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Contribution of Working Memory, Orthographic and Sentential Processing to Chinese Text Comprehension by Tibetan and Yi Students

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ABSTRACT

Two groups of 12-year-old ethnic minority (EM) users of alphasyllabary (66 Tibetan and 45 Yi) were compared with 42 Han Chinese students in comprehending Chinese narrative and expository texts, each with inferential questions requiring short open-ended written answers. Three constructs (verbal working memory, orthographic and sentential processing), each with two indicators, were hypothesized to predict text comprehension differentially in the three groups. A 43-item Students' Approaches to Learning (SAL) scale showed the EM students might not have developed effective strategies in learning Chinese. A task x group MANCOVA with SAL as covariate showed substantial differences in the students' performance. Multiple comparisons found group differences changed across tasks. Structural equation modeling, multiple regression analyses point to the significant and differential contribution of the constructs and the tasks to the two genres of Chinese text comprehension in the different groups. Educational implications include strengthening teaching the structure and function of Chinese characters, words, syntax and the need for adaptive curriculum materials.

INTRODUCTION

Children's reading comprehension has been shown to be influenced by phonological sensitivity (Cain, Oakhill, & Bryant, 2004); oral language skills (Hulme & Snowling, 2011; Kendeou, van den Broek, White, & Lynch, 2009); and rapid, automatic decoding of words (Perfetti, 2007). There is also a confluence of cognitive and metacognitive strategies. These include verbal working memory (Cain, et al., 2004; Swanson, 1992), monitoring comprehension, activating background information, integrating multiple strategies of questioning, clarifying and searching for information, identifying text themes, summarizing main points and predicting outcomes (Oakhill, Cain, & Bryant, 2003; Perfetti, Landi, & Oakhill, 2005; Willson & Rupley, 1997). The Reading Systems Framework recently proposed by Perfetti and Stafura (2014) emphasize the interaction between the word identification system and the comprehension system in building propositional units in text comprehension. In addition, the socio-emotional factor of motivation also contributes to reading comprehension (Baker & Wigfield, 1999; Cartwright, Marshall, & Wray, 2015; Guthrie et al., 2007; Lin, Wong, & McBride-Chang, 2012; Wigfield & Guthrie, 1997).

The various studies cited above pertain almost entirely to the alphabetic writing system, particularly the English orthography. In what way do similar theoretical notions of reading comprehension apply to the morphosyllabic Chinese writing system? What are some of the linguistic, cognitive and emotive factors which may explain individual differences in reading Chinese text by ethic or language minority (EM/LM) Tibetan and Yi students? These are the main issues that the present study examined.

At the outset these questions may be asked: Why studying Chinese text comprehension and with the minority Tibetan and Yi students in China? On the broad question of studying Chinese we aimed at examining some linguistic, cognitive and motivational factors that may be universal in processing different language and writing systems and that may also be specific to particular systems (Perfetti, Cao, & Booth, 2013). Research findings will add to what is known from studies of alphabetic systems and also go beyond "Anglocentric" research issues (Share, 2008) in our quest toward a "universal science of reading" (Perfetti, 2003; Perfetti et al., 2013). On the question of studying the reading performance in Chinse of these ethnic minority Tibetan and Yi LM groups we also aimed at deriving appropriate and effective instructional principles (Cuo, 2011; Tsung, 2009; Tsung & Cruickshank, 2009; Tsung, Wang, & Zhang, 2012).

SKETCH of LINGUISTIC CHARACTERISTICS of TIBETAN, YI and CHINESE

We first provide a sketch of the linguistic background of the Tibetan and Yi minority students and the salient characteristics of the Han Chinese writing system. We then focus on these linguistic minority students' orthographic and sentential processing skills, their working memory capacity and reading engagement in an attempt to understand the multi-componential text comprehension of Chinese.

The linguistic minority learners in this report were predominantly of ethnic Tibetan origin from Qinghai Province and from Liangshan Yi Autonomous Prefecture of south-western Sichuan Province in China. These EM students were compared with ethnic Han students drawn from the same schools. Modern printed Tibetan (the *dbu can* script) is phonologically based and typologically is an alphasyllabary (Daniels & Bright, 1996; van der Kuijp, 1996).The Yi script or Wei writing is syllabic and also morphemic (Daniels & Bright, 1996; Shi, 1996). In Yi a single symbol is matched with a single syllable and this leads to the claim that the Yi writing is similar to the morphosyllabic Chinese writing system (Wasilewska, 2012). These alphasyllabaries write each consonant-vowel sequence as a unit in which the obligatory vowel diacritically modifies the consonant (Daniels & Bright, 1996). Studies suggest that in learning to read words in alphasyllabaries, children make use of phonological and orthographic representations and older grade school children may be using a mixture of phonological and orthographic strategies according to task demands. The question arises: Would these minority alphasyllabary language users, who speak their home languages and learn Chinese in school, be using similar strategies as ethnic Han Chinese students in learning to read the morphosyllabic Chinese?

To answer this question we first outline the main characteristics of the Chinese writing system relevant to the present study. At the lexical level the basic processing units of Chinese characters are visually complex. An example is the two-character word 染料 or 染 ("dye stuff, dye") which is often written incorrectly, even by adult learners, with the constituent of 丸 ("pill") in the top right-hand corner of 染, thus creating a pseudoword. The original word when decomposed denotes using water (the three dots to the left), wood as dye stuff (the bottom half) and rinsing nine times (top right component) to make the color fast. Knowledge of orthographic constraints of character components and their function is critical to the learning of characters and words, which in turn underpins sentence comprehension.

At the sentence level there are certain characteristics in Chinese which may make for difficulties for learners (Li & Thompson, 1981; Wang & Yang, 2008). Native Chinese readers rely both on word meaning and the canonical subject-verb-object (SVO) word order in interpreting simple noun-verb-noun (NVN) Chinese sentences. When there is a conflict between the two kinds of information, word meaning predominates and children tend to adopt the semantic strategy (Miao, 1981, 1999; Miao & Zhu, 1992).

While Chinese sentences are basically of the canonical subject-verb-object (SVO) kind, they also admit of subject-object-verb (SOV), and verb-object-subject (VOS) arrangement, especially in oral communication. (Chao, 1968; Li & Thompson, 1981). This flexible sentence arrangement is one source of difficulties for learners. Syntactically and semantically plausible sentences are another source of difficulty for all Chinese learners. A sentence such as "Visiting relation is fun" can be interpreted according to the phrase structure constraint or Halliday's (2004) constituency analysis with minimum and maximum bracketing in systemic functional linguistics. The topic could either be "relation" or the act of "visiting". A corresponding sentence in Chinese could be: "咬死了 / 猎人的狗 or 咬死了猎人的 / 狗。(literally "[Biting dead] [hunter's dog]" or "[biting dead hunter] [dog]" or "The dog that bites dead the hunter.")

Another characteristic of Chinese sentences causing difficulties for non-Chinese speakers is the use of semimorphological markers such as *bei* 被 and *ba* 把 (to hold). These linguistic devices are used in the absence of morphological markers such as inflection, tense, number, gender and case. The marker *bei* is meant to express unhappy or unexpected events. An example is: 我們被 [*bei*] 人打了。("We are [were] beaten by others") but not with the negation: *我們被 [*bei*]人不打了。("We were not beaten by others."). The marker *ba* is used in a sentence such as 我把那本书卖了。("I [*ba*] that book sold") but this marker cannot be used with negation such as *我把那本书不卖了。("I [*ba*] that book not sold"). All these linguistic principles were utilized in our design of appropriate lexical and sentential tasks, as discussed in the relevant sections.

For the framework of our study, we were broadly guided by the "Blueprint of the Reader" in comprehending language by Perfetti (2000, summarized in variant schematic Blueprints in Figure 6.1 and Figure 6.2; Perfetti et al., 2005; Perfetti, Liu, & Tan, 2002). The Blueprint shows a dynamic pattern of a series of interacting linguistic systems involving orthographic, morphological, phonological and semantic units affecting comprehension processes (see also Reading Systems Framework of Perfetti & Stafura, 12014). From the concept-driven and datadriven perspectives of the Blueprint, comprehension processes involve a complex network of microstructure and the global macrostructure forming the textbase which enables the comprehender to construct a situation model to integrate language and text information (Kintsch & Kintsch, 2005; Perfetti, 2000).

The Blueprint has been tested empirically in different writing systems including English, Chinese and Korean (see also Perfetti, 2003; Perfetti et al., 2013). The psycholinguistic and cognitive processes schematized in the Blueprint are in general accord with modern grammar of both spoken and written Chinese as explicated by the eminent Chinese linguists Yuen Ren Chao (1968) and Lee Wang (1985), among other scholars.

LINGUISTIC and COGNITIVE FACTORS

The present study focused on the contribution to Chinese text comprehension at the levels of characters/words and sentences; and the effect of verbal working memory. The study also examined the effect of reading engagement on reading comprehension.

Orthographic and Sentence Processing

Orthographic processing in Chinese is defined operationally as the understanding of the positional constraint of intra-character constituents of the semantic and phonetic radicals, their integration and function. Such knowledge also extends to the inter-character integration to form new words. Language minority students may have difficulty in differentiating the visual-orthographic constraints of Chinese characters and the phonetic and semantic functions of character components. Orthographic skills at the radical level were shown by Leong, Tse, Loh, and Ki (2011) to predict significantly Chinese reading comprehension in third grade alphasyllabary language users learning Chinese in Hong Kong, after controlling for working memory and rapid naming. Using a picture-character verification task, Tong and Yip (2015) showed experimentally that learners of Chinese as a foreign language used both phonetic and semantic radicals to code novel characters, but clearly preferred semantic radicals over phonetic ones.

At the sentence level, Yeung et al. (2011) used oral cloze tasks of the kind "My favorite food is ________ ." to gauge Chinese children's syntactic skill. But this is more of a sentence completion task and allows for a range of answers. Chik et al. (2012) also used as sentence processing skills the cloze type tasks, but added word order and connectives to study sentence reading comprehension of Grades 1 and 2 Chinese children. In a hierarchical multiple regression analysis, age, IQ and Chinese word reading were found to account for 64% of the individual variation while composite syntactic skills added a significant 4% of the variation. Chung, Ho, Chan, Tsang, and Lee (2013) found syntactic awareness made a significant independent contribution to Chinese reading comprehension and word reading over and above the contribution of morphological awareness, vocabulary knowledge and working memory. Similarly, Tong, Tong, Shu, Chan, and McBride-Chang (2014) showed that syntactic skills, especially a conjunction cloze task, contributed unique variance to reading comprehension in 11-year old Chinese children after controlling for age, nonverbal IQ, phonological and morphological awareness and vocabulary knowledge, as well as auto-regressive effects of earlier reading comprehension skills.

Verbal Working Memory

In addition to the linguistic component skills affecting reading literacy in Chinese as discussed briefly above, cognitive factors are also involved. The main one is verbal working memory. Working memory refers to processing resources of limited capacity that individuals need to maintain information while simultaneously acting on the same or other information. Verbal working memory tasks generally require respondents to hold increasingly complex verbal information in memory while responding to questions about the tasks. These memory tasks have been shown to play a role in activating and integrating information in text comprehension (Cain et al., 2004; Daneman & Carpenter, 1983; Daneman & Merikle, 1996; Seigneuric & Ehrlich, 2005); and in differentiating between learning disabled and skilled readers (Swanson, 2003).

This finding also applies to text comprehension in Chinese as shown by Leong, Tse, Loh, and Hau (2008) in their study of inferential text comprehension with an open-ended written answer format in 518 Grades 3 to 5 Chinese children. Using structural equation modeling and hierarchical multiple regression analyses, Leong et al. found that verbal working memory, together with a small contribution from Chinese pseudoword reading, had a strong and unique effect on Chinese text comprehension.

Students' Approaches to Learning (SAL)

There are also the effects of socio-psychological aspects of motivation on language learning including reading (Baker & Wigfield, 1999; Dörnyei & Ushioda, 2011; Guthrie et al., 2007; Lin et al., 2012; Wigfield & Guthrie, 1997).). Using interview-based coding of motivation derived from the Motivations for Reading Questionnaire (MRQ) with 18 items, Guthrie et al. (2007) found 31 fourth-grade American children's reading motivation to be a multifaceted construct with multiple constituents including self-efficacy, curiosity or interest, and social interaction. The MRQ was adapted by Lin et al. (2012) to study reading motivation and reading comprehension in 104 Hong Kong Chinese fifth graders reading Chinese and English as a foreign language. However, the modified MRQ subscales explained only 16% variance in Chinese and 12% variance in English.

Further search of the literature showed the well-validated and cross-cultural Students' Approaches to Learning (SAL) scale to be most appropriate for assessing cognitive-affective aspects of academic learning. SAL is based on "OECD's brief self-report measure of educational psychology's most useful affective constructs" (Marsh, Hau, Artelt, Baumert, & Peschar, 2006, p. 311) and assesses self-regulated learning strategies, motivation, self-beliefs and learning preferences. It is derived from the data base of approximately 4,000 fifteen-year-olds from 25 countries in OECD's Program for International Student Assessment (PISA) (OECD, 2001). From the original 53 items 43 items pertaining to reading and learning grouped into 11 dimensions were used for our study. These items were then translated into Chinese and also back translated into English as a check for fidelity. The translated Chinese version was given to all the students. The SAL is further described under the Section on tasks.

The PRESENT STUDY

Research Questions

In the present investigation we were interested in the performance of two groups of Tibetan and Yi speaking EM students, compared with their Han Chinese age controls, in Chinese (*Hanyu*) text comprehension and related tasks. These were our research questions:

(1) Do the three groups of students differ in their motivation in learning Han Chinese? This information would provide some insight into aspects of self-efficacy and learning strategies in the absence of other relevant information such as home background and parental education because of privacy laws.

(2) Do the ethnic minority learners perform less well in reading-related tasks in Chinese compared with their Han Chinese age peers because of their different cultural and linguistic milieu?

(3) What is the role of the constructs of verbal working memory, orthographic and sentential processing in accounting for individual variation in elementary Chinese text comprehension in the different groups of students? Does the contribution of these constructs differ for expository and narrative texts, as assessed by short written answers to open-ended inferential questions?

Participants

The participants consisted of 66 Tibetan EM students (Tib) with 30 boys and 36 girls (mean age = 12.36 years, *SD* = .87 year); 45 Yi EM students (Yi) with 20 boys and 25 girls (mean age = 12.42 years, *SD* = .69 year); 42 Han Chinese students (Han) with 19 boys and 23 girls (mean age of 12.48 years, *SD* = .59 year); and 153 students for the total group with 69 boys and 84 girls (mean age of 12.41 years, *SD* = .75 year). One-way ANOVA found there was no age difference among the 3 groups. These students were recruited because the first author has been working with their teachers on a number of occasions and knows the regions well.

Tasks and Procedure

To ensure consistency all the tasks were administered in Han Chinese in the schools by the second author assisted by the classroom teachers. We first assessed the students' approaches to learning. We then administered to the students specially designed reading or reading-related tasks conceptualized as constructs, each of which was subserved by multiple indicators: Chinese text comprehension task with 4 short texts, verbal working memory with 2 tasks, orthographic processing with 2 tasks, and sentence processing with 2 tasks. The details of these tasks are described below.

Students' Approaches to Learning (SAL)

The 43-item SAL scale (Marsh et al., 2006) in simplified Chinese provides a five-point written response from 1 meaning strongly disagree to 5 meaning strongly agree. Students would simply mark the 1 to 5 values to indicate the degree of their disagreement or agreement with the statement. The administration of the scale took 10 minutes plus a few minutes for instruction. Some sample items from the original factors are: "I study in order to get a good job" (dimension of motivation); "When I study, I will work as hard as possible" (dimension of learning strategies); "I can learn something well if I want to" (dimension of self-belief) and "I read in my spare time" (dimension of motivation). The SAL should provide some basis to gauge the students' motivation to learning in general and reading in particular.

Text Comprehension

The criterion Chinese text comprehension task was modified and simplified from that used by Leong et al. (2008). From the original 8 texts 2 expository and 2 narrative passages with about 100 characters each (M = 113) were deemed suitable and rewritten to the level of the students. The narrative passages were on the topics of: "Shutting the Pen after Losing the Sheep" (Text 1), "Peanuts" (Text 2). The expository passages were on the topics of "Pearl of the Orient" (Text 3), and "Alfred Nobel" (Text 4). The contents were familiar to the students to ensure that background knowledge would not have an undue effect on comprehension.

The text comprehension task with the 4 passages, each followed by 3 open-ended inferencing questions, was administered to groups of students as a reading-writing task in 40 minutes plus about 10 minutes for a short practice example. The students were told to read silently each printed passage on the top half of each page, to write down on the bottom half of the proforma their written answers to each of the inferencing questions, and not to worry about writing errors or grammatical construction in their short answers. Credits of 0, 1, 2 or 3 were awarded for each answer according to its shallowness or depth of the written answers in relation to the inferencing question. Writing errors and poor grammatical construction were discounted in the scoring. Inter-rater reliability of the text comprehension task was assessed on the performance of a group of 28 students not in the study. The coefficients of .95, .98, .96 and .93 respectively for each of the 4 passages suggest there was high consistency in marking according to the scoring scheme

Orthographic Processing

Orthographic constraints. The basic idea is derived from the orthographic constraints test for English by Treiman (1993, pp. 167-170). This test consists of 16 pairs of non-words and children are asked which item conforms to the orthographic pattern of English (e.g., *ckun, nuck*; *beff, ffeb*). Our version (OrthoC) consists of 15 items. Each item has five orthographically similar graphic symbols with one correct real Chinese character and 4 pseudo-character foils. The task was administered to groups of students and the administration time was 8 minutes. One mark was awarded for each correct answer and the maximum score was 15. Cronbach's alpha coefficient was .741.

Orthographic choice. The orthographic choice (OrthoCh) task required students to read silently and rapidly 20 item-pairs of two-character words printed on a sheet and to circle the one 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., soap, sope; gawn, gone).

For this task we attempted to cover different kinds of Chinese words. 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 牛奶 (milk) 牛乃 (a pseudoword); (b) 5 item-pairs of regular inconsistent characters (characters pronounced the same as the phonetic radicals but with different tones) such as 米饭 (cooked rice) 米反 (rice against, a pseudoword); and (c) 5 item-pairs of irregular or exception characters (characters pronounced with different sounds and tones from the phonetic radicals in isolation) such as 地铁 (underground rail or metro) 地跌 (ground fallen, a pseudoword). The total testing time for this task was 8 minutes and the maximum score was 20. Cronbach's alpha coefficient was .629.

Sentence Processing

In essence, syntactic processing and sentential comprehension involve the integration of different information sources and are constrained by these linguistic categories: (a) word-level constraints such as grammatical categories, (b) contextual constraints particularly important for the resolution of plausibilities and ambiguities, (c) working memory capacity and processing efficiency, and (d) phrase structure contexts (Gibson & Pearlmutter, 1998). There were two tasks in this construct, one is on grammaticality and the other on the detection and correction of syntactic errors in short sentences.

Grammaticality task. In second language learning grammaticality judgment or grammaticalness in language is considered to elicit a particular kind of sentence processing involving word order (McDonald, 2000; Munnich, Flynn, & Martohardjono, 1994). 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 adapted the Chinese version of 22 parallel pairs of grammatically correct and grammatically anomalous simple sentences from Leong, Tsung, Tse, Shum and Ki (2012) who used reaction time measures as the metric. These sentences emphasize 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。meaning "you are my best friend"); (*我两年中文学了。vs. 我学了两年中文。meaning "I have learnt Chinese for two years"). These 22 pairs of sentences were arranged at random on the printed page and administered as a paper-and-pencil task for group administration. The participants were asked to check YES or NO to the grammatically correct or incorrect sentence. One mark was given to the correct choice and the maximum score was 44. The reliability from the original Leong et al. (2012) RT measures was .991.

Sentence integrity task. The aim of this task with 26 short sentences was to tap the learners' implicit understanding of standard modern Chinese and the explicit production of correct sentences. Each of these sentences contains an error which violates syntactic integrity because of the use of "interlanguage" from the alphasyllabary mother tongue or from imperfect or deficient understanding of word order, the use of semimorphological markers such as *bei* (denoting negativity), *ba* (to hold) and other grammatical categories. A typical example of difficulties with *bei* is: 王平被选为主席。("Wang Ping *bei* elected as chairman"), where the semimorphological marker *bei* is used only to denoted negativity. The correct sentence should be: 我們选王平为主席 ("We elect Wang Ping as chairman"). The semimorphological marker *bei* usually has "unfavorable meanings" according to the eminent linguist Y.R. Chao (1968, p. 703) and the anomalous usage of *bei* is likely the result of translation of the English passive verb "by" (Tse, Shum, Miao, & Ki, 2001). Another example is *我请你坐 (verbatim translation "*I invite you sit") where the correct usage is 请坐 ("Please sit") without the need to express the subject or topic 我. The 26 sentences were printed on proforma sheets. The students were required to detect the errors and write out the short correct sentences. One mark was given for each syntactically correct written sentence, which could vary for individuals, and the maximum score was 26. The inter-rater reliability was .721.

Verbal Working Memory

The working memory construct was subserved by two tasks: a verbal span working memory task (VSWM) and an operation span working memory task (OSWM) involving numbers and very simple Chinese words.

Verbal span working memory. The verbal span working memory task (VSWM) was based on the rationale and format of Daneman and Carpenter (1983) as modified by Swanson

(1992). A total of 6 sets of two, three and four sentences, all unrelated in meaning, were read orally by the experimenter to small groups of students. They first listened to each set of two-, three- or four-sentences plus the question, all spoken in Putonghua, 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" and the last words should be: "book [note the reverse order in Chinese], school, and ice cream". The total testing time for this task was 20 minutes and all the answers were scored independently by two RAs. One mark was awarded for each correct answer and the maximum score was 24. Cronbach's alpha coefficient was .807.

Operation span working memory. The operation span working memory task (OSWM) was modeled after the operation span task of Engle, Tuholski, Laughlin, and Conway (1999). Groups of students heard in Putonghua 6 sets of 3 or 4 sentences, each of which involved very simple mental arithmetic calculation with either a correct or wrong answer and followed by a simple word spoken in Chinese. Students had to wait till the end of the spoken sentence set before writing down on the designated forms just YES/NO to the answers of the simple calculation and the one word at the end in the correct order. An example of a three-sentence set is as follows: "Is 16 – 9 = 7? (Bear) (狗熊） <u>YES</u>/NO; Is 12 x 2 = 24? (Car) (汽车) <u>YES</u>/NO; Is 20 – 6 = 12? (Book) (图书) YES/<u>NO</u>." The total testing time for this task was 15 minutes. A credit of one was given for each correct answer and the maximum score was 42. Cronbach's alpha coefficient was .813.

RESULTS

The strategies in analyzing the data were as follows. We first wanted to know if the groups of EM and Han students were equally motivated in learning school Chinese (Research Question 1). We then examined the performance of the 3 groups in the different tasks, taking into account their scores in the SAL scale in a multivariate analysis of covariance (Research Question 2). Finally, we examined the differential contribution to text comprehension of the predictor tasks of working memory, orthographic and sentential process in several multiple regression analyses and also tested their structure in the EM students in a structural equation modeling (SEM) analysis (Research Question 3).

The means and standard deviations of the main tasks (narrative and expository texts comprising 2 passages each, 2 verbal working memory, 2 orthographic processing and 2 sentence processing tasks together with the 2 components in z-scores for each group are shown in Table 1. The inter-correlations of the variables for the combined 111 Tibetan and Yi students and the 42 Han students are shown in Table 2.

Table 1

Descriptive Statistics of Variables for 3 Groups of Students and Total Group

Variable	66 Tibetan EM Students Mean (*SD*)	45 Yi EM Students Mean (*SD*)	42 Han Students Mean(*SD*)	Total Group of 153 Students Mean (*SD*)
Age in Years	12.36(.87)	12.42(.69)	12.48(.59)	12.41(.75)
Narrative Text Comprehension (Max18)	8.59(5.16)	6.82(4.34)	13.79(3.08)	9.50(5.19)
Expository Text Comprehension (Max 18)	10.41(4.48)	11.60(4.21)	14.26(2.65)	11.82(4.26)
Verbal Span Working Memory (Max 24)	8.80(5.71)	9.20(4.34)	13.00(4.60)	10.07(5.33)
Operation Span Working Memory (Max 42)	6.45(4.34)	8.96(4.40)	9.64(4.48)	8.07(4.60)
Orthographic Constraints (Max 15)	11.27(1.84)	10.24(2.22)	11.83(1.17)	11.24(1.90)
Orthographic Choice (Max 20)	18.36(2.29)	18.96(.77)	19.48(.59)	18.84(1.65)
Grammaticality (Max 44)	36.76(7.67)	36.38(6.07)	39.86(3.77)	37.50(6.46)
Sentence Integrity (Max 26)	9.85(6.49)	9.31(3.84)	13.83(4.85)	10.78(5.68)
Learning Strategies/Motivation (z-score)	-0.12(1.02)	-0.23(0.94)	0.44(0.92)	0.00(1.00)
Self-belief/Self-concept (z-score)	0.23(1.01)	0.00(1.05)	-0.36(0.83)	0.00(

Table 2

Inter-Correlations of Variables for 111 Tibetan and Yi Students (above Diagonal) and 42 Han Students (below Diagonal)

Measure	RNar	RExp	VSWM	OSWP	OrC	OrCh	Gram	Sent	Stra	Self
Narrative Text Comprehension	1	.65***	.58***	.34***	.19*	.44***	.44***	.61***	.10	.11
Expository Text Comprehension	.14	1	.56***	.47***	.18	.50***	.49***	.51***	-.08	-.05
Verbal Span Working Memory	.63***	.32*	1	.60***	.26**	.53***	.37***	.59***	.22	.10
Operation Span Working Memory	.16	.34*	.36*	1	.21*	.41***	.32**	.46***	- .01	-.06
Orthographic Constraints	-.06	.33*	.10	.00	1	.20*	.29**	.29**	-.31*	.15
Orthographic Choice	.11	.24	-.06	.10	.36*	1	.46***	.50***	-.01	-.06
Grammaticality	.13	.27	.30	.33*	.18	.24	1	.56***	-.13	-.04
Sentence Integrity	.49**	.10	.61***	.06	-.09	.03	.30	1	.34*	-.05
Learning Strategies/Motivation	.11	-.08	.22	-.01	-.31*	.01	-.13	.34*	1	-.16
Self-belief/Self-concept	.11	-.05	.10	-.06	.15	-.06	-.04	-.05	-.16	1

Note. RNar – narrative text comprehension; RExp = expository text comprehension; VSWM = verbal span working memory; OSWM = operation span working memory; OrC = orthographic constraints; OrCh = orthographic choice; Gram = grammaticality; Sent = sentence integrity; Stra = learning strategies/motivation; Self = self-belief/self-concept

*p < .05, **p <.01, ***p <.0

SAL and group performance. The 43 items from the Marsh et al. (2006) Students' Approaches to Learning (SAL) scale were subjected to a principal component analysis followed by varimax rotation with a view to deriving a more parsimonious pattern of the structure of SAL. Two components with eigenvalue > 1 emerged, explaining 52.27 % of the variation. Items dealing with learning strategies (memorization, elaboration, control, effort and perseverance, co-operative learning) all loaded on Component I (eigenvalue of 3.06) and accounted for 27.84% of the total variation. This component was labeled Learning Strategies and Motivation. Items dealing with self-concept, perceived self-efficacy and control expectation loaded on Component II (eigenvalue of 2.69) and accounted for 24.42% of the total variation. Component II was labeled as Self-Belief and Self-Concept.

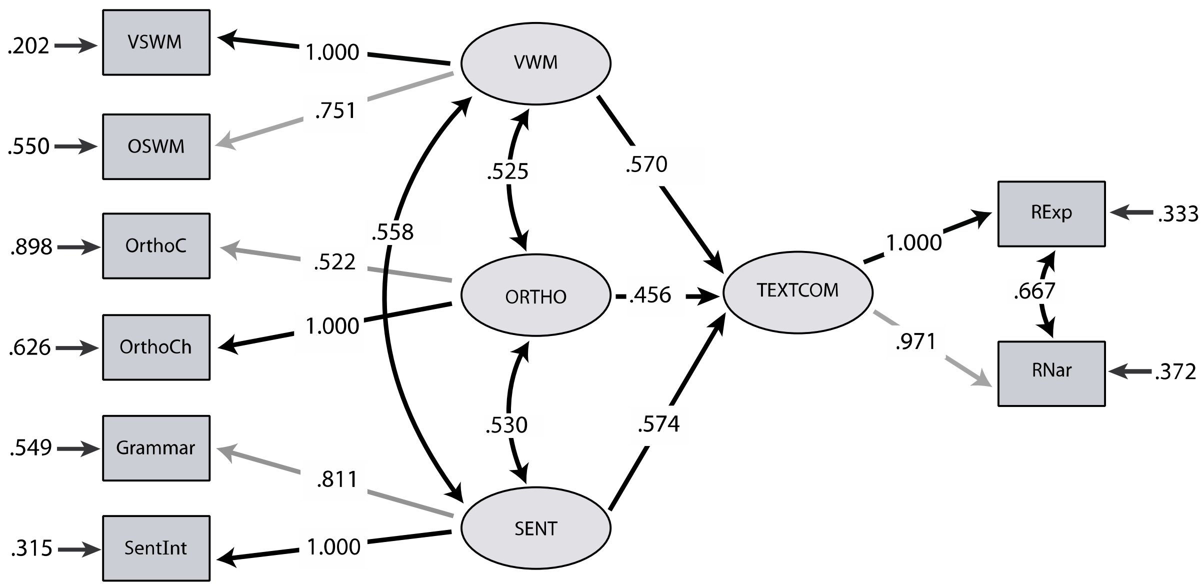
A 3 (language group) x 2 (SAL component) MANOVA showed significant difference among the Tibetan, Yi and Han groups in SAL (Wilks' Lambda = .867, F(4, 298) = 5.491, $p = .000$, $\eta^2 = .069$). The 3 groups also differed significantly overall in both components: Component I of Learning Strategies with F(2, 150) = 6.095, $p = .003$, $\eta^2 = .075$; Component II of Self-belief with F(2, 150) = 4.678, $p = .011$, $\eta^2 = .059$. Pairwise comparisons showed that the Han group outperformed the Tibetan and Yi groups, but there was no difference between the latter two groups. These results suggest that the 3 groups of students differed in their motivation to learn Chinese, their self-efficacy and their strategies in reading Chinese. The analyses answer Research Question 1.

To answer the question of the differential performance of the 3 groups in the individual predictor tasks, a MANCOVA with the 2 components of the SAL scale as covariate was carried out. Wilks' Lambda of .723, F(4,148) = 4.202 was significant ($p = .000$, $\eta^2 = .150$). Univariate ANCOVAs showed all the tasks were significantly different among the 3 groups: verbal span working memory (F (4, 148) = 10.926, $p = .000$, $\eta^2 = .228$), operation span working memory (F (4, 148) = 7.127, $p = .000$, $\eta^2 = .162$), orthographic constraints (F (4, 148) =6.085, $p = .000$, $\eta^2 = .141$), orthographic choice (F (4, 148) =7.197, $p = .000$, $\eta^2 = .163$), grammaticality (F (4, 148) = 4.592, $p = .002$, $\eta^2 = .112$), and sentence integration (F (4, 148) =12.247, $p = .000$, $\eta^2 = .249$).

Pairwise comparisons found the Han group outperformed the Tibetan group in all tasks except for orthographic constraints, scored significantly higher than the Yi group in verbal working memory, orthographic constraints, and sentence integrity. There was no difference in the performance between the Tibetan and Yi groups in verbal working memory, orthographic choice, grammaticality and sentence integrity. The MANCOVA and pairwise comparison results show the differential performance of the EM and the control groups after making adjustment for the differential level of motivation and learning strategies. These results provide some answer to Research Question 2.

Structural equation modeling. Since the Tibetan and Yi EM students did not differ from each other in their age, SAL performance and for most of the cognitive and linguistic task, these 2 EM groups of 111 students were treated as one group and the patterns of cognitive and linguistic processing in relation to reading comprehension were further tested. To examine the structure of the 6 predictor tasks subserving the 3 independent constructs of Verbal Working Memory, Orthographic Processing and Sentential Processing in predicting the dependent Text Comprehension construct subserved by the two indicators of expository and narrative texts, a structural equation modeling (SEM) analysis was carried out (Jöreskog & Sörbom, 1996-2001).

On the basis of the various goodness-of-fit indices recommended by Marsh, Hau and Grayson (2005) there was a good fit of the model to the data. : χ^2 (14) =18.398, $p = .189$; root mean square error of approximation (RMSEA) = .053 (90% confidence interval = 0 - .113); non-normed fit index (NNFI) = .969; comparative fit index (CFI) = .985; standardized root mean square residual (RMR) = .033; adjusted goodness of fit index (AGFI) = .897. All these indices, such as RMSEA >.05, CFI > .95, RMR < .08 reflect the appropriateness of the tasks as measurable indicators of the latent constructs for the Tibetan and Yi EM students. These results are summarized in Figure 1.



χ^2 (14, N = 111) = 18.398, p = .189, RMSEA = .053, NNFI = .969, CFI = .985

Figure 1. Path diagram modeling Chinese text comprehension in 111 Tibetan and Yi students. VWM = Verbal working memory construct subserved by verbal span working memory (VSWM) and operation span working memory (OSWM); ORTHO = Orthographic processing construct subserved by orthographic constraints (OrthoC) and orthographic choice (OrthoCh); SENT = Sentential processing construct subserved by grammaticality (Grammar) and sentence integrity (SentInt); TEXTCOM = Text comprehension construct subserved by expository (RExp) and narrative (RNar) text comprehension

Multiple regression analyses. Separate multiple regression analyses were carried out for the 111 ethnic minority students and the 42 Han students with each of the two genres of text reading as criterion variables. The aim was to answer the question of the relative contribution of the linguistic and cognitive tasks to narrative and expository text comprehension. The two indicators for each construct were first standardized and combined to form the domain competence scores which were used to predict the two genres of text comprehension. To control for the possible effects of age and gender we included them as predictors in the regression. Their effects were small and mostly non-significant. Still, we would expect students' literacy performance to increase with age. As our participants all came from the narrow range of the same educational level, the effect of age was basically not different from zero. The small significant difference due to gender (-.161) indicated the slightly different performance by the ethnic minority boys and girls in expository text comprehension.

In the regression analyses, all variables were entered simultaneously so that the beta weights should be interpreted as the unique contributions of different variables after controlling for the differences in other variables. In a sense these are the unique effects of the different variables on and above the effects of other linguistic and cognitive constructs. The results as summarized in Table 3 provide some answers to Research Question 3.

Table 3

Multiple Regressions to Predict Narrative and Expository Text Comprehension for 111 Tibetan and Yi Students and 42 Han Students after Controlling for Age and Gender

	Tibetan and Yi Students					
	Narrative Text			Expository Text		
Predictor	Beta	t	Sig. Level	Beta	t	Sig. Level
Age	0.059	0.754	0.453	0.130	1.665	0.099
Gender	-0.040	0.049	0.624	-0.161	-1.998	0.048
Verbal Working Memory Construct	0.355	3.854	0.000	0.253	2.758	0.007
Orthographic Processing Construct	0.084	0.880	0.381	0.070	0.738	0.462
Sentential Processing Construct	0.059	0.754	0.453	0.340	3.289	0.001
R Square	0.429			0.432		
	Han Students					
Age	-0.117	-0.794	0.432	0.017	0.112	0.912
Gender	0.181	1.202	0.237	0.037	0.237	0.914
Verbal Working Memory Construct	0.439	2.673	0.011	0.350	2.071	0.046
Orthographic Processing Construct	0.318	2.333	0.032	-0.035	-0.237	0.814
Sentential Processing Construct	-0.011	-0.071	0.944	0.270	1.621	0.114
R Square	0.309			0.267		

DISCUSSION

This study examined the performance of 2 groups of alphasyllabary EM Tibetan and Yi learners of Chinese and an age-control group of Han Chinese students in their comprehension of simple Chinese narrative and expository texts. It further examined the contribution of verbal working memory, orthographic processing and sentence processing in predicting reading comprehension. Our study could be one of the few psycholinguistic studies in examining Tibetan and Yi students learning school Chinese as L2. As such, there were shortcomings including our lack of information on these EM students' reading performance in their mother tongues of Tibetan and Yi and on parental support for learning Chinese. Our sample size of 111 Tibetan and Yi students was a modest one. Our multivariate correlational design would allow us to draw conclusions only about relationships, and no causality is implied from the structural equation modeling results.

The 43-item Students' Approaches to Learning (SAL) provide some evidence that the EM students compared with the Han Chinese peers were less well motivated in learning Chinese and might not have developed effective strategies for their learning. These students' own perception of their learning approaches, motivation, self-belief and self-concept from the SAL scale suggests attitudinal and motivation factors might play a part in the students' reading literacy of school Chinese. One plausible reason for the EMs' performance could be related to the lack of appropriate teaching materials and effective teaching methods as observed by the first two authors in the schools. Parental support and home resources such as availability of books in Chinese also played a role. Parenthetically, the SAL based on data from 107,899 fifteen-year-olds from 25 countries (OECD, 2001) promises to be efficacious for use with different linguistic and cultural groups. The present results showing the two components explaining 52.27% of individual variation in reading is considerably higher than that of similar scales discussed earlier. It is suggested that this theoretically and methodologically rigorous scale should be used more for cross-linguistic studies of students' self-regulated learning including reading literacy research (see also Hau & Ho, 2010).

Text Comprehension

The descriptive statistics for text comprehension shown in Table 1 suggest that overall the students found the passages difficult. We set the level higher than usual so as to challenge the students. Examination of some of the answer protocols shows that the better able students could master the different aspects of the task. The differential level of reading performance of narrative and expository texts (Table 3) should be noted. This differential performance is in keeping with what is found in the literature with English language users (e.g., Best, Floyd, & McNamara, 2008; Eason, Goldberg, Young, Geist, & Cutting, 2012).

Eason et al. showed that their regression models accounted for 49%, 42% and 38% of the variation respectively for comprehending expository, narrative, and "functional" (e.g., instructions, posters) text types with 126 American children ages 10 to 14 years. Our multiple regression results with the 111 Tibetan and Yi students showed similar proportion of 43% individual variation accounted for the two genres of text comprehension. Our use of open-ended short written answers to inferential questions from text provided more scope for students to show their understanding of text materials (Kintsch & Kintsch, 2005).

Contribution of Verbal Working Memory

It is significant to note that the construct of verbal working memory subserved by the indicators of verbal span working memory and operation span working memory contributed significantly to the prediction of performance in both genres of text comprehension (Figure 1, Table 3). These results are generally in keeping with the findings of previous research (e.g., Cain et al., 2004; Leong et al., 2008; Seigneuric & Ehrlich, 2005; Swanson, 1992). Working memory contributes to reading comprehension because readers have to process segments of information in memory during reading while encoding and integrating the next segment of the passage (Harrington & Sawyer, 1992). What needs to be determined is whether it is the processing or the storage component of working memory or a combination of both components that might explain the present findings (Alloway, Pickering, & Gathercole, 2006).

Of the two indicators OSWM proved to be much more difficult than the VSWM. The below-chance performance of the students in both indicators (respectively 42% and 19% for the total group, Table 1) might compound the students' difficulties in text processing. As a construct, verbal working memory contribution considerably to individual variation in the EM students' text comprehension (Table 3 & Figure 1).

These results of strong effect of working memory on reading are at variance with those found by Chung et al. (2013). These researchers showed syntactic awareness explained more individual differences than working memory in their 14-year-old Cantonese speaking students with and without dyslexia. Plausible reasons for the different results include the different samples and tasks used. Whereas Chung et al. used a multiple choice format to assess reading comprehension; we used a more stringent open-ended reading and writing format and this would likely make a difference.

To enhance the efficacy of working memory the two indicators subserving the construct could be further refined and tasks such as memory updating could be added. Furthermore, longitudinal studies with appropriate repeated measures would show the role of controlled attention in relation to growth in reading and variation in age (Swanson & Jerman, 2007). In addition, it is important to research into the strategies such as semantic and imagery rehearsal training that might facilitate working memory performance and increase the validity of predictive scores of reading proficiency (see Turley-Ames & Whitfield, 2003).

Contribution of Orthographic Processing

The results of the orthographic processing tasks (Figure 1) support the findings of Ho, Wong and Chan (1999), Wang, Liu, and Perfetti (2004), Packard et al. (2006), and Yeung, Ho., Chan, and Chung (2016) that stable and precise knowledge of word form (orthography), meaning (semantics), speech sound (phonology) and their integration are central to lexical knowledge and text comprehension in Chinese. Furthermore, Tong, McBride-Chang, Shu, and Wong (2009) found in their study of early Chinese reading literacy with special reference to spelling that orthographically based errors accounted for 33.3% of the variations in Chinese character identification, word dictation, and reading comprehension after controlling statistically vocabulary and chronological age. These authors stated that "orthographic knowledge… appears to be a stable predictor of early Chinese literacy skills" (p. 447). Yeung et al. (2016) showed that orthographic skills including positional and functional knowledge of radicals predicted significantly Chinese text comprehension in Grades 2-4 Chinese children. Our results generally support these findings (see also Leong, 2015 for a review).

Contribution of Sentential Processing

For the grammaticality task the 3 groups of Tibetan, Yi and Han students performed at 84% and 83% and 91% respectively (Table 1). The simpler sentence structure and the dichotomous YES/NO answer might have facilitated the performance of all three groups. However, the sentence integrity task proved much more challenging for all 3 groups with the Tibetan EM students scoring at 38%, the Yi group at 36% and the Han group at 53%. What might be the reasons for this relatively low performance?

The sentence integrity task tapping understanding of syntactic structure was designed to challenge the students. The combined tasks of detecting the syntactic errors, correcting them and writing down the correct sentences might have proved quite difficult for all the students. Many poor comprehenders might fail to detect a breakdown in sentence comprehension and, if they detected it, might not be able to correct the errors. Our finding of the contribution of the sentence integrity task supports the results of the "explicit grammar knowledge" in second language (English) reading comprehension studied by Zhang (2012). Following the suggestions of Linnel (2001), Tse et al., (2001) and others, we scrutinized the written answer protocols and noted some of the sources of difficulties. These included the lack of understanding of the permissible and flexible subject-object-verb (SOV) and the verb-object-subject (VOS) structures (Li & Thompson, 1989).

CONCLUSION and EDUCATIONAL IMPLICATIONS

Drawing in part on Perfetti's Blueprint of the Reader (2003, Perfetti et al., 2002, 2005) we found verbal working memory, orthographic and sentential processing made considerable contribution to individual differences in comprehending Chinese narrative and expository texts. What are some of the further implications in addition to the processing differences by the students?

First, both the research literature and field studies by the authors in Tibetan and Yi EM schools suggest the need to enhance teacher preparation and teaching materials for EM students (Cuo, 2011; Tsung, 2009; Tsung & Cruickshank, 2009, 2010). Second, strengthening sustained and systematic teaching of the structure and function of Chinese characters and sentence processing helps text comprehension. Third, we should further study text characteristics and the format of examining text comprehension (Best et al., 2008; Eason et al., 2012; Leong et al., 2008). In particular, expository text should be introduced early in addition to narrative materials (Best et al., 2008). Factors such as home support contributing to reading literacy should also be studied in EM and indeed in all other students (Shum, Gao, Tsung, & Ki, 2011). This support will enhance the students' motivation for reading and their performance in text comprehension.

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