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Enhancing orthographic knowledge helps spelling production in eight-year-old Chinese children at risk for dyslexia

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Abstract We investigated the effects of enhancing orthographic knowledge on the spelling of Chinese characters and words in 131 eight-year-old Chinese children at risk for dyslexia. The traditional approach (37 children) emphasizing memory and repeated writing was the control condition. The analytic and synthetic approach (ASA, 33 children) stressed insight into character structure. The integrated analytic and synthetic approach added to ASA self-correction and metacognitive activities (INA, 61 children). The children were first asked to write down as many words as possible associated with pictures of home, school, and community; the correctly written words formed the baseline information. The children were then instructed by their classroom teachers in six especially designed short texts and assessed in eight measurable *bujian* or radical tasks subserving three constructs: morpheme completion, bujian analysis and synthesis and bujian compounding. Multivariate analyses of variance showed that the children in the INA condition outperformed those in the other conditions in three of the measurable bujian tasks. A confirmatory factor analysis verified the stability of the eight tasks and their clustering into three constructs. From these results, we tentatively propose a "bujian sensitivity hypothesis" as a means of helping young Chinese children at risk for spelling disorders.

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Children with developmental dyslexia are characterized by unexpected difficulties relative to other cognitive abilities in accurate, automatic word identification, decoding, spelling, and secondary problems in text comprehension (Lyon, Shaywitz, & Shaywitz, 2003). Over the years, considerable progress has been made in understanding the neurobiological basis of this learning disorder (Shaywitz, 2003); the influences of molecular genetics expressed through their correlations and interactions with the environment in reading impairment (Galaburda, LoTurco, Ramus, Fitch, & Rosen, 2006; Olson, 2006); the subtle abnormal neuronal migration to the cerebral cortex of the dyslexic brain with the possibility that dyslexia may result from the mutation in a neuronal migration gene (Galaburda, 2005); the role of phonemic awareness and learning rate as a causal factor in dyslexia (Snowling & Hayiou-Thomas 2006); the comorbidity among the developmental disorders of speech sound disorder, language impairment, and reading disability (Bishop & Snowling, 2004; Pennington & Bishop, 2009); and the interplay of grammatical, semantic, and pragmatic language skills affecting text comprehension difficulties in children with dyslexia (Snowling & Hulme, 2005).

While accurate, automatic single-word decoding is the hallmark of efficient reading and developmental dyslexia, authors also acknowledge that children with dyslexia experience considerable difficulties in writing and spelling (Høien & Lundberg, 2000; Lyon, 1995; Lyon et al. 2003). The spelling of dyslexics has been shown to be more primitive than their non-dyslexic counterparts and is characterized by symptoms of strephosymbolia or twisted symbols (Orton, 1937) and neographisms, such as fusions of consecutive letters; omission and addition of letters, syllables, and words; and inconsistent spellings (Critchley, 1970). Given these findings, research and clinical studies of spelling in children with dyslexia are underdeveloped as compared with studies of reading impairment and need to be further developed.

Given the role of spelling difficulties in dyslexia in the English orthography, we would like to know how Chinese learners acquire and develop knowledge of Chinese characters and words (Leong, Cheng, & Lam, 2000). Do they segment characters by an analysis-by-synthesis iterative process? If so, what are the salient subcomponents conducive to reading and spelling Chinese and, by extension, as impediments to reading and spelling? Are these subcomponents the phonetic or the semantic radicals (*bujians*) in terms of their functions and not so much their left–right or top–down positional effects? What are the integrative activities in learning characters and words and in preventing reading and spelling difficulties? These were some of the questions that the present study set out to answer.

Processes of spelling

Spelling is often thought of and "reviled as a [school] subject [with] its legacy of persistent drudgery" (Templeton, 2003, p. 738) and less as a scientific endeavor of language use (Perfetti, 1997). Both of these astute observations are particularly pertinent to Hong Kong, mainland China, Taiwan, Singapore, and other regions using the Chinese writing system. If the drudgery is still pervasive, especially in spelling in Chinese, scientific endeavors are moving ahead. There are research papers published in leading journals and book chapters in the science of reading and spelling in alphabetic writing systems. There are book-length studies of spelling acquisition in young children (e.g., Treiman, 1993); developmental and experimental studies (e.g., Brown & Ellis, 1994; Nunes & Bryant, 2009; Perfetti, Rieben, &

Fayol, 1997); spelling impairment (e.g., Hulme & Joshi, 1998); and on language structure in alphabetic reading and writing for teachers (Henderson, 1990; Moats, 2000), among others. All these theoretical accounts and empirical findings have greatly enriched our understanding of children's spelling of English words. They may use different strategies—phonological, orthographic, morphological, and mnemonic—to access lexical or sublexical items of different grain sizes (syllables, onsets and rhymes and phonemes to graphemes).

In comparison, scientific studies of spelling and writing to dictation in Chinese are sparse. The promotion of theory-based approach to learning and teaching spelling in Chinese young children and the concomitant reduction, if not wholesale elimination, of pedagogical drudgery are among the main aims of the present study. How would theories and research findings from the English language apply to the spelling of characters and words in the rather disparate writing system, that of Chinese? What are the universal features common to the alphabetic English and the morphosyllabic Chinese? What are the features specific to spelling in writing to dictation in Chinese? Do similar strategies apply to the learning of Chinese spelling as to English spelling? These were our general research questions in the present study.

Orthographic structure of Chinese characters and words

As a preliminary, a necessary but brief description below illustrates the psycholinguistic principles of the design of Chinese characters and words.

A word 詞 *cí* in Chinese usually consists of two or more characters. The basis of character 字 *zì* compositionality is the corpus of 540 foundational 部件*bùjiàns*, which subsume the 214部 首*bùshǒus* or *radicals*. Bujians refers to the 540 orthographic classifiers introduced in the authoritative analytical dictionary of characters (Shuōwén Jiézi) compiled by Hsu Shen in the Han Dynasty (ca. AD 100; Ting, 1928/1970). Bujians are much broader in scope than radicals which serve an indexing function in accessing dictionaries (Zhōngguó guójiā yǔwěi [Chinese National Language Committee], 1998). Bujians are components of characters and relate in meaning and pronunciation to them (Wang & Tsou, 1999). A character almost always corresponds to a morpheme in the spoken language, whereas a word as the smallest independent unit of meaning in modern written Chinese is usually polymorphemic (Chao 1968; Wang, 1985). Take as an example the English word "swimming, to swim." In Chinese, this word consists of two graphic units or characters (*zi*) to denote "to play in the water" 游 泳yóu yǒng, with both characters having the semantic bujian in the left half of the character to denote water or as the equivalent of hydro. The right half of the character or the phonetic bujian indicates the speech sound or the most likely pronunciation. In the present study, the term bujians and radicals are used interchangeably, but the former term is preferred.

Computational corpus analysis of 3,027 most commonly occurring left–right compounds by Hsiao and Shillock (2006) has shown that around 90% of the left–right structured characters have their semantic bujians on the left and the phonetic bujians on the right. Furthermore, about 33% of these phonetic compounds are found to be regular and 52% irregular. These researchers have also shown similar distribution patterns in characters of a vertical structure. As an example, 雲 yún, meaning cloud, has the semantic of rain at the top half and the phonetic at the bottom half; 霧 wù, meaning fog, also has the same semantic of rain at the top half and the phonetic at the bottom half.

At the level of school Chinese, Shu, Chen, Anderson, Wu, and Xuan (2003) have shown from their systematic and detailed analyses of a corpus of 2,570 characters used in grades 1 through 6 in school textbooks in China and elsewhere that phonetic regularity and semantic

transparency bear an inverse relationship to increase in school grades, even after stratifying by frequency and visual complexity (number of strokes). Characters used in earlier grades are typically less complex visually and less likely to be regular or transparent as compared with characters introduced in later grades, and low-frequency characters tend to be visually complex, phonologically regular, and semantically transparent (Shu et al., 2003). Among their other findings, Shu et al. (2003, p. 42) showed that only about 23% of the characters in their corpus are "perfectly regular" (regular consistent) and an additional 16% are regular, except for lexical tone (regular inconsistent). The important and detailed Shu et al. (2003) psycholinguistic analyses of the corpus of 2,570 characters in Chinese school textbooks show the complex nature of the information about pronunciation, orthographic patterns, and meaning of Chinese characters.

This complexity arising from these constituents and their integration is one of the stumbling blocks in learning to spell and read Chinese. There is, however, logic to the connection between the spoken language and the writing system, and those children who understand this logic will more easily acquire early reading and spelling (Shu et al., 2003). The basic question we address was: What is it that helps children to spell correctly Chinese characters and words?

The present study

Orthographic knowledge

The present study of spelling acquisition in young children at risk of dyslexia was predicated on the importance of orthographic knowledge or knowledge of bujians. Orthographic knowledge in English is explained by Barker, Torgesen and Wagner (1992) as "[involving] memory of specific visual-spelling patterns that identify individual words, or word parts, on the printed page" (pp. 335–336). The orthographic form of a word is generally regarded as a sequence of letters relating in a systematic way to the phonological properties of the word (Ehri, 1997). The sequence of letters must specify letter identities comprising the spelling of a word and also the order among the graphemes, which specify abstract letter identity (Venezky, 1970). Orthographic knowledge is also explained as knowledge of orthographic conventions and of word-specific representations (Shahar-Yames & Share, 2008).

Sharing some of the features of the above operational definition for English, orthographic knowledge in Chinese refers to an understanding of the positional constraint and the role of intra-character or zi constituents of the phonetic and semantic bujians and their integration. These units may provide some clues to pronunciation and meaning. From their corpus study of school Chinese, Shu and her colleagues found that 88% of semantic–phonetic compound characters have informative bujians in the sense of provision for information about meaning. However, these researchers also cautioned against over-simplified generalization of the positional constraint of semantic–phonetic bujians and their one-to-one relationship to meaning and sound.

To take an example of orthographically similar characters貧 (poor) and貪(greedy). The character 貧can be decomposed into the orthographic constituents which also coincide with the morphological constituents of分(to divide) and貝(form of money). In dividing the money, one has less of it and is that much poorer. But here the addressed phonology is less than transparent. The character 貪 is decomposable into今 and貝, with the former orthographic (also morphological) constituent meaning love of and also indicating the pronunciation. The integrated constituents convey the meaning of greed. For most of the characters, semantic bujians provide partial information for meaning, and semantic

transparency increases as frequency of usages decreases (Shu et al. 2003). When the logic of word formation with its orthographic and morphological constituents is explained to learners, it is less likely they would make errors in spelling similarly constructed lexical items.

There is thus a need to analyze and also synthesize the constituent components of the characters in both reading and spelling and to help learners develop more precise intra-character orthographic knowledge and inter-character morphological knowledge. Morphological relatedness in Chinese mostly concerns with compounding and, to a minor extent, prefixing and suffixing a constituent form to a base form to produce two-character and multi-character words (see Chao, 1968; Packard, 2000 for discussion of linguistic and psycholinguistic aspects). The *analytic* process of segmenting intra-character bujians is part of the productivity of orthographic knowledge, which helps Chinese language learners to be more sensitive to the functions in additions to forms of intra-character relationships. The *synthetic* process of inter-character morphological knowledge relates to the productivity of new Chinese words. Morphological awareness and processing are the subjects of increasing investigation in relation to early reading (e.g., McBride-Chang, Cho, Liu, Wagner, Shu, Zhou, Cheuk & Muse 2005), reading disorders (e.g., Shu, McBride-Chang, Wu, & Liu, 2006), and in Chinese reading comprehension and its difficulties at the secondary school level (Leong & Ho, 2008).

Activating children's orthographic and morphological knowledge

Chinese children have some awareness of the relationship between phonetic and meaning bujians at the orthographic level, and the better readers are those with greater orthographic awareness (Shu & Anderson, 1997). Chinese children may be able to use their partial orthographic knowledge in reading Chinese characters (Anderson, Li, Ku, Shu, & Wu, 2003). First and second grade Chinese children were found to show awareness of both the structure and meaning of Chinese compound words, and this awareness helped in vocabulary acquisition and character reading (Chen, Hao, Geva, Zhu, & Shu, 2009). The awareness of the function of phonetics and semantics in character identification develops gradually over the elementary school grades (Shu & Anderson, 1999). Like their English counterparts, Chinese children as young as 6 years of age can be trained to make phonological and semantic analogies in reading Chinese characters, although it is not known if they can use analogies spontaneously (Ho, Wong, & Chan, 1999).

From the various studies discussed, we reasoned that we could build on children's implicit learning or partial knowledge of characters and words by making explicit the morphosyllabic principle of Chinese. We could help young Chinese children to activate and organize their partial or inert intra-character orthographic knowledge and, to some extent, inter-character morphological knowledge in developing spelling in Chinese. We aimed at achieving these goals in authentic classroom situations and in a way that was pleasurable and conducive to learning.

Theoretical framework

Theoretically, we used a version of Share's orthographic learning mechanism as a framework in understanding Chinese spelling. In his orthographic learning hypothesis, Share (1995, 1999, 2004) has proposed phonological decoding or recoding as a sine qua non for early reading acquisition. Children learn about grapheme–phoneme correspondence and use this phonological knowledge to build up word-specific knowledge in learning to read. In the various studies by Share and colleagues, children read a novel pseudoword embedded in short stories and are asked to choose the novel pseudoword from a number of alternative orthographic forms, including a homophonic foil. It has been found that even

second graders show evidence of orthographic learning in Hebrew (Share, 1995, 1999, 2004); in unassisted oral and silent reading in third grade Dutch children (de Jong & Share, 2007); and in English (Cunningham, 2006; Cunningham, Perry, Stanovich, & Share, 2002). The assumption is that orthographic learning occurs mainly through words familiar in spoken language but not familiar in the written form.

In a recent study, Shahar-Yames and Share (2008) extended Share's studies of orthographic learning from early reading to early spelling in 45 third grade Israeli children using the highly regular Hebrew orthography. They hypothesized that because of the close attention to letter sequence and identity to word–spelling–sound mapping, (a) spelling would lead to a significant level of orthographic learning, (b) spelling would result in better learning relative to reading, and (c) the posttest outcome would be stronger in spelling production than spelling recognition because the writing aspect has the added advantage of the motor-kinesthetic movement. The results confirmed the main prediction that spelling would yield significant orthographic learning and also better learning than reading. The results also suggested that the demands of close attention to letter sequence and configuration and the need for motor-kinesthetic processing facilitated stronger spelling production than spelling recognition. The motor-kinesthetic practice or multisensory training in letter learning and spelling bears this out and has been shown to be a powerful approach in helping poor readers and spellers (Hulme, 1983; Hulme, Monk, & Ives, 1987; Moats, 2000).

Specifically, we taught groups of grade 2 Chinese children with dyslexia and who are at risk of dyslexia to recognize and understand the function in addition to form of the constituents of a number of characters. We helped them analyze and synthesize the meaning (semantic) and sound (phonetic) components inherent in these characters. We also taught these children to use analogies and conditional learning (If, then) in orthographic compounding to learn with precision the spelling of new characters and words. In brief, we instructed these young children systematically and dialogically to analyze bujians of Chinese characters and words, to integrate these components in meaningful learning related to life experience, and to generate new characters and compound words.

The above short discussion underscores that phonological and orthographic processing is important in word reading and composing, including spelling. The conjoint instruction and learning of *zhōngguó yǔwén* referring to both the Chinese language and writing system makes clear the reading and writing relationship in Chinese. To further this notion, "a model for Chinese must represent units at the radical (*bujian*, term in italics added) level.… In Chinese, the phonological units are syllables, linked to characters, which themselves include perceptual functional components" (Perfetti & Liu, 2006, p. 235). For the present study, the focus was on orthographic processing in spelling without neglecting the conjoint contribution of phonology and semantics.

Method

Our main emphasis in focusing on Chinese spelling was to help young learners learn to think about the compositionality of constituent orthographic elements (bujians). It was reasoned that the ability to spell Chinese characters and words correctly (allowance being made for some acceptable misalignment of strokes in defining correctness) utilizes orthographic, morphological, phonological, and semantic knowledge. After learning about the logic of the constituent bujians, the young children would then learn to analyze and synthesize the components through recognition, reading, and writing to dictation. The different approaches and methods are shown by the integrative approach to early Chinese literacy based

on principles of applied Chinese linguistics (Tse, 2001), theory-based pedagogy in Chinese (Tse, Marton, Ki, & Loh, 2007), and teaching reading literacy with reference to special needs Chinese children (Tse, Cheung, Loh, & Lui, 2008). The writing of the characters prompted by pictures, partial phonetic and semantic cues, and sentence context would help cement the correct spelling of the characters and minimize writing errors.

There were several aims in the instructional study. One main aim was to compare the efficacy of three different approaches (see following sections) to instructing and learning Chinese characters and words to three groups of 8-year-old Chinese students with dyslexia and at risk of dyslexia. The approach was to combine word reading, spelling with practice of handwriting, and application. The teaching–testing of visually fairly complex but reasonably high-frequency Chinese characters and words embedded in six short texts in 15 lessons took an average of 12 weeks. The in situ experimentation was carried out by classroom teachers under guidance and should promote learning of spelling.

Participants

Two elementary schools in Hong Kong with 131 children (67 boys and 64 girls) in grade 2 classes volunteered to take part in the project. Of these participants, 44 children were diagnosed by educational psychologists as dyslexic or at risk for dyslexia. The diagnostic criteria were according to those of the second edition of the Hong Kong Test of Specific Learning Difficulties (HKT-SpLD) for reading and writing developed by Ho, Chan, Chung, Tsang, Lee, and Cheng (2007) for primary school children in Hong Kong. The HKT-SpLD test consists of three literacy and nine cognitive subtests, and children with dyslexia are defined as those scoring at least one standard deviation below the age means of their literacy composite scores and at least one of the cognitive composite scores. The other 87 children were assessed as having difficulties in reading and spelling despite their average or above average nonverbal general intelligence. These 87 children were classified as "poor readers and spellers" by the teachers. The larger than usual enrolment in these schools of children with, or at risk for dyslexia was due to many factors, including a drastic decline in school enrolment and the danger of school closure with considerably reduced intakes of typical children. In both schools, either the principals or the panel chairs of Chinese or both had received advanced training in the integrative approach of teaching Chinese characters and words devised by Tse and colleagues (Tse, 2001; Tse et al. 2007). These senior teachers in the schools in turn helped instruct and guide their participating teachers in the instruction and assessment of learning to spell Chinese characters and words.

Eight-year-old children at the end of grade 2 were selected because Chinese children in Hong Kong start learning to read either in preschools or are taught at home at the age of 5 or even 4. Also, grade 2 children are quite adept in writing Chinese characters and words with their complex strokes according to the proper sequence. For practical reasons and to avoid disruption to normal instruction, the different intact classes were randomly assigned to the three groups. There were 33 children in two classes (15 boys, 18 girls, total Mean_{age}=8.232 years, SD = 0.603 year) in the analytic and synthetic (ASA) experimental group; 61 children in three classes (33 boys, 28 girls, total Mean_{age}=7.956 years, SD= 0.675 year) in the integrative approach (INA) experimental group; and 37 age peers in two classes (19 boys, 18 girls, total Mean_{age}=7.998 years, SD=0.562 year) in the control (TRA) group. The larger INA group was necessitated by the need to work with all the children in the three classes as requested by the principals rather than randomly selecting about half of that number for the project. For the total group of 131 children, Mean_{age}=8.038 years, SD=0.633. The age differences in the three groups were not significant ($F_{2,128}$=2.177, p=0.118).

Three teaching approaches

There were three approaches in the instruction and learning in the study. One approach was the traditional approach (TRA) as used by many, if not most, teachers of Chinese in elementary schools. The other was the analytic and synthetic approach (ASA). The third was the integrated analytic and synthetic approach including self-correction (INA).

In TRA, teachers typically emphasize memorizing and repeated writing of Chinese characters and words as a means of learning spelling. This unanalyzed approach based on memorization is more or less akin to the whole character approach and is adopted by many primary teachers in Hong Kong. This is because the procedure is routinized and easy to implement. The emphasis is on the outcome of learning by rote and recitation through drill and practice and not so much on the why and how of spelling.

In ASA, the emphasis is on analyzing and synthesizing orthographic components of characters (bujians, radicals, and roots or stems) embedded in interesting short texts taught and learnt in game-like activities. The goal is the writing of new characters or orthographic compound characters as morphemes.

The INA incorporates the analytic and synthetic features of ASA. Furthermore, this integrative approach is strengthened with the use of word banks and metacognitive activities of reflection and self-correction by the children. From the characters and words embedded in texts, the INA children are also shown how to generalize to new lexical items of similar structure by analogical reasoning and to create a larger and more precise vocabulary. In some contrast to TRA, both the ASA and the INA approaches stress explicit learning of the why and the how of Chinese word formation. The hypothesis was that the analysis and synthesis plus metacognitive activities approach (INA) would be more effective in instruction and learning as compared with the other two approaches. As well, this impact should show a differential effect in different constituents of the bujian learning. Details of the three approaches are further provided in the subsequent sections.

The teaching program

The study emphasized learning from instructed lessons and the possible transfer from the characters and words used in these six texts to new context with the help of pictures, partial bujian cues, sentences, and dictation.

The instructional program can be gleaned from a sample lesson “Little Bee.” The short text (see Appendix) containing 27 characters or morphemes was specially written by our research team. The 27-character text contained repetition of some characters, use of onomatopoeic words (e.g., buzz, buzz), olfactory imagery (sweet honey gold), and alliteration (bee, buzz). The mean printed frequency was 14,956 according to the Chinese Character Database (Kwan, 2003). But when the four low-frequency characters [e.g., honey bee, buzz, making (honey)] were removed, the frequency was estimated at 18,883. The text with rhyming and high-frequency characters lent itself to reading aloud and role playing in the classroom.

The instructional goals were: (a) learning words from onomatopoeic characters; (b) learning characters by analyzing bujians (left–right combination for this lesson); (c) identifying characters and words, distinguishing between those needed for writing and for daily use; and (d) learning auditory, visual, and olfactory imagery (e.g., buzz, sweet honey gold).

Before the instruction, the children were shown three black and white line drawings on the three themes of family, school, and community. They were asked to write down in

5 min for each drawing shown in full view as many Chinese words as they could elicit and write from each picture. Their aggregate score formed the baseline in correctly spelling characters and words. Each of the 131 protocols was scored by two research assistants with allowance made for misalignment of strokes and other slight but acceptable motoric deviations. The children were also administered the Matrix E subtest (15 items in 15 min) of the British Ability Scales Matrix (Elliott, Murray, & Pearson, 1978) to estimate their level of nonverbal intelligence in general and ability in reasoning by eduction and correlates in particular. The BAS Matrix task is similar in logic to the Raven's progressive matrices (Raven, Raven, & Court, 2000), except that instead of the multiple choice format in Raven's, children have to complete or draw the correct shapes in the proper location and direction in a 3 × 3 matrix. It was reasoned that this production task would be more discriminating than the multiple choice format as in Raven's.

The instructed lessons A typical instructional lesson was as follows: (a) children sharing their experience about bumble bees; (b) after teacher's demonstration, children reading the 27-character short text aloud, paying attention to juncture, stress, prosody, and other features; (c) children learning the use of phonology (rhyming, alliteration) in reading and spelling characters and words; (d) children learning the combinatory properties of left–right bujian constituents; (e) children learning high-frequency characters and words with many strokes; (f) children learning to identify particular bujians from the lesson; (g) children learning to identify and write auditory, visual, and olfactory imagery words from text; and (h) children learning to copy correctly designated new words and later write them to dictation singly or in different sentential context.

The other five lessons were: "Blowing Bubbles" with 29 morphemes and a mean frequency of 8,054, or 11,437 when seven low-frequency characters (e.g., ding dong, rainbow, drift) were discounted; "Cooking" with 47 morphemes and a mean frequency of 19,679 or 21,882 when four low-frequency characters (e.g., frying) were not taken into account; "Friends" with 48 morphemes and a mean frequency of 14,998 or 15,911 when two low-frequency characters (e.g., worry) were not taken into account; "Riding on a Swing" with 44 morphemes and a mean frequency of 15,163 or 18,759 after discounting seven low-frequency characters (e.g., soothing, peaks, swing); "City Sun" with 56 morphemes and a mean frequency of 15,862 or 17,460 when five low frequency characters (e.g., skyscraper, dizzy, score) were discounted.

Assessment tasks

After the instruction of the six texts in 15 lessons, the children were given short tasks or exercises using the characters and words learned in the lessons to assess learning effects. These exercises assessing eight interrelated orthographic knowledge areas were designed according to these three constructs important for spelling acquisition and development: (a) morpheme completion, (b) bujian analysis and synthesis, and (c) bujian compounding. Care was taken to ensure that the grade 2 children would be able to sustain their attention and do the tasks to the best they could. Hence, the tasks were relatively short and the total set of tasks was typically divided into two sessions according to the conception of the three constructs of three, three, and two tasks each in administration. In general, scoring for the tasks was to award 1 mark for each character correctly written; a 0.5 mark was deducted from each wrongly written character, with a maximum deduction of 5 marks. The tasks are described below and sample items are shown in the Appendix.

Morpheme completion construct

Writing bujian The children were shown a picture on paper and a two-character word with missing bujians in one of the constituent characters. They were asked to complete in writing the missing bujian in the two-character word. The missing bujians were either left-headed or right-headed or were of the top/bottom arrangement. There were ten items with a maximum of ten points, and the task took 5 min plus time for explanation.

Writing dictated words The children were given answer sheets with 12 squares marked with one horizontal and one vertical grid line in the middle of each square as guides. They then listened to the teacher dictating six two-character words and were asked to write down accurately and rapidly the total of 12 characters in the six items. The maximum score was 12 marks and the task took 8 min plus time for explanation.

Writing dictated sentences The idea and implementation were similar to writing words from dictation, except that the stimulus materials were two short sentences, one with 14 morphemes plus two punctuation marks and the other with 11 morphemes plus three punctuation marks. The teacher dictated each sentence including the articulation of punctuation marks, and the children wrote each sentence after listening to the dictated sentence. The task took 8 min plus explanation. Scoring was similar to that of dictated words, with a maximum of 30 marks.

Bujian production On a sheet with a 3 × 3 matrix, the children were shown three very frequently used bujians and were asked to write in each of the nine slots a character embedding the stimulus bujians. The maximum score was 9 marks, and 5 min was given plus time for explanation. Same as in the earlier task, a maximum deduction of 5 marks was made for all the errors.

Bujian analysis and synthesis construct

Bujian completion The children were shown cards with five bujians. They were asked to use the newly acquired knowledge to write freely single characters from four bujians based on the same logic for either left/right or top/bottom combinations of bujians. There were four items for a total of 12 marks. The task took 5 min plus time for explanation. Similar to the earlier tasks, a deduction of 0.5 was made for each error up to a maximum of 5 marks.

Bujian search In this task, the children were asked to search the four characters in each item to locate the common or invariant bujian, either left/right or top/bottom, and to write down the correct answer. There were seven items and they took 5 min plus time for explanation. The maximum was 7 marks. Again, a deduction of a 0.5 mark up to a maximum of 5 marks was made for errors.

Bujian compounding construct

Bujian segmentation The children were asked to either add the missing bujian to the missing part of a character or to subtract the bujian from the whole character to form the target partial bujian. There were nine items with a maximum of 9 marks. The task took 5 min plus time for explanation.

Bujian integration Similar to Bujian composing but using a free composing format, the children were shown on a proforma a 5 × 4 matrix with 20 high-frequency bujians which were also morphemes (except for two items). In 10 min, they were asked to write down freely as many characters as they could using any of the given bujians supplied in the matrix. One mark was given for each correctly written character with no upper limit. Deduction for errors was similar to that of earlier items.

The above eight tasks were used to assess the differentiation of the different facets of orthographic knowledge of the three training conditions or groups in the children's spelling. Their overall performance was assessed in their post-training writing to the same three pictures used to elicit their writing responses prior to the training. The format, timing, and scoring were the same as those from the pretesting using the same stimulus materials. The total testing time for the above eight assessment tasks was 51 min (21+15+15) plus time for explanations, and the writing from the three pictures took 15 min plus short explanations. Again, scoring was both stringent in that each task was scored by two RAs and at the same time liberal in giving the second graders the benefit of the doubt in case of some undifferentiated writing.

Summary and hypotheses

To summarize the instructional lessons, assessment tasks, and procedure outlined above, there were six carefully sequenced texts taught in 15 lessons in the instructional program and eight short tasks predicated on three interrelated orthographic constructs. The instructed program given to the three groups of children varied in the degree of learning from analogic reasoning and conditional rules. The 37 control group children (TRA) were taught in the traditional way of memorization and drill of the characters and words. The 33 ASA experimental children were taught in analyzing and synthesizing the structure of the characters and words. The 61 children in the INA experimental group combined the ASA approach with metacognitive activities. For the two experimental groups, the ASA and INA approaches were used in lieu of normal teaching during the duration of the project.

Prior to the instructed lessons, the 131 children were asked to write down as many characters and words they could think of from three stimulus pictures on the themes of family, school, and community to provide baseline data. The children were also given the BAS Matrix completion task as a check on their nonverbal general intelligence and ability to reason by analogy. The eight tasks subserving the constructs of morpheme completion, bujian analyais and synthesis, and bujian compounding were then administered to the children to assess their performance on facets of orthographic knowledge. The children were again asked to write down as many characters and words they could from the same three stimulus pictures to gauge the overall results of learning from the instructed lessons as shown and to complement findings from their performance in the eight tasks.

These were the predictions: (1) The eight tasks subserving the three constructs of morpheme completion (writing morphemes), bujian analysis and synthesis, and bujian compounding would cluster for the total group of 131 children as hypothesized. This prediction would be tested with confirmatory factor analysis. (2) There would be differences in performance in the three groups. The integrative group (INA) would outperform the ASA experimental group and the control (TRA) group and that the TRA controls would yield the lowest scores in the eight assessment tasks. This prediction would be tested with multivariate analyses of variance (MANOVA).

Results

Confirmatory factor analysis

Table 1 shows the intercorrelations of the different tasks. The coefficients were moderate with writing bujian and writing dictated words and dictated sentences having higher and significant correlations with other indicators. The moderate coefficients suggested that there was not much overlap among the tasks, although they were related. Because the focus was on the instruction and learning of the two experimental groups compared with the controls, their means and standard deviations in the performance of these tasks are shown in Table 2.

To test the structure of the eight tasks, a confirmatoy factor analysis (CFA) was carried out for the total of 131 children (Brown, 2006; Jöreskog & Sörbom, 1996–2001). As hypothesized, three factors emerged: morpheme completion, bujian analysis and synthesis, and bujian compounding. On the basis of the various goodness-of-fit indices recommended by Marsh, Hau, and Grayson (2005), the fit of the model to the total group of N=131 children was good: $\chi^2(38)=51.664$, $p=0.004$; root mean square of approximation (RMSEA)=0.0526 (90% confidence interval=0.00–0.0861, $p=0.426$); non-normed fit index=0.973; comparative fit index=0.981; root mean square residual=0.0545; adjusted goodness of fit index=0.883. All these indices, especially RMSEA with its associated confidence level, reflect the appropriateness of the tasks as measurable indicators of the three latent constructs.

These results are summarized in Table 3 and the path diagram in Fig. 1. The path diagram shows that the lambda-*X* parameter (L*X*-parameter) values from the latent independent *ksi* constructs to the *X* indicators were high for the morpheme completion construct, with values of 0.734, 0.777, and 0.838 except for the indicator of bujian production (0.328). The lambda values for the indicators subserving the constructs of bujian analysis and synthesis and bujain compounding were moderately high (0.613, 0.669, 0.635), except for the indicator of bujian completion (0.268). The lambda-*Y* parameter (L*Y*-parameter) values of 0.859, 0.910, and 0.870 from the latent *eta* construct of spelling to the *Y* indicators were very high. In particular, the gamma parameter value of 0.533 linking the independent latent construct of morpheme completion to the dependent latent construct of spelling was moderate. All these parameter values testified to the stability and validity of the model. Hypothesis 1 of the clustering of the tasks was supported.

To test if the pretest on writing characters and words from the three pictures of family, school, and community and the BAS Matrix differed among the three groups, a 3 (group) × 2 (pretest writing from pictures and Matrix) MANOVA was carried out. Wilks' lambda of 3.064 was significant overall ($p=0.017$, $\eta^2=0.046$). But the univariate test ($F_{2,128}=4.490$, $p=0.013$, $\eta^2=0.066$) was significant in favor of the controls only for the pretest writing of Chinese words from the three pictures. There was no significant difference among the groups for their Matrix performance. Because the pretest writing from the three pictures was in favor of the controls, a 3 (group) × 3 (posttest writing from three pictures) MANCOVA with the pretest picture writing as a covariate was carried out to estimate the effect of the post-writing. There was no significant difference among the three groups in their overall spelling of Chinese characters and words in response to stimulus pictures. The difference among the three groups might lie in the individual orthographic tasks.

Table 1 Intercorrelations of orthographic processing tasks for total group of 131 grade 2 children

	Family	School	Society	Writing *bujian*	Writing word	Writing Sentences	*Bujian* Seg	*Bujian* Com	*Bujian* Search	*Bujian* Product	*Bujian* Integra
Family	1.000										
School	0.772**	1.000									
Society	0.745**	0.801**	1.000								
Writing *bujian*	0.426**	0.375**	0.379**	1.000							
Writing word	0.542**	0.493**	0.413**	0.587**	1.000						
Writing Sent	0.464**	0.424**	0.389**	0.636**	0.659**	1.000					
Bujian Product	0.435**	0.478**	0.388**	0.463**	0.485**	0.544**	1.000				
Bujian Com	0.017	−0.049	−0.043	0.036	0.035	0.083	0.211*	1.000			
Bujian search	0.190*	0.100	0.099	0.101	0.173*	0.297**	0.295**	0.164	1.000		
Bujian Seg	0.092	0.080	0.045	0.147	0.166	0.294	0.160	0.099	0.137	1.000	
Bujian Integra	0.377**	0.354**	0.303**	0.335**	0.257**	0.320**	0.398**	0.033	0.132	0.208*	1.000

*$p<0.05$, **$p<0.01$

Writing Sentences writing dictated sentences, *Bujian Seg* bujian segmentation, *Bujian Com* bujian completion, *Bujian Product* bujian production, *Bujian Integra* bujian integration

Table 2 Means and standard deviations of post-writing on three pictures and eight indicator tasks for 37 controls, 33 ASA, and 61 INA experimental groups of grade 2 Chinese students

Task	Controls	ASA	INA
Writing morpheme construct			
Picture of family	10.135 (4.518)	8.455 (3.547)	11.648 (4.067)
Picture of school	11.865 (5.822)	7.652 (3.624)	9.434 (3.996)
Picture of community	13.770 (7.420)	8.061 (4.491)	9.861 (4.313)
Morpheme completion construct			
Writing bujian	7.770 (2.329)	7.682 (2.087)	7.902 (2.000)
Writing dictated words	8.554 (3.246)	8.364 (2.708)	8.156 (2.580)
Writing dictated sentences	26.960 (7.326)	26.364 (3.272)	25.492 (4.195)
Bujian production	6.730 (2.250)	6.470 (2.878)	7.754 (2.047)
Bujian analysis and synthesis construct			
Bujian completion	8.581 (3.226)	10.030 (1.816)	9.385 (2.602)
Bujian search	4.216 (3.433)	6.788 (1.219)	6.705 (1.266)
Bujian compounding construct			
Bujian segmentation	6.405 (1.509)	6.682 (0.430)	6.336 (1.234)
Bujian integration	7.365 (4.570)	4.455 (2.711)	5.975 (3.842)

Controls traditional approach (TRA), *ASA* analytic and synthetic approach, *INA* integrated analytic and synthetic approach

Multivariate analyses of variance

In order to estimate the training effect of the different facets of orthographic knowledge on the different conditions of training, a series of MANOVAs was carried out according to the three constructs hypothesized (Table 3 and Fig. 1).

Morpheme completion construct For the first construct—morpheme completion—subserved by the measurable indicators of writing bujian, writing dictated words, writing dictated sentences, and bujian production, Wilks' lambda was 1.922 (p=0.057, η^2=0.058). The univariate test ($F_{2,127}$=4.925, p=0.009, η^2=0.072) was significant for bujian production where the children were asked to write characters to complete the character from the bujians 艹 人 日 provided. Contrast results showed that the INA outperformed the controls (p=0.006) and also the ASA group (p=0.023).

Bujian analysis and synthesis construct For the second construct—bujian analysis and synthesis—subserved by the measurable bujian completion and bujian search, Wilks' lambda was 14.099 (p=0.000, η^2=0.183). The univariate test ($F_{2,127}$=8.768, p=0.000, η^2=0.121) was significant for bujian completion where the children were asked to write freely characters to complete the missing bujians. Univariate test ($F_{2,127}$=27.383, p=0.000, η^2=0.301) was significant for bujian search where the children were asked to search the bujians common to the given characters. For the bujian completion task, contrast results showed that the INA group outperformed the controls (p=0.005), and the comparison with the ASA group was in the border zone (p=0.059). For the bujian search task, the INA group outperformed the controls (p=0.000), and there was no difference between the INA and the ASA groups (p=0.539).

Table 3 Confirmatory factor analysis of all tasks for the total grade 2 sample (N=131)

Task	Factor loading			
	Writing morphemes	Bujian analysis and synthesis	Bujian compounding	
Writing bujian	0.734			
Writing dictated words	0.777			
Writing dictated sentences	0.838			
Bujian production	0.328			
Bujian completion		0.268		
Bujian search		0.613		
Bujian segmentation			0.669	
Bujian integration			0.635	
Correlations among factors	Spelling	Writing morphemes	Bujian analysis and synthesis	Bujian compounding
Spelling	1.000			
Writing morphemes	0.636	1.000		
Bujian analysis and synthesis	0.189	0.462	1.000	
Bujian compounding	0.560	0.677	0.385	1.000

Bujian compounding construct For the third construct—bujian compounding—subserved by the measurable bujian segmentation and bujian integration, lambda was 3.052 (p=0.018, η^2=0.046). Among the three groups, the univariate test was not significant for bujian segmentation ($F_{2,127}$=2.738, p=0.068, η^2=0.041) and was also not significant for bujian integration ($F_{2,127}$=2.796, p=0.065, η^2=0.042).

Summary of MANOVAs To summarize the MANOVA results, these measurable tasks were performed significantly differently among the three groups, with the INA group generally outperforming the other two groups: bujian production, bujian completion, and bujian search (see Appendix for sample tasks). The first two are active production tasks, while the third requires active search without having to write down the bujians or characters. These three tasks might be considered the more potent of the eight orthographic processing tasks and might also be used for the screening of young children at risk of dyslexia or at least for spelling difficulties. The MANOVAs summarized in the above sections support hypothesis 2 with the INA group generally outperforming the other two groups.

Discussion

Theoretically, the present study of the role of orthographic structure or knowledge in young Chinese children's learning the spelling of Chinese characters and words was based on

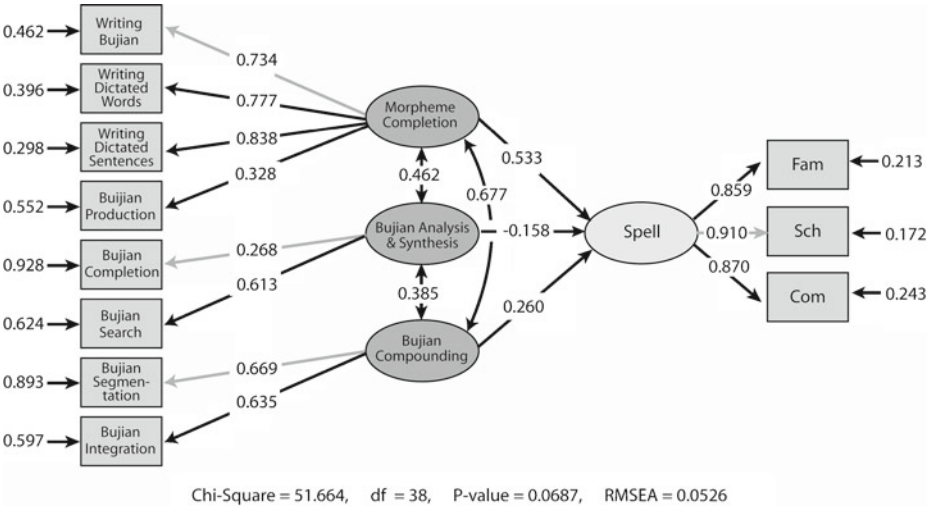

Fig. 1 Path diagram modeling spelling for 131 eight-year-old Chinese children at risk of dyslexia

diachronic and synchronic linguistic and psycholinguistic studies of the Chinese language (Chao, 1968; Wang, 1985). The study was also placed in the context of spelling acquisition in the English language. Pedagogically, the study was motivated by the research team members' dissatisfaction from our in situ observation in elementary schools of the traditional approach. This memory approach has been and continues to be in use in many or most schools in Hong Kong and other regions in Asia using the Chinese language. We attempted to redress this incorrect approach based on earlier studies with Chinese children acquiring word reading and spelling (Tse, 2001; Tse, Cheung, Loh, & Lui, 2008; Tse, Marton, Ki, & Loh, 2007) and on the present investigation.

Overall, the short assessment tasks were found not to be just separate measures but also cohered to form three constructs. Individually, the three tasks most efficacious in favor of the performance of the INA group related to completing and producing missing bujians and were consonant with the notion of the active production of components of characters preceded by bujian search. What was unexpected was that the writing of bujians, of words, and in the sentential context were not discriminating among the three groups, even though these indicators supported the notion of the morpheme completion construct and this construct had the stronger effect on the dependent spelling construct (Fig. 1). Even with the need for enhancement of the tasks, the results generally supported and extended the findings by Ho, Ng and Ng (2003) of the role of semantic and phonetic radicals in reading Chinese.

Strengths and weaknesses of the study

Our study had the following strengths:

(a) We used eight specially designed inter-acting orthographic processing tasks subserving three latent constructs to probe the constituents of early spelling in Chinese (see CFA in Table 3 and path diagram in Fig. 1). These tasks covered fairly exhaustively the broad

spectrum of Chinese orthographic structure or knowledge pertinent to spelling. They involved active search for bujians, analysis and synthesis of segments of bujians, production of bujians, and writing to dictation of morphemes, words, and short sentences. These multitasks converged to explain some 65% of the variance of Chinese spelling in young Chinese children, as found in an exploratory factor analysis (see also Table 3).

(b) We provided a game-like training program undertaken by the teachers in situ in the classrooms with six interesting short passages linked to real life experience. The 131 children were assigned to three different conditions: two experimental conditions (ASA and INA) compared with controls (TRA). The 15 instructed lessons were monitored by our team members and the principals of the two schools to ensure a reasonably high level of fidelity of treatment.

(c) We emphasized in our lessons in instructing and learning spelling different characters and words the use of multiple strategies: retrieval from memory, using addressed phonology from *initials* (onsets) and *finals* (rimes) of the Chinese syllable, using analogy rules to infer function and form, and verifying correct spelling by visual checking in spelling different characters and words. This emphasis is consonant with the overlapping waves model developed by Siegler to explain reading and spelling English words (Rittle-Johnson & Siegler, 1999). The model has been tested and supported in studies of American and Canadian children acquiring reading and spelling involving different morphological forms of English words (Kwong & Varnhagen, 2005; Leong, 2009; Sharp, Sinatra, & Reynolds, 2008; Steffler, Varnhagen, Friesen, & Treiman, 1998).

(d) Overall, the 61 children in the integrated approach (INA) outperformed the 33 children in the ASA condition and the 37 controls (TRA) in the psycholinguistic tasks of bujian production, bujian completion, bujian search (see Fig. 1, CFA analysis, and Appendix for sample items). The differential performance of the three groups and the better performance of the integrative approach (INA) group were as hypothesized.

Our study had certain shortcomings:

(a) The study was confined to grade 2 (mean age of 8 years) Chinese children. Though the sample size of 131 was adequate and a fairly representative one, any generalization to older children should be made with caution. We also note the larger sample size of the INA group compared with the other two groups.

(b) Orthographic structure, emphasized in the present study, may not be where Chinese spelling acquisition should begin, nor where it should end. This leads to the question of the basis of such knowledge and other cognitive and linguistic factors in promoting spelling in Chinese characters and words. Ideally, we should aim at studying the developmental trajectory of orthographic processing from at least grade 2 to grade 6, the end of elementary schooling. This longitudinal design will provide information on the structure of Chinese spelling continuum and the rate of change over elementary grades (see Keuning & Verhoeven, 2008 for a Dutch case).

(c) We chose fairly high-frequency characters with some orthographically fairly complex characters and words amenable for segmentation in the analysis and synthesis process. It should be noted that of the 540 foundational bujians, some 156 bujians cannot stand alone as phonetics. Thus, tasks of segmenting (both additive and subtractive) bujians, producing, and integrating bujians may not strictly apply to 29% of the bujian corpus. This begs the question of bujian-specific and character-specific learning. A careful study of the 29% of "outliers" shows that they are rarely used and do not appear in children's textbooks. Thus, our general approach of multiple strategies of learning and

instructing spelling and reading in Chinese is theoretically sound and is practicable in both classroom and home situations.

On balance, we believe that our theoretical framework is in accord with theories of Chinese applied linguistics and psycholinguistics and our quasi-experimentation also worked well to answer our research questions. The strengths and weaknesses outlined above alert us to areas needing further study.

Orthographic processing in Chinese and English spelling

One important question in studying spelling acquisition in Chinese is what precedes orthographic learning. Our emphasis throughout the present study was the importance of word-specific knowledge in the intra-character relationship between phonetic and semantic bujians, analysis and synthesis of bujian components, and the production of characters from stimulus bujians. Prior to learning about the logic, the compositionality, and the function of bujians in character and word formations, young Chinese children already have some idea of word formation. This claim of word-specific learning in Chinese children as young as age 4 is based on our observation and what is known in the overemphasis on formal learning of reading Chinese characters, words, and writing them in preschools and many homes in Hong Kong.

This claim is also consonant with a similar claim of Bryant and his colleagues from their studies of British and Greek children (Chliounaki & Bryant, 2007; Nunes & Bryant, 2009). In their cumulative studies of British children, Nunes and Bryant emphasize that word reading and spelling are generative. Children use past knowledge to read and spell novel words; and they also use if–then conditional rules to think about the words to be spelled, to test which condition will help to write the novel words correctly. In their 2-year longitudinal study of 90 six-year-old Greek children, Chliounaki and Bryant (2007) showed that word-specific learning might be the basis for the Greek children's later use of morphological rules in spelling inflections and base forms in real and pseudowords. From a different perspective and working with 8-year-old Chinese children using the morphosyllabic Chinese orthography, our results support the Chliounaki and Bryant finding from young Greek children. We also found that these young Chinese children used analogies and word-specific knowledge to write the correct forms of Chinese characters and words.

Furthermore, studies by Keuning and Verhoeven (2008) with Dutch children and Conrad (2008) with Canadian children all emphasize a reciprocal association between reading and spelling and the need for early study of spelling competence. This relationship was shown to be stronger from spelling to reading than the other way round by Conrad (2008) who also found that orthographic representation could be used for both spelling and reading. With Chinese children, Packard, Chen, Li, Wu, Gaffney, Li and Anderson (2006) have shown explicit teaching of orthographic and morphological structure of Chinese characters and words help Chinese children in writing characters. This is also the conception of the present study in integrating speech sound, configural composition, and semantics of Chinese characters and words (Chao, 1968, Wang, 1985, 1989). Tse and his colleagues have successfully applied these linguistic principles in some exploratory studies with different groups of Chinese children (Tse, 2001; Tse et al. 2007, 2008).

Present study supports a version of Share's orthographic processing in spelling

In the present study, our results generally support a version of Share's orthographic learning. One important difference is that Chinese is mainly meaning-based, even though

there is phonological involvement at the "large grain size" of *initial* (onset) and *final* (rime) phonological subunits and in dealing with lexical tones. The phonological involvement is at the suprasegmental and not at the segmental stage of processing. Hence, Share's notion of phonological processing as a sine qua non of early reading and spelling does not carry as much weight in the self-teaching of Chinese characters and words. Instead, stable and precise knowledge of word form (orthographic structure), meaning (semantics), and speech sound (phonology) and their integration as interactive constituents are much more important in Chinese lexical knowledge with Chinese children (Ho, Wong, & Chan, 1999), with grade 1 Chinese–English bilingual children (Wang & Cheng, 2008), and also with adult second-language learners (Perfetti & Liu, 2006; Perfetti, Liu, & Tan, 2005; Wang, Perfetti, & Liu, 2003, 2004).

If phonological processing plays a less important role in self-teaching in Chinese character and word reading and spelling, where does insight or knowledge of orthographic structure come from? As discussed earlier, we are in agreement with Nunes and Bryant (2009) that from a developmental and learning perspective even young children have some word-specific knowledge before learning formally reading and spelling. This word-specific knowledge of learning the configuration, bujian sequence, is much heightened in Hong Kong Chinese children as young as age 4 because of intensive formal teaching in preschools and home coaching.

This brings us to the role of kinesthetic aspects of writing words in word-specific orthographic representations as alluded to by Shahar-Yames & Share (2008) in spelling Hebrew words by third grade Israeli children. Much more so than Hebrew, Chinese word formation conforms to the Gestalt principle of *Pragnanz* or "goodness of forms" of connectivity, linearity, symmetry, and visual balance in the compositionality of Chinese characters. In the present study, we used a reasonably stringent scoring method by two assistants in assessing the production of correct spelling. We are in agreement with the observation of Tzeng (2002) that learning to read and write Chinese requires students to copy and write characters and words in accordance with the *Pragnanz* principle. Moreover, there is neuroscience evidence by Tan, Spinks, Eden, Perfetti, and Siok (2005) to show experimentally the important role of writing in learning to read Chinese characters and words. This spelling–reading relationship is also emphasized by Foorman, Francis, Novy and Liberman (1991) and Shahar-Yames and Share (2008) at the behavioral level in the study of the multidimensional spelling process. This is also the principle we made use of in the present study.

Summary

In the present study, we have emphasized the instruction and learning aspect with the provision of insight into the structure of Chinese characters. We carried out a training program with six short essays taught by the classroom teachers with high fidelity to the 131 grade 2 children at risk for dyslexia assigned to two experimental groups and a control condition. The INA was found to be generally more effective as compared with the other two groups in three of the eight bujian processing tasks subserving the three constructs of morpheme completion, bujian analysis and synthesis, and buijin compounding (Table 3 and Fig. 1).

Our study has shown evidence that the intensive in situ training carried out by classroom teachers helped Chinese children as young as 8 years in developing insight into the structure of orthographic components of characters and words. This insight combined with guided practice in writing (Tan, Spinks, Eden, Perfetti & Siok 2005; Tzeng, 2002) should

facilitate their learning of correct spelling of Chinese characters and words. By analogy with Shahar-Yames and Share's (2008) suggestion of an orthographic sensitivity hypothesis in spelling words in alphabetic languages, we would like to propose a "bujian sensitivity hypothesis" as a viable way to instruct and learn spelling in young Chinese children.

As in the present study, this bujian or radical sensitivity should incorporate a number of interrelated bujian analysis and synthesis, integration, and compounding tasks taught and learnt in meaningful contexts to provide learners with insights into the orthographic structure of Chinese characters and words. From a neuropsychological perspective, developmental dyslexia in Chinese could result from impairment in developing connections between orthographic and phonological representations via the lexical semantic pathway (Yin & Weekes, 2003). From a psycholinguistic perspective, developmental dyslexia in Chinese could result from inefficient or ineffective use of the morphological and morphographic constituents of the phonetic and semantic bujians and their integration (Leong, 1999). A deficit at this level may lead to reading and spelling difficulties (Leong, Cheng, & Lam, 2000). Leong et al. (2000, p. 255) emphasized that the "analysis-by-synthesis of the phonetic and semantic radicals (bujians) and the building up of the associative network of these components with many consistent characters, are necessary for proficient reading and spelling in Chinese." This emphasis is consonant with findings of multiple linguistic and cognitive deficits in Chinese dyslexics by Ho and her team (Ho, Chan, Lee, Tsang, & Luan, 2004; Ho, Chan, Tsang, & Lee, 2002).

Another fruitful study is the analysis of spelling errors by both children with dyslexia and their normal peers. Shen and Bear (2000) have shown from 7,000 invented spellings collected from the spontaneous Chinese writing samples of 1,200 grades 1 to 6 children in Mainland China that for younger children phonological strategies predominate and for older children graphemic and semantic strategies increase. Following Shen and Bear, Tong, McBride-Chang, Shu, and Wong (2009) analyzed the spelling samples of 171 six-year-old Cantonese-speaking Chinese children. These authors found that phonologically-based errors, orthographic-based errors, and morpho-lexically-based errors respectively accounted for 30.3%, 33.3%, and 14.2% of the variation in Chinese character identification, word dictation, and reading comprehension after controlling statistically vocabulary and age. They stated that "orthographic knowledge…appears to be a stable predictor of early Chinese literacy skills" (p. 447). Our present study lends support to this claim. It should also be noted that there are data on the writing errors of Cantonese-speaking dysgraphic patients with theoretical implications (Law, 2004; Law, Yeung, Wong, & Chiu, 2005). This topic should be further explored.

We would like to conclude by reiterating that the study of spelling and its difficulties should be placed within a cross-linguistic context as called for by various researchers (Chliounaki & Bryant, 2007; Keuning & Verhoeven, 2008; Nunes & Bryant, 2009; Pollo, Treiman, & Kessler, 2008; Treiman & Kessler, 2005). Treiman and Kessler (2005, p. 129), for example, urge more research in writing systems besides English: "Little research has examined writing development in children learning syllabic and onset-rime systems". The cross-linguistic perspective is important in showing how specific properties of orthographies may make it easier or harder for children to learn spelling and how best they learn it. It is hoped that the present study may provide some insight in this direction.

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Appendix

A. 部件默寫 Writing *Bujian*


霧 → 雲霧


花口 → 花圃


革 韆 → 鞦韆


礻 仙 → 神仙

B. 詞語默寫 Writing Dictated Words

樂	趣	環	境	保	護

C. 句子默寫 Writing Dictated Sentences

1. 太陽發光又發熱，照得我們眼昏。
2. 小明朋友多，結伴到郊外玩。

D. 部件默寫 *Bujian* Production

艹　　人　　日

E. 部件組合 2 *Bujian* Completion

Component cards

艹	日	十	女	口

Sample Answers

早	田	苗	早	草
苦	如	茹	姑	菇

F. 部件尋找 *Bujian* Search

1. 浸　汲　泳　淑
2. 然　魚　黑　煎
3. 忙　惟　慎　怕

G. 部件組合 *Bujian* Segmentation

1. 票 + 風 = 飄　　2. 釀 – 襄 = 酉
3. 四 + 維 = 羅　　4. 巔 – 顛 = 山

H. 部件組合 3 *Bujian* Integration

口	田	虫	馬
言	⺾	羊	工
丁	冫	牙	古
欠	包	食	目
火	魚	月	白

Sample Lesson

小蜜蜂	Little Bee
小蜜蜂，嗡嗡嗡，	Little bee, buzz, buzz, buzz,
飛進花叢中，	Flies into flower buds,
採花粉，釀蜜糖，	Picks pollens, makes sweet honey gold,
釀好蜜糖好過冬。	Makes sweet honey for winter cold.

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