntactic properties of Chinese suggests that a number of psycholinguistic skills pertaining to these features should be important for children's development of writing abilities in Chinese. For examples, at both the sub-lexical/character level (e.g., sensitivity to orthographic structure and ability to decompose and integrate components of characters) and the lexical level (i.e., discrimination of homophones), children should have adequate orthographic processing skills to support the development of accuracy and fluency in spelling/writing words, a skill that is fundamental to written composition in Chinese. For example, to express the idea of *swim* or *swimming*, students should know that 游 永 or 油泳 are wrong candidates. It is thus unsurprising that research has consistently shown that orthography-based skills, particularly spelling or character writing ability, are a significant predictor of Chinese-speaking children's writing performance (Yan et al., 2012; Yeung et al., 2013a, 2013b, 2016).

Yan et al. (2012), for example, found that Cantonese-speaking children's Age 8 word dictation ability and Age 9 fluency of copying sentences were significant, unique predictors of their Age 9 written composition. Yeung et al. (2013b) aimed to establish the relationship of Chinese textual writing in native-speaking children with a number of cognitive-linguistic skills identified to be important for Chinese spelling and text writing, respectively. Notably in the context of the current discussion on orthographic skills, Yeung et al.'s orthographic knowledge (i.e., pseudo-character meaning judgment) and morphological awareness (i.e., homophone discrimination) respectively addressed orthographic processing at the sub-lexical/character and the lexical level we mentioned earlier. Path analysis revealed that these two skills significantly predicted children's word spelling/dictation, which in turn significantly predicted text writing. In a more recent study that aimed to examine Juel, Griffin, and Gough's (1986) simple view of writing in Chinese, Yeung et al. (2016) found from an SEM analysis that a latent variable of transcription skills indicated by children's stroke sequence knowledge, word spelling, and handwriting fluency significantly predicted their written composition performance.

In addition to highlighting skills pertaining to orthographic processing and spelling, recent studies have also revealed syntactic processing as an important predictor of Chinese-speaking children's written composition (Authors blinded for review, 2013; Authors blinded for review, 2014; Tong & McBride, 2016; Yeung et al., 2013a, 2013b, 2016). Yeung et al. (2013b), for example, used a scrambled sentence task with a focus on word order to test Cantonese-speaking children's syntactic skills in Chinese. Path analysis revealed that over and beyond transcription skills (e.g., word spelling), children's syntactic skills consistently surfaced as a significant predictor of their written composition across three different time points. This finding was later supported by the same authors' later study (Yeung et al., 2016) that aimed to test the

simple view of writing where syntactic skill was operationalized and measured as an oral language skill. In a study that addressed reading-writing connection in Chinese, Authors blinded for review (2014) used a scrambled sentence task (i.e., syntax construction) and an error detection and correction task (i.e., syntax integrity) to measure the syntactic processing skills of children from three different grades. It was found both tasks significantly correlated with text comprehension and composition. SEM analysis revealed that across grade levels, the effect of syntactic processing on written composition was mediated by text comprehension. A similar finding was reported in Tong and McBride (2016), using slightly different syntactic processing measures.

Compared with psycholinguistic skills like orthographic and syntactic processing, cognitive skills like working memory have not been a consistent focus of research on Chinese writing where the effects of subskills are concurrently modeled. Working memory refers to processing resources of limited capacity in that individuals need to maintain information while simultaneously acting on the same or other information. Verbal working memory tasks generally require learners to hold increasingly complex verbal information in memory while responding to questions about the tasks. These verbal memory tasks have been shown to play a role in activating and integrating information in text comprehension (Daneman & Carpenter, 1983; Daneman & Merikle, 1996; Authors blinded for review, 2008). Similarly, written composition requires the generation, integration and production of ideas, and also makes demands on working memory (Kellogg & Whiteford, 2012; Kellogg, Whiteford, Turner, Cahill, & Mertens, 2014). Thus, it is unsurprising that Authors blinded for review (2014) dominance analysis found a latent variable of working memory, indexed by a verbal span and an operational span task, surfaced as the strongest predictor – the other two being morphological awareness and syntactic processing –

of Chinese children's written composition at different grade levels. Yeung et al.'s (2016) SEM analysis also supported the importance of working memory in Chinese written composition.

Writing in Different Genres

Despite the effort in the studies reviewed above to unravel the psycholinguistic and cognitive underpinnings of Chinese written composition, two notable gaps exist. One is little attention to writing in different genres; the other is that the focus has been almost exclusively on L1 writers with little attention to writing in Chinese as a Second Language (CSL), an issue we will discuss in detail in the next section.

From a socio-cultural perspective, genres can be defined as "ways in which people get things done through their use of language in particular contexts" (Johns, Bawarshi, Coe, Hyland, Paltridge, Reiff, & Tardy, 2006, p. 236) or as goal-directed socially situated ways of communication (Tardy, 2012). From a cognitive processing perspective, genres are text types characterized by certain linguistic conventions and classified into categories (Boscolo, Gelati, & Galvan, 2012; Hidi, Bendorff, & Ainley, 2002). Genre structure has macro-level stages such as introduction, theme statements, supporting statements, and conclusions. There are also micro-stages of lexico-grammatical characteristics at the sentence level.

Guided by these principles and by Halliday's (2004) Sydney School of systemic functional linguistics (Rose, 2008, 2011), we use the terms narration, explanation (exposition) and argumentation in our discussion of genres. In general, narration and explanation writings are related in organization principles with three main parts of beginning, middle, and end, but these genres are represented differently. Narrations are agent-oriented with a focus on people and their action; and motivation and events unfold in a temporal sequence (Berman & Nir-Sagiv, 2007). In

some contrast, explanations are topic-oriented with a non-temporal focus on issues, and ideas unfold in a logical structure typically beginning with a main idea, then body of text and conclusion restating the main idea (Britton, 1994). Different from the genres of narrations and explanations, argumentation compositions require writers to marshal facts, to argue and counter argue, all based on plausibility and factual information (Kuhn & Udell, 2003; Toulmin, 2003).

Developmentally, different types of writing may pose different levels of challenges to students. For example, narration writing is generally more familiar to less skilled writers or L2 learners, who may thus likely need to make greater use of their word transcription skills, while explanation and argumentation writing needs tighter and syntactically more mature sentences and more world knowledge (Berman & Nir-Sagiv, 2007; Donovan & Smolkin, 2006). Inference could be drawn from studies that aimed to examine the quality of students' writing in different genres in English through computational analysis (e.g., Beers & Nagy, 2011; Olinghouse & Wilson, 2013). Beers and Nagy (2011), for example, have shown that persuasive writing had more subordinate clauses as compared with narrative, descriptive and compare/contrast writing in Grades 3, 5 and 7 American students. In addition, because of the greater complexity of explanation and argumentation (e.g., information density), writing in these two genres may be cognitively more demanding than narration; and as a result, composition in these two genres, compared to narration, may be more subject to students' working memory capacity. Hypothetically, the orchestration of a same set of psycholinguistic and cognitive skills may vary depending on which genre is the focus of the writing task.

The aforementioned issue, to our knowledge, has rarely been a focus in published studies on how different subskills contribute to Chinese written composition. Those studies either did not consider writing in different genres at all (i.e., a holistic representation of written

composition ability without differentiating between different types of genre) (e.g., Yan et al., 2012; Yeung et al., 2013a, 2013b, 2016); or measured writing in different genres with a purpose to better represent the construct of writing ability without aiming to analyze them separately (e.g., Authors blinded for review, 2014). In the latter case, Authors blinded for review (2014) made a distinction between narration, explanation, and argumentation writing and measured all three types of writing in Grades 4, 5 and 6 Chinese children. These types of writing all loaded significantly on a latent factor of written composition ability across grade levels; yet, the SEM analysis did not consider them as separate endogenous variables. Consequently, there was no information on how the latent predictors (i.e., morphological awareness, syntactic processing, and working memory) might show different patterns of predictive effects on composition in the three genres. Actually, some inconsistencies in the findings of previous studies (e.g., Yan et al., 2012; Yeung et al., 2016) may be attributed to variations in the focal genre(s) of their composition measures.

L1 versus L2 Writing in Chinese

The insights into psycholinguistic and cognitive underpinnings of written composition in Chinese as reviewed above have been almost exclusively based on native-speaking children. We should not assume that the patterns would necessarily hold for L2 writers. Globally, an increasing number of people are learning Chinese as an additional language, either in a non-Chinese-speaking context out of personal interest or for improving professional mobility, or in a Chinese-speaking society because of factors like immigration. The former is often referred to as a Foreign Language context where the target language is not the user's L1 or used in a milieu not normally used (e.g., the United States). The latter is often denoted as a Second Language context where the target language (Chinese in this case) is used not only in the classroom but also in a

native speaker's milieu as a tool of communication (e.g., Hong Kong). In this study, the term L2 is used to refer to Chinese being learned by ethnic minority students who may or may not be born in Hong Kong, yet all speak a language(s) other than Cantonese or any other variety of Chinese at home.

Previous studies on L2 reading literacy have suggested that reading abilities develop under the mandate of the linguistic and language-to-print mapping properties of the target language; yet students' target language experiences also play a critical role (Authors blinded for review, 2011; Koda & Zehler, 2007; Author blinded for review, 2017; Authors blinded for review, 2018). Compared to their native-speaking counterparts, L2 learners typically learn to become literate in the target language, Chinese or any other language, with limited language and literacy experiences in the language. Consequently, these experiences may constrain the development of necessary orthographic and linguistic (e.g., syntactic) processing skills that support the development of high level literacy ability like composition. The presumably under-developed sub-skills in L2 learners may further suggest that written composition could cognitively be particularly challenging to them; and cognitive skills like working memory may play a heightened role in predicting Chinese L2 writers' composition ability (Kormos, 2012).

Authors blinded for review (2011), for example, compared the orthographic processing skills at both sub-lexical/character and lexical levels between native Chinese-speaking (L1) and non-native-speaking ethnic minority (L2) students in Hong Kong. It was found that across all three measured skills, L1 students significantly outperformed their L2 counterparts; yet, in both the L1 and L2 groups, orthographic processing was found to be a significant, unique predictor, out of a number of linguistic and cognitive tasks, of reading comprehension. A similar finding was found in Author blinded for review (2017), which also revealed orthographic processing as a

significant predictor of word reading in both L1 and L2 readers of Chinese; yet the pattern of how orthographic processing, phonological, and morphological awareness concurrently predicted reading varied between the two groups.

Although the foregoing findings were based on L2 Chinese reading, they clearly have implications on the study of writing in L2 learners as well. In a recent study on 12-year-old non-native-speaking ethnic minority children Hong Kong, Wong (2018) found that character writing fluency and syntactic skills were both significant, independent predictors of sentence writing ability, which was measured with a keyword-prompted, picture description task. The effect of syntactic skills on writing was particularly strong ($\beta = .81$). Although these findings tended to corroborate those of previous studies reviewed earlier on the importance of orthography-based and syntactic processing skills, the lack of consideration of students' cognitive skills like working memory and writing in different genres are notable limitations.

Research Questions

To address the gaps of research outlined above and to generate a nuanced insight into the processes of written composition in Chinese, we conducted the present study to examine the effects of some psycholinguistic (i.e., orthographic and sentence processing) and cognitive factors (verbal working memory capacity) on written composition in different genres by non-native students who are L2 users of Chinese in Hong Kong. These were our research questions:

(1) Are orthographic and sentence processing factors and verbal working memory capacity significant predictors of Chinese written composition performance? Based on the orthographic and syntactic properties of Chinese and the findings reviewed earlier on developing L1 and L2 Chinese writers, it was predicted that all three factors are significant, independent predictors of Chinese written composition.

(2) What are the relative magnitudes of the contribution of these variables to the

prediction of three genres of written composition performance: narration, explanation, and

argumentation? We predicted that all three skills are significant predictors of all three genres of

written composition. In addition, as mentioned earlier, explanation and argumentation tend to be

linguistically more complex and greater in information density than narration; and narration is

more person-oriented and usually taught earlier and thus more familiar to students. Therefore,

syntactic processing and working memory may emerge to be more important for explanation and

argumentation than for narration.

Method

Participants

The language users in this study were mainly of ethnic Pakistani and Indian origin in

Hong Kong. At home they speak Urdu or Hindi, intermixed with English and spoken Chinese

(Cantonese). Our survey showed that 92% of them speak their mother tongue at home and 75%

of the groups use English over Chinese (75% vs. 25%). In school and in communication with

their class mates they use English as the predominant language over Chinese (96% and 91%

respectively as compared with 50% and 42%). This strong preference for and prominent usage of

English over Chinese had an effect on acquiring Chinese literacy, as discussed later.

The total sample of 129 students came from 23 classrooms mainly from three schools

admitting mostly non-Chinese speaking or inter-mixing with Chinese speaking students. These

students were all participants of the Students Support Program for Non-Chinese Speaking

Students organized by the Hong Kong education authorities. Their average number of years

living in Hong Kong was 10.10 with an *SD* of 5.12 years. The mean age of the total group was

14.95 years and *SD* of 1.89 years. The survey further showed that the group learnt Chinese for

2.41 years with a *SD* of 2.60 years. There were 53 boys with a mean age of 14.29 years and *SD*

of 1.81 years and 76 girls with a mean age of 15.41 years and *SD* of 1.82 years. For various

reasons such as lack of home support in learning Chinese and/or being fairly recent immigrants

to Hong Kong, these 15-year-old students were found to be reading and/or writing Chinese at

about Grades 3 or 4 level, although most of them possessed conversational fluency in Cantonese.

This was verified from in-class observation and discussion with the teachers. The students were

provided with curriculum materials specially designed for their needs. The teachers of these

classes were either attending short courses on the teaching and learning of Chinese as a second

language or had just completed these courses before the present study commenced.

Writing Tasks

The students were asked to write from 50 to 150 characters on each of the topics of "A

School Picnic", "My Favorite Sport" and "Should Students watch TV?" This length requirement

may seem short, but it took into account the average written performance of these students at

about the Grades 3 or 4 level. The writing was given as an in-class exercise with 35 to 40

minutes for each composition. The topics were selected to represent broadly narration,

explanation and argumentation writing. We emphasized in short talks to the students that

narration writing should focus on people, their action in a temporal sequence; explanation

writing on issues with ideas unfolding in logical structure; and argumentation writing on

argument and counter-argument based on plausible and factual information (Anderson, Chinn,

Chang, Waggoner, & Yi, 1997; Kuhn, 2005; Nussbaum & Kardash, 2005).

Text Quality

Based on the "learning to write, reading to learn" framework and program of Rose (2008,

2011), which in turn is derived from Halliday's systemic functional linguistics, we developed a

rubric with descriptors for grading the compositions. The quality of the students' compositions was rated on three related but separable components: (a) "Discourse and Grammar" with five sub-components of lexis, appraisal, conjunction, reference and inter-language from spoken Cantonese to modern written Chinese. Each sub-component was scored from 0 to 3 for a total of 15 marks as maximum; (b) "Application of Language" focusing on range of vocabulary, suitability of purpose, phases and internal structure of the composition with a maximum of 10 marks; and (c) "Accuracy" focusing on punctuations, legibility of hand writing and errors with a maximum of 5 marks. The maximum total score was 30 marks. The rubric for the important components of Discourse and Grammar is shown in Appendix. A similar rubric was also developed for Application of Language and Accuracy.

All the written compositions were scored independently by two experienced teachers who were trained and guided by the research team to grade the compositions as part of their professional development to augment knowledge and skills in working with ethnic minority students learning Chinese. Their ratings showed high inter-rater reliabilities: .87 (narration writing), .76 (explanation writing) and .90 (argumentation writing). Students' writing scores were an average of the two teachers' scores (see Table 1).

Orthographic Processing Construct.

The literature generally discusses orthographic processing in terms of knowledge at both the sub-lexical and lexical levels (Chao, 1968; Deacon, Benere, & Castles, 2012). Following this discussion, we define orthographic knowledge in Chinese as understanding of the positional constraint and the role of intra-character constituents of the semantic and phonetic *radicals* and their integration (i.e., sub-lexical/character insight); and the ability to discriminate homophones in lexical context in print (i.e., lexical-level insight). The construct was measured with an

orthographic choice and an orthographic choice in context tasks as indicators, both of which had been used in the authors' earlier studies on native and non-native readers/writers of Chinese (e.g., 2011, 2017).

Orthographic choice task. The orthographic choice (OrthoCh) task required students to read silently and rapidly 20 item-pairs of two-character words or pseudowords printed on a sheet, and to circle the correct real or meaningful two-character words. The original concept was from Olson, Kliegl, Davidson, and Foltz (1985) who used lexical items consisting of one real English word and one homophonic pseudoword with similar word shape (e.g., <u>soap</u>, sope; gawn, <u>gone</u>).

Our 20 pairs of two-character words consisted of: (a) 10 item-pairs of regular consistent characters (characters pronounced the same way as the phonetic *radicals* in isolation and with the same lexical tone, *initials* (onsets) and *finals* (rimes), such as 洋光 (ocean light) <u>陽光</u> (sunlight); (b) 5 item-pairs of regular inconsistent characters (characters pronounced the same as the phonetic *radicals* but with different tones such as 青山 (green or verdant hill) 蜻山 (dragon fly hill, a pseudoword); and (c) 5 item-pairs of irregular or exception characters (characters pronounced with different speech sounds and tones from the phonetic *radicals* in isolation such as 皮球 (leather ball) 皮救 (leather save, a pseudoword). The total testing time for this task was 8 minutes and the maximum score was 20. Cronbach's alpha coefficient was .93.

Orthographic choice in context task. The paper-and-pencil orthographic choice in context (OrthoCon) task was similar in principle to the orthographic choice task, except that the focus was identifying and discriminating heterographic homophonic Chinese characters in compound word context. Students were asked to read silently and rapidly 20 short sentences in Chinese, each embedding 4 two-character words one of which was the correct choice and would

complete the meaning of the sentence. The three distractors were phonologically similar two-

character words of regular consistent, regular inconsistent or exception real words or

pseudowords. A sample sentence embedding the 4 two-character words is as follows: (花原 / 花

源 / 花圍 / 花園) 裏有很多花草。(In the garden there are many flowers and weeds). The total

testing time for this task was 15 minutes and the maximum score for the 20 items was 20.

Cronbach's alpha coefficient was .87.

Sentence Processing Construct

We assessed students' sentence processing ability with a grammaticality judgment task

and a task requiring the detection and correction of syntactic errors in short sentences. These two

tasks were designed in accordance with the characteristic of Chinese syntax (e.g., word order) as

discussed earlier. These two tasks had been previously used by the authors in studies on young

Chinese-speaking writers (e.g., Authors blinded for review, 2013, 2014) and been proved to be

both reliable and valid.

Grammaticality decision task. Our interest in the present study was in the linguistic

intuition derived from the analysis and control processing of simple sentences, and not in the

judgment of gradation of acceptability hierarchies. We assembled 22 parallel pairs of

grammatically correct and grammatically anomalous simple Chinese sentences emphasizing

correct word order and syntactic integrity. This is analogous to the English pair (e.g., "The

runner turned off the road." vs. "*The runner turned the road off."). Actual sample items

included: 你是我最好的朋友 vs. *我最好的朋友你是 (You are my best friend); and

外面正下着大雨。vs.*正下着大雨外面。(It is raining outside). These 22 pairs of sentences

were arranged at random on the printed page and administered as a paper-and-pencil task. The

participants were asked to check YES or NO to the grammatically correct or incorrect sentence. The total testing time was 20 minutes. One mark was given to the correct choice and the maximum score was 44. Cronbach's alpha coefficient was .89.

Sentence integrity task. The aim of this task with 20 short sentences plus 4 practice examples was to tap the learners' implicit understanding of standard modern Chinese and the explicit production of correct sentences. Students were presented with a set of sentences each containing an error which violates syntactic integrity. An example is 我高過他 (I am taller than he) where the comparator *bi* 比should be used for comparison such as 我比他高. The 20 sentences were printed on a sheet and the students were required to detect the errors and write out the short correct sentences. The total testing time was 30 minutes. One mark was given for each correctly written sentence and the maximum was 20. Cronbach's alpha coefficient was .88.

Verbal Span Working Memory Task

The verbal span working memory task (VSWM) was based on the rationale and format of Daneman and Carpenter (1983) as modified by Swanson (1992). There were 2 parallel tasks (1 & 2), each with a total of 6 sets of two, three and four sentences, all unrelated in meaning. These sentences were very simple lexically and grammatically and were at or below the proficiency level of the learners. They were read aloud in Cantonese by the experimenter to small groups of students. They first listened to each set of two-, three- or four-sentences plus the question, and were then to write down on designated forms their short answers to the comprehension question and the last word in each sentence of the set. A verbatim translated example from a three-sentence set is: "I was [under the tree] reading a book. Teacher Chan took the mini-bus to school. Sister was eating ice cream." The answer to the comprehension question "How did teacher Chan get to school [by what kind of transportation]?" should be "mini-bus" [a very common means of

transportation in Hong Kong]." And the last words should be: "book, school, and ice cream". The total testing time for VSWM 1 and 2 was 20 minutes and all the answers were scored independently by two research assistants. One mark was awarded for each correct answer and the maximum score was 12 for each sub-task. Cronbach's alpha coefficient for VSWM as a whole was .94.

Matrix Task

As a measure of cognitive flexibility and of general ability, the British Ability Scale Matrix D test with 12 items (Elliott, Murray, & Pearson, 1978) was administered to all the students. This is a standardized non-verbal general ability test tapping reasoning by analogy and deduction. Students are asked to complete a pattern of horizontal, vertical, and slanting lines; triangular, square, oblong and circular shapes; and partial or full shading based on the principle of eduction of relations and correlates from these parts of the overall pattern. This task took 15 minutes plus discussion time for the sample items. Raw scores were converted to scaled scores for statistical treatment. This task was used to sample cognitive flexibility, and subsequently served as a control variable when the relationships of psycholinguistic and cognitive skills with written comprehension were modeled. This is in keeping with the thinking that writing is a problem solving activity, and general problem solving strategies are used in moving from novice to expert status (Kellogg & Whiteford, 2012).

The writing tasks and the 6 cognitive-linguistic tasks were administered on three days spread out over a three-week period in the second term of the school year. The schedule of administration with some flexibility to accommodate normal school activities was as follows: week 1: narrative writing (40 minutes), matrix (15 minutes), grammaticality (20 minutes); week 2: explanation writing (40 minutes), orthographic choice (10 minutes), sentence integrity (30

minutes); week 3: argumentation writing (40 minutes), orthographic choice in context (20 minutes), verbal span working memory (20).

Data Analysis Method

SEM (Kline, 2016) was the primary data analysis method to model the relationships of psycholinguistic and cognitive skills to written composition in Chinese. All SEM analyses were tested on M*plus* 7 (Muthén & Muthén, 1998-2015) with Maximum Likelihood (ML) estimation. Various goodness-of-fit indices have been recommended in the literature. Following Hu and Bentler (1999) and Marsh, Hau, and Grayson (2005), we used Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), and Standardized Mean Square Residual (SRMR) for the evaluation of model fits. Cutoff values of CFI > .95, RMSEA < .06, or SRMR < .08 indicated an SEM model with very good fits.

Results

Bivariate Correlations

Table 1 shows the means, standard deviations, reliability, and inter-correlations of the literacy tasks (3 narration, explanation and argumentation written compositions, 2 orthographic processing, and 2 sentence processing), and 2 verbal memory and matrix cognitive tasks for the group of 129 students. The correlations of students' years of residence in Hong Kong were also included. Age was not included in the table because it barely correlated with any literacy task. All tasks showed fairly good reliability. Their correlations were almost all significant; in particular, all cognitive, orthographic processing, and sentence processing tasks showed moderate to strong correlations with all the three types of written composition. Students' years of residence in Hong Kong also correlated with almost all the literacy abilities.

Insert Table 1 about here

Predicting Written Composition

To answer the first research question, an SEM model (Model 1) was constructed where in the measurement model, the two tasks that measured a skill were used to indicate the latent variable of the skill (i.e., Working Memory, Orthographic Processing, Sentence Processing); the three types of writing were indicators of a latent variable of Written Composition. In the structure model (see Figure 1), Written Composition was hypothesized to be predicted by Working Memory, Orthographic Processing, Sentence Processing. In addition, students' years of residence in Hong Kong and non-verbal ability were also included as covariates. They were hypothesized to predict all four latent variables with the exceptions of covariance between Working Memory and non-verbal ability and no prediction of Working Memory by years of residence. Finally, the three latent predictors of Written Composition were allowed to covary.

There was reasonably good fit of the model to the data: χ^2 (33) = 55.79, p = .008; RMSEA = .073 (90% confidence interval = .038 - .106), SRMR = .070, and CFI = .978. The factor loadings were significant for all four latent variables (see Table 2). In addition to factor loadings, Table 2 also summarizes the estimates of the path coefficients predicting Written Composition. Altogether, the five latent and non-latent predictors explained about 80% of the variance in Written Composition. Working Memory (β = .314, p = .006) and Orthographic Processing (β = .631, p = .042) emerged as significant, unique predictors controlling for each other's influence and the other three predictors. Over and above the other four predictors, Sentence Processing (β = -.080, p = .829), however, did not uniquely predict Written Composition. Figure 1 shows a graphic representation of the structural component of Model 1 with all standardized structural parameters included.

Insert Table 2 and Figure 1 about here

Predicting Written Composition in Different Genres

To answer the second question of the relative contribution of the psycholinguistic and cognitive tasks to different types of written composition, another SEM analysis (Model 2) was conducted with narration, explanation, and argumentation as three separate endogenous variables rather than a latent variable of Written Composition as in Model 1. The residuals of these three writing variables were allowed to covary. All other parameters of Model 2 were exactly the same as Model 1 (see Figure 2).

Model 2 also showed good fit to the data: χ^2 (23) = 43.35, p = .006; RMSEA = .083 (90% confidence interval = .043 - .120), SRMR = .069, and CFI = .980. The factor loadings of the three latent predictors showed minimal change from those in Model 1. Table 3 summarizes the estimates of the key path coefficients that predicted written composition. All five predictors explained a significantly proportion of variance in the three types of writing: 56.7%, 59.9%, and 50.8%, respectively for narration, explanation, and argumentation. Some different patterns, however, were found between these types of writing.

Specifically, no significant, unique contribution was found of any one of the three latent predictors to narration writing after controlling for all the other predictors, including non-verbal ability and years of residence in Hong Kong. For explanation writing, however, Working Memory (β = .397, p = .003) emerged as a significant, unique predictor. The unique contribution of Orthographic Processing (β = .712, p = .059) was also marginally significant. Both Working Memory (β = .271, p = .056) and Orthographic Processing (β = .702, p = .068) also had a marginally significant, unique contribution to argumentation writing. For both explanation and argumentation writing, students' non-verbal ability surfaced as a unique, significant predictor. Finally, like the finding revealed in Model 1 where writing was modelled as a latent endogenous

variable, Sentence Processing did not emerge as a significant, unique predictor over and above the other two cognitive/psycholinguistic predictors as well as students' non-verbal ability and years of residence in Hong Kong. Figure 2 shows a diagram of the structural part of Model 2 with all standardized structural parameters inserted.

Insert Table 3 and Figure 2 about here

The above results led to another issue related to the focus of the second research question, that is, whether the path coefficient of each latent predictor was the same or different between the three genres. To address this issue, we imposed pairwise constraints on the three path coefficients of each predictor for each genre in Model 2 and examined to what extent each constrained model would be the same as the baseline model or deviate from it. The χ^2 difference is used for comparing models. If $\Delta\chi^2$ is significant, a constrained model is considered to show non-trivial deviation from the baseline model, and thus should be rejected; on the other hand, if $\Delta\chi^2$ is not significant, the constrained or the more parsimonious model should be retained.

Table 4 shows the results of the model comparisons. The finding suggests that Working Memory had a larger effect on explanation than on narration; however, its effect on writing did not show any difference between explanation and argumentation on the one hand and between narration and argumentation on the other. The effect of Orthographic Processing was essentially the same for all three types of writing. Lastly, the effect of Sentence Processing on narration writing was significantly larger than on both explanation and argumentation; the effect on the latter two types of writing did not show any difference.

Insert Table 4 about here

Discussion

This study examined the effect of some linguistic and cognitive tasks on the quality of L2 Chinese compositions with a focus on 129 non-native users of Chinese in Hong Kong. It was the first of its kind that aimed to examine the psycholinguistic and cognitive underpinnings of writing in different genres in L2 Chinese. In previous studies on Chinese writing, quite often different genres of composition were not differentiated and explicitly built into research design; in rare situations when composition ability was measured for different genres (e.g., authors blinded for review, 2014), these measures were aggregated as an omnibus measure, thereby losing finer-grained information. To address this gap in the literature, we differentiated between narration, explanation, and argumentation writing, and analyzed how the prediction of writing by target psycholinguistic and cognitive skills may vary as a function of these genres.

Contributions to Written Composition in General

Our first research question sought to examine the contribution of selected psycholinguistic and cognitive skills, after controlling for students' years of residence in Hong Kong and non-verbal ability, to written composition in general with a latent variable of writing indicated by the three genres. The three predictors (Figure 1) explained a substantial amount of variance in writing (about 80%). The hypothesis of a unique, significant contribution of all predictors, however, was only partially supported.

A significant contribution of working memory capacity, i.e., the measure of cognitive skill, surfaced in this study, over and beyond the contribution made by orthographic and syntactic processing skills. This finding was not unexpected because written composition as a high-level literacy skill requires the orchestration and coordination of a number of linguistic skills; and it is executed under limited mental resources (Kellogg & Whiteford, 2012; McCutchen, 1996, 2000; Olive, 2012; Swanson & Berninger, 1996). Working memory is

actually one of the four important resources in the framework conceptualized by Hayes and

Berninger's (2014) on cognitive processes in writing. Writers with a higher working memory

capacity would show a more coordinated process and write in a more efficient way, from putting

ideas into words and integrate words to formulate sentences and finally transcribe

words/sentences on paper, among other processes. Given similar background knowledge, good

readers/writers, compared with poor ones, tend to make more integrative inference and better use

of their semantic and syntactic skills (Oakhill, Cain, & Bryant, 2003). Poor literacy learners are

constrained by their working memory to build mental models of text and writing. While this is

true of L1 writers (Yeung et al., 2016), it appears to be more so of L2 writers (Kormos, 2012),

especially beginning or low proficiency learners, who may struggle with fluency in their

transcription and linguistic knowledge to construct textual meanings.

The significant contribution of orthographical processing did not come as a surprise as

well, because it is fundamental to transcription in Chinese. Finings of previous studies have

consistently highlighted orthography-based skills, particularly (fluent) spelling, as playing an

essential role in Chinese written composition (e.g., Yan et al., 2012; Yeung et al., 2016). Tong,

McBride-Chang, Shu, and Wong's (2009) study on native speaking children's early Chinese

literacy found that orthographically based errors were a major type in the errors in children's

word dictation. These authors concluded that "orthographic knowledge… appears to be a stable

predictor of early Chinese literacy skills" (p. 447). In the present study, the orthographic choice

and orthographic choice in context tasks touched upon sub-lexical/character as well as lexical

level processing skills, both of which are actually essential for the accuracy and fluency of

spelling / character writing, and subsequently are critical for written composition in Chinese. Our

scrutiny of the participants' writing protocols actually also revealed a notable pattern of writing

errors, particularly in poor writers, that is, confusing characters with similar orthographic patterns (e.g., 「挑」戰＞「排」戰 meaning *to challenge*; 挑 and 排) or similar sounding characters (e.g., 「但是」＞「且是」 meaning *yet*).

This finding based on L2 writers, together with those of previous studies on native speaking children, seems to suggest that whether writing in Chinese as an L1 or L2, students need adequate orthographic processing skills to support their writing development. It supports the finding of a recent study on L2 Chinese written composition in a group of students with a similar profile in Hong Kong (Wong, 2018). It also seems to corroborate the findings of our own previous studies that orthographic processing was consistently a significant predictor of Chinese word reading or reading comprehension, disregarding students' L1 or L2 status (Authors blinded for review, 2011; Author blinded for review, 2017).

The lack of a unique, significant contribution of syntactic or sentence processing was against our prediction. Because syntactic processing was operationalized in this study as a skill important for text generation, we expected that the contribution would be independent and significant. This finding also seems to contradict those of previous studies on L1 as well as L2 writers. In a few recent studies on native-speaking Chinese writers (e.g., Authors blinded for review, 2014; Yeung et al., 2013b), syntactic awareness / processing was found to be a significant predictor of written composition when other related skills were controlled for. In a study that aimed to document the developmental relationship between Dutch-speaking students' L1 and English L2 writing, Schoonen, van Gelderen, Stoel, Hulstijn, and de Glopper (2011) found grammatical knowledge to be a unique, significant predictor in both languages.

Theoretically, it does not seem to make sense to draw a conclusion from the present study that syntactic processing is unimportant to L2 Chinese writers. We conjecture that the result

might be attributed to students' developmental stage or low proficiency in Chinese. The participants in this study had studied Chinese only for a few years, although their period of residence in Hong Kong was overall longer. At this developmental stage, although theoretically syntactic knowledge is fundamental to their writing (and reading) activities, it may not emerge to account for learners' composition quality if composition all remains at the rudimentary level. This can be seen from students' very low performance, and huge variability in performance, across the three types of writing (see Table 1). In other words, whether syntactic knowledge would surface as an independent predictor may depend on learners' developmental stage. Additionally, this unexpected result might be related to the moderate to high correlations between the orthographic and syntactic processing measures, which suggests that orthographic processing might have actually mediated the effect of syntactic processing on written composition.

Contributions to Written Composition in Different Genres

To answer the second research question, we fitted to the data an SEM model where the predictors remained the same but narration, explanation, and argumentation were modeled as separate skills. Slightly different patterns of predictive relationships were found for the three genres of writing based on significance testing for each skill as an independent predictor; more importantly, comparisons of the strength of prediction of each skill between the three genres of writing also revealed some interesting patterns. Overall, some predictions appeared to be supported, whereas others came out of our expectations.

Working Memory, in the presence of all other predictors, including students' years of residence in Hong Kong and their nonverbal ability, was a (marginally) significant predictor of explanation and argumentation writing rather than narration writing. The comparisons of the

strength of its path coefficients (Table 4) revealed that it had the greatest effect on explanation; its effect on narration appeared to be the least in strength. Theoretically this finding seems to be reasonable as explanation (and argumentation) writing tends to be cognitively more demanding. From the perspective of text generation, for example, formulating ideas for explanation and argumentation purposes tends to be a more complex process and requires writers to hold multiple pieces of information in mind concurrently and constantly updating information – a process much more than following a temporal order, a characteristic of narration writing – for coherence building. The heightened role of working memory is perhaps also in alignment with the finding reported in Table 4 on the stronger effect of nonverbal ability on explanation and argumentation than on narration. Compared to the two other genres of writing, narration seemed to more depend on the learners' years of residence in Hong Kong (see Table 4). This seems reasonable because narration has a stronger basis in learners' oral language proficiency, which developmentally should be closely related to their years spent in the target language community.

Turning to Orthographic Processing, Table 4 indicates that there was little difference in the magnitude of its effect on the three types of writing, although it was identified to be a significant predictor of explanation and argumentation as opposed to narration when the effects of the other four predictors were also considered. This finding was perhaps not at all unexpected because writing requires orthographic skills for accurate and fluent word spelling or transcription. In this regard there should reasonably be little difference between narration, explanation, and argumentation, although at the grammatical and discourse level, the three genres have notable differences as discussed earlier in this paper.

Sentence Processing did not surface as a significant predictor when the other four predictors were also considered for any one of the three types of genre. On the other hand, as

shown in Table 4, its effect on narration was stronger than on explanation and argumentation. We speculated earlier on students' developmental stage as a possible reason why syntactic processing did not emerge as a significant, independent predictor. Here we focus on why the strength of relationship was stronger for narration, which actually came as a surprise, because, as discussed earlier in this paper, explanation and argumentation texts are usually grammatically more complex than narration. We conjecture this finding might be a result of the nature of the grammatical competence measured in the grammaticality judgment and the sentence integrity task. More specifically, while a number of key syntactic features were covered in the tasks, they might be more representative of those features important for constructing narratives (e.g., the *ba* and *bei* structures and aspectual markers) than for explanation and argumentation (e.g., compound connectives for indicating logical relationships like 雖然… 但是… *although… but…* or 即使…也… *even if …*).

Limitations and Directions for Future Research

We acknowledge the caveat that better tasks could have been used to represent some skills measured in this study, and there could be other predictor tasks that might also explain Chinese writing performance. For example, the sentence processing tasks could have been more characteristic of syntactic features of all focal genres. In addition, the sentence integrity appeared to be particularly challenging to the learners, which might be because of a focus of the task on syntactic features not represented in the learners' native language(s). The working memory tasks were administered in L2 / Cantonese because the participants' diverse L1s had made it virtually impossible for L1-mediated administration. Although we tried to make the prompt sentences as simple as possible lexically and grammatically, and the participants were overall

conversationally fluent in Cantonese, there was a possibility that their performance on the working memory tasks might have shown some influence from L2 proficiency.

Because working memory is a system comprising separable but related components, multiple tasks are needed to study alternative theoretical accounts of working memory capacity (Alloway, Pickering, & Gathercole, 2006). One such task is memory updating for more fine-grained results. As a system comprising separable components and multiple tasks, working memory needs to be assessed over time to examine different theoretical accounts of capacity and processing (Kellogg et al., 2014; Olive, 2012).

The integrated studies of hand writing, spelling and writing-reading relationship are other candidates (Abbott et al., 2010). For example, the design of the present study could have been augmented with measures of character writing or word dictation and hand writing fluency. Yeung et al. (2016) tested the simple view of writing in L1 Chinese with measures of a number of transcription, oral narrative, and cognitive skills. More skills than what were measured in the present study could be tested in the future to examine whether that view would hold for L2 writers. Further, the criterion tasks of different genres of written composition could be strengthened. Finally, the present study focused on L2 writers. The diverse considerations in the literature on Chinese (L1) writing development for predictors and written composition measures have made it difficult to subject their findings to reliable comparisons with those of the present study. Future studies could consider including an appropriate L1 group and directly compare the patterns of contributions made by different skills to writing in different genres.

Summary and Conclusion

The present work is one of the first of its kind that studied the psycholinguistic and cognitive underpinnings of writing in different genres in L2 Chinese writers. Focusing on a

group of adolescent ethnic minority students in Hong Kong, this study showed that orthographic processing and working memory, as opposed to syntactic processing, as two significant, independent contributors to the students' L2 composition represented by narration, explanation, and argumentation. Subsequent separate analyses for the three types of genre, however, found varied patterns of how the measured subskills contributed to Chinese written composition. Two notable findings are the stronger involvement of cognitive skills in explanation and argumentation writing than in narration and the importance of orthographic processing across genres of writing. The latter finding, in conjunction with those of previous studies on reading (Authors blinded for review, 2011; Author blinded for review, 2017), suggests that orthographic processing is essential to literacy development in Chinese disregarding who the learners are and where Chinese literacy is learned. These results highlight the distinctive characteristics of the Chinese writing system. On the other hand, the lack of syntactic processing to writing in general may point to a distinctive pattern of L2 writers, suggesting that how subskills contribute to written composition may be influenced by learners' general proficiency or vary at different developmental stages. These findings, although based on L2 Chinese writers, enriched our understanding about Chinese writing and L2 writing in general.

Several implications for pedagogy for L2 Chinese writing could also be drawn from the present findings. First, orthography-based skills warrant particular pedagogical attention. The importance of orthographic processing revealed in this study through the SEM analysis was actually substantiated by our subsequent studies of writing errors not reported in detail in this paper. Some of the errors could be traced to the students' difficulties in hand writing and writing to dictation (refer to the example provided in the Discussion section). These writing skills in turn

could be linked to an understanding of the compositionality of the stroke patterns and stroke sequencing.

Second, given the importance of working memory capacity, working memory training could be a possible target of pedagogical attention (Klingberg, 2010). Teachers could help students to focus attention on important information and to suppress tangential ideas to foster efficient writing (Torrance & Galbraith, 2006). This may be particularly important when L2 writers compose in cognitively more demanding genres (e.g., argumentation). Kellogg (2008), for example, discussed the progression of writing from the knowledge telling and knowledge transforming phases (Bereiter & Scardamalia, 1987) to his advanced "knowledge crafting" phase as involving multi-faceted representations in working memory and the coordinating of multiple writing processes.

Finally, although sentence processing did not surface as a significant, independent predictor of written composition, the finding should by no means be interpreted to imply that grammar is unimportant for L2 writing. Learning to use grammar integrated into text and context should be encouraged in the classroom (Donovan & Smolkin, 2006; Hyland, 2007). The differential patterns of relationships found for different genres also points to a need for genre pedagogy (Rose, 2008).

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Authors blinded for review. (2018).

Appendix

Rubric for scoring written Chinese compositions

語篇 (Discourse)

詞彙 lexis	詞彙是指作者用來建立文章語場的字詞選擇。請*標示出作者使用到的字詞。*作者使用的字詞是否多樣化？字詞的使用是否恰當？ Lexis refers to the choice of characters and words to establish the linguistic "field". Are the characters and words used appropriately? Are there varieties of words?	0-3
評價 appraisal	這是指作者用來評價的字詞，包括感覺、對人物的評論、對事物的評賞，與及增強和減弱的詞語。*請標示出作者使用到的評價字詞。*作者用來評價的字詞是什麼？是否能恰當的使用評價字詞以達到吸引、游說和評審的目的？ Appraisal refers to the use of suitable words to show emotion, the assessment of people, ideas and objects. What and how are the appraisal words used? Do they achieve the aim of persuasion and assessment?	0-3
連詞 conjunction	連詞表示出句子間和句子內的邏輯關係。*請標示出作者使用到的連詞。*有時句子的邏輯關係也可能是隱性的。是否所有句子的邏輯關係皆為清晰？ Conjunction shows the inter-relation and integration of sentences. What and how well are the inter-sentential connectives used? Are they clear and explicit?	0-3
照應 reference	照應是用以追踪文本中人和事的字詞，包括代名詞、指示詞 (這個、那個)等。*請標示出所有照應詞。*每句所照應的人物或事物是否清晰？ References include the use of anaphoras (pronouns), linguistic pointers (e.g., this, that), discourse pointers, and contrastives to show temporal relations. Are the references well used?	0-3

語法 (Grammar)

	中文書面語的語法運用是否準確?就其所處的學習階段,文中使用的句式和詞組是否多樣化?句法使用是否恰當或過於簡單? Proper use of grammar will serve as inter-language to bridge the gap between spoken Cantonese and modern written Chinese. Are there varieties of sentences, both simple and complex? Is the usage suitable?	0-3

Table 1

Descriptive Statistics, Reliability, and Inter-Correlations of Variables

	Task	*M*	*SD*	Reliability	1	2	3	4	5	6	7	8	9	10	11
1	Wnar	9.16	7.71	.87	–										
2	Wexp	9.51	7.23	.76	.73***	–									
3	Warg	7.11	6.46	.90	.69***	.70***	–								
4	VSWM1	6.20	3.79	.94	.56***	.66***	.55***	–							
5	VSWM2	5.93	3.99	.94	.61***	.62***	.56***	.88***	–						
6	OrthoCh	15.43	5.15	.93	.60***	.58***	.54***	.54***	.53***	–					
7	OrthoCon	9.91	5.02	.87	.69***	.64***	.61***	.57***	.58***	.74***	–				
8	Grammar	15.75	6.17	.89	.61***	.63***	.58***	.60***	.60***	.74***	.80***	–			
9	SentInt	7.94	6.72	.88	.64***	.71***	.66***	.61***	.60***	.61***	.78***	.69***	–		
10	Matrix	107.22	16.54	.85	.36***	.45***	.44***	.29***	.32***	.25**	.29***	.38***	.32***	–	
11	YrHK	10.11	5.12	–	.26**	.20*	.19*	.28***	.25**	.24**	.22*	.07	.16^	.05	–

Note. Reliability refers to inter-rater reliability for Wnar, Wexp, and Warg; and Cronbach's α for all other variables.

Wnar = narration writing; Wexp = explanation writing; Warg = argumentation writing; VSWM = verbal span working memory; OrthoCh = orthographic choice; OrthoCon = orthographic choice in context; Grammar = grammaticality; SentInt = sentence integrity; Matrix = non-verbal ability; YrHK = years of residence in Hong Kong.

^ $p < .10$ * $p < .05$ ** $p < .01$ *** $p < .001$

Table 2

Structural Parameter Estimates of the SEM Model Predicting Written Composition

Dependent Variable	Predictors	β	p	R^2
Measurement Model (factor loadings)				
Working Memory	← VSWM1	.941	<.001	.885
	← VSWM2	.930	<.001	.865
Orthographic Processing	← OrthoCh	.804	<.001	.646
	← OrthoCon	.918	<.001	.843
Sentence Processing	← Grammar	.853	<.001	.727
	← SentInt	.812	<.001	.660
Written Composition	← Wnar	.835	<.001	.697
	← Wexp	.869	<.001	.755
	← Warg	.807	<.001	.651
Structural Model (path coefficients）				
Written Composition	← Working Memory	.314	.007	.801
	← Orthographic Processing	.631	.042	
	← Sentence Processing	-.080	.829	
	← Matrix	.230	.001	
	← YrHK	.017	.828	

Note. VSWM = verbal span working memory; OrthoCh = orthographic choice; OrthoCon = orthographic choice in context; Grammar = grammaticality; SentInt = sentence integrity; Wnar = narration writing; Wexp = explanation writing; Warg = argumentation writing; Matrix = non-verbal ability; YrHK = years of residence in Hong Kong.

Table 3

Structural Parameter Estimates of the SEM Model Predicting Different Types of

Written Composition

Dependent Variable	Predictors	β	p	R^2
Wnar	← Working Memory	.106	.372	.567
	← Orthographic Processing	.238	.452	
	← Sentence Processing	.385	.294	
	← Matrix	.083	.269	
	← YrHK	.123	.131	
Wexp	← Working Memory	.397	.003	.599
	← Orthographic Processing	.712	.059	
	← Sentence Processing	-.343	.446	
	← Matrix	.244	.003	
	← YrHK	-.051	.564	
Warg	← Working Memory	.271	.056	.508
	← Orthographic Processing	.702	.068	
	← Sentence Processing	-.302	.512	
	← Matrix	.262	.002	
	← YrHK	-.033	.722	

Note. Factor loadings in the measurement model are not included because they were largely the same as those shown in Table 2.

Wnar = narration writing; Wexp = explanation writing; Warg = argumentation writing; Matrix = non-verbal ability; YrHK = years of residence in Hong Kong.

Table 4.

Model Comparisons to Test the Equivalence of Effect of Each Latent Predictor on Each Genre of Writing

Model		Parameter Constrained	$\chi^2(df)$	CFI	RMSEA (90% CI)	$\Delta\chi^2(df)$	Summary
Baseline Model							
	Model 2		43.353(23)**	.980	.083(.043, .120)	–	– –
Model Comparisons							
MEM:	Model 2a1	Wnar – Wexp	47.677(24) **	.977	.087(.050, .124)	4.324(1)*	Wnar < Wexp
	Model 2a2	Wnar – Warg	44.221(24) **	.980	.081(.042, .118)	.868(1)	Wnar = Warg
	Model 2a3	Wexp – Warg	44.904(24) **	.980	.082(.043, .119)	1.551(1)	Wexp = Warg
ORTHO:	Model 2b1	Wnar – Wexp	45.304(24) **	.979	.083(.044, .120)	1.951(1)	Wnar = Wexp
	Model 2b2	Wnar – Warg	44.616(24) **	.980	.082(.043, .118)	.1263(1)	Wnar = Warg
	Model 2b3	Wexp – Warg	43.430(24) **	.981	.079(.039, .116)	.077(1)	Wexp = Warg
SENT:	Model 2c1	Wnar – Wexp	47.616(24) **	.977	.087(.050, .124)	4.263(1)*	Wnar > Wexp
	Model 2c2	Wnar – Warg	46.686(24) **	.978	.086(.048, .122)	3.333(1)^	Wnar > Warg
	Model 2c3	Wexp – Warg	43.396(24) **	.981	.079(.039, .116)	.043(1)	Wexp = Warg
YrHK:	Model 2d1	Wnar – Wexp	47.493(24) **	.977	.087(.050, .123)	4.140(1)*	Wnar > Wexp
	Model 2d2	Wnar – Warg	46.543(24) **	.978	.085(.048, .122)	3.19(1)^	Wnar > Warg
	Model 2d3	Wexp – Warg	43.419(24) **	.981	.079(.039, .116)	.066(1)	Wexp = Warg
BASScale:	Model 2e1	Wnar – Wexp	46.651(24) **	.978	.086(.048, .122)	3.298(1)^	Wnar < Wexp
	Model 2e2	Wnar – Warg	46.269(24) **	.978	.085(.047, .121)	2.916(1)^	Wnar < Warg
	Model 2e3	Wexp – Warg	43.370(24) **	.981	.079(.039, .116)	.017(1)	Wexp = Warg

Note. MEM = Working Memory; ORTHO = Orthographic Processing; SENT = Sentence Processing; YrHK: years of residence in Hong Kong; BASScale: nonverbal ability; Wnar = narration writing; Wexp = explanation writing; Warg = argumentation writing.
^ $p < .10$ * $p < .05$ ** $p < .01$

Figure Caption

Figure 1. Path diagram modeling Chinese written composition performance.

MEM = Working memory construct subserved by verbal working memory (VWM1 & VWM2); ORTHO= Orthographic processing construct subserved by orthographic choice (OrthoCh) and orthographic choice in context (OrthoCon); SENT = Sentence processing construct subserved by grammaticality (Grammar) and sentence integrity (SentInt); WRITE = Written composition performance construct subserved by narration (WNar), explanation (WExp) and argumentation (WArg) written composition; Matrix = non-verbal ability; YrHK = years of residence in Hong Kong.

$^\wedge p < .10$ $* p < .05$ $** p < .01$ $*** p < .001$

Figure 2. Path diagram modeling performance on different types of written composition.

MEM = Working memory construct; ORTHO= Orthographic processing construct; SENT = Sentence processing construct; WNar = narration writing; WExp = explanation writing; WArg = argumentation writing; Matrix = non-verbal ability; YrHK = years of residence in Hong Kong.

$^\wedge p < .10$ $* p < .05$ $** p < .01$ $*** p < .001$

X2(33) = 55.79, p = .008; CFI = .978, RMSEA = .073 (CI: .038, .106)
* p < .05   ** p < .01   *** p < .001

YrHK

-.033   -.051   .123

.080   -.07

MEM

.106   WNar

.397**   .238

.591***

ORTHO

.712^   .385   WExp

.324***

.271^

.702^

1.045***   .328***

.714***

-.343

WArg

.325***

SENT   -.302

.244**

.302***

.314***   .083

.425***   .262**

Matrix

X2(23) = 43.35, p = .006; CFI = .980, RMSEA = .083 (CI: .043, .120)

^ p < .10   * p < .05   ** p < .10   *** p < .001