Spelling without sound and meaning

Lam Pui Mei, May

A dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science (Speech and Hearing Sciences), The University of Hong Kong, April 30, 2004.

Student number: 2000239297

Abstract

It was predicted that logographemes existed as an independent psychological entity. This hypothesis was testified using a delayed copying paradigm. Grade 2, 3 and 4 primary students were asked to copy pseudocharacters with varying number of logographemes carried neither sound nor meaning. It was found that there was significant number of logographemic effect across grades, similar to the word length effect found in the alphabetic writing system. Result obtained supported the existence of logographemes as an independent psychological entity. The metalinguistic awareness of logographemes in spelling was also found to have developed as early as in the second-graders.

Introduction

The term spelling is traditionally applied to alphabetic writing systems. Is it possible for a non-alphabetic orthography like Chinese to be spelt? According to Longman English-Chinese dictionary (1993), spelling is putting component letters of the word in correct sequence. For example, spelling the English word “five” is the process through which the letters “f”, “i”, “v” and “e” are integrated in correct order either in spoken or written form. In spoken form, the letters are named aloud orally and in written form, the letters are written out in the correct sequence. (The following discussion will be focused only on written spelling). Based on the above definition of spelling, there are two criteria for an orthography to be spelt. First, an orthography must contain internal structures like letters f”, “i”, “v” and “e” of the word “five”. Second, there are implicit orthographic rules governing the position specificity of the building blocks and the order of their combination within a word (e.g., letters “f”, “i”, “v” and “e” are positioned from the first to the last position linearly in the word “five”). If the orthographic rules are violated (e.g., the positions of the letters “i” and “v” in the above example are reversed), a nonword “fvie” will be resulted.

Before investigating the possibility of spelling Chinese, a brief introduction to the Chinese orthography is indispensable. Generally, Chinese is considered to be a logographic system where the basic orthographic unit is character. Most Chinese characters appear as a cluster of strokes constructed in a square structure. Based on the composition of Chinese characters, Chinese characters can be grossly differentiated into two categories, namely Wen (文) and Zi (字). There are 5- 10% Wen and 90- 95% Zi, according to Huang & Hu's study (as cited in Chen, Allport & Marshall, 1996). Wen refers to simple characters which cannot be decomposed into smaller units (e.g., "大" /tai$_6$/ [big] and "不" /pɐt$_7$/ [not]). In other words, the simple character can be considered as one cluster of strokes and it is not spellable. *Zi* refers to composite characters consisting of simple characters (e.g., the character "奀" /ŋɐn$_1$/ [small] is vertically structured with the top character "不" /pɐt$_7$/ [not] and the bottom character "大" /tai$_6$/ [big]). Most of the simple characters have lost their original meanings and pronunciations in modern Chinese and become graphical forms of part of composite characters (e.g., the graphical form "   " on the left, "夂" at the right top and "㐄" at the right bottom of the character "降" /kɔŋ $_3$/ [falling]). If the simple characters and the graphical forms can be considered as the sub-character units when they combine to form another character, Zi will have internal structures. Recent studies (C.Y. Lee, 2003; Li & Chen, 1997; Peng & Wong, 1997; Taft & Zhu, 1997) revealed the frequency effect of sub-character units on the speed and accuracy of Chinese character recognition. Their studies supported the notion that Chinese characters have internal structures.

Having internal structures within character is a necessary but not a sufficient condition for spelling an orthography. There must also exist orthographic rules constraining the arrangement of the ordering of internal structures. Further examination of the position of the sub-character units where they occur in different characters reveals that the positioning of units in character is not random (Taft, Zhu & Peng, 1999). For example, when "不" /pɐt$_7$/ (not) acts as a sub-character unit, it can appear at the top of a character like “奀” /ŋɐn$_1$/ (small) or on the right side of a character like “杯” /pui$_1$/ (cup) but not at the bottom of a character. Putting “不” /pɐt$_7$/ (not) at the bottom of a character will result in a nonword. The occurrence of a nonword implies that there are orthographic rules constraining the spatial arrangement and the position specificity of each sub-character unit. Recent research (Li & Chen, 1997; Taft, Zhu & Peng, 1999) also found the existence of positional specificity effect of the sub-character units on the speed and the accuracy of character recognition. These studies supported the notion that there are orthographic rules in Chinese characters and the sub-character units are spatially coded.

It has come to a consensus that Chinese characters have internal structures and there are implicit orthographic rules, it is possible for Chinese characters to be spelt. The next reasonable question to ask is what are the functional orthographic units (refer to the basic abstract processing units) of Chinese? In other words, what are the letters equivalent in Chinese? There are at least two groups of researchers addressing this issue employing different experimental paradigms.

Previous research on the functional orthographic units in Chinese

Chen et al. (1996) argued that the functional orthographic units of Chinese characters were “stroke patterns” which consisted of simple characters and graphical forms. They found the number of stroke patterns effect on the speed (reaction time) in recognizing the same or difference of a pair of Chinese characters. One shortcoming of the study was that the orthographic frequency of the stroke patterns and syllable frequency of stroke patterns were not controlled across the two levels of testing conditions (e.g., stimuli with two stroke patterns like “雪” /syt$_8$/ [snow] consisted of the stroke patterns “雨” and “彐” and stimuli with three stroke patterns like “ ”/wɐn$_1$/ [warm] consisted of stroke patterns “氵”, “曰” “ and “皿”). The problem for not controlling the orthographic frequency of the stroke patterns was that the frequency effect of the stroke patterns would confound with the number of stroke patterns effect, if there were significant orthographic frequency difference across the two levels (stimuli with two stroke patterns and stimuli with three stroke patterns). It was because the higher the frequency of a stimulus, the lower the activation threshold, the faster would be the reaction time. The problem for not controlling the syllable frequency would be similar to that of not controlling orthographic frequency of stroke patterns, since the syllable frequency could be different for stroke patterns which were themselves characters (e.g., “雨” /jy$_5$/ [rain], “曰” /jœk$_9$/ [say], and “皿” /miŋ$_5$/ [a basin] in the above examples). Because of the existence of confounding variables in their experiment, their claim on stroke patterns as the functional orthographic units based on the number of stroke patterns effect would still await further verification.

Law & Leung (2000) argued the functional orthographic units of Chinese writing system were “logographemes” which could be strokes, graphical forms and characters. By analyzing the spelling errors of a patient with dysgraphia in a delayed copying task, they found four types of logographemic errors (e.g., substitution, deletion, transposition and addition) and more than 50 percent of the patient’s errors at the level of logographemes. Since the hypothesis of logographemes existing as an independent psychological entity has only been investigated on patients with acquired neurological disorder and on pre-school children (C.Y. Lee, 2003), more evidence is required to support this hypothesis.

Development of the metalinguistic awareness of the functional orthographic units

Supposing there are functional orthographic units equivalent to letters in Chinese orthography, the other issue needs to be addressed is the development of the metalinguistic awareness of these functional orthographic units in spelling. This issue is paramount because it is believed that the stage of spelling development could reflect the degree of orthographic knowledge which could further predict the future reading development (Frost, 2001; Shen & Bear, 2000). Shen & Bear (2000) studied the spelling errors on children's spontaneous writing. They claimed that children initially used phonological strategy in their spelling development based on the predominated homophonic-orthographic dissimilar errors at character level (e.g., the target 熊 /huŋ$_4$/ [panda] was substituted by 紅 /huŋ$_4$/ [red]). If Chinese characters have internal structures, spelling development of the building blocks would be a more fundamental issue than the whole character substitution errors which are on top of the building blocks. As spelling development of the functional orthographic unit has not been done before, this issue will be addressed in this paper.

To avoid confusion of different terms aforementioned for the functional orthographic units, the term "logographemes" adopted from Law & Leung (2000) was used in the paper thereafter.

Objectives

To bridge the gap of the current understanding of the functional orthographic units in Chinese writing system and their development in spelling, two questions were asked in this study: First, whether logographemes existed as an independent psychological entity. Second, if this unit existed, when would children develop the metalinguistic awareness of this structure in their spelling.

Characteristics of the current study

The delayed copying paradigm was adopted in this study. This paradigm was to mimic the spelling process of real characters in the sense that the retrieved characters needed to be temporarily stored for the final retrieval in spelling (Kay & Hanley, 1994). The stimuli of the delayed copying task were pseudocharacters constructed from different number of logographemes (pseudocharacters differing from nonwords where the component logographemes' position specificity was kept in pseudocharacters but not in nonwords). The pseudocharacters were constructed in two levels of conditions, namely pseudocharacters with two- logographemes (e.g.,  consisted of and ) and pseudocharacters with three- logographemes (e.g.,  consisted of , , ). This was to investigate if there was number of logographemic effect. To avoid confounding factors as aforementioned (e.g., lexical factors like syllable frequency and orthographic frequency of logographemes), all the component logographemes chosen in the experiment carried no phonological and semantic information and the orthographic frequency of chosen logographemes was controlled across levels (two-logographemes and three-logographemes) and across grades (grade 2 to 4).

By considering both the characteristics of Wen and Zi, it had been believed that the Chinese orthographic structure consisted of at least three levels, namely the stroke, the logographemic and the character levels (Li & Chen, 1997; Peng & Wong, 1997; Taft & Zhu, 1997). To better understand children's knowledge of the spelling units, a qualitative analysis on the spelling errors across these levels was done.

Prediction

If the outcome measurement of the accuracy in delayed copying of pseudocharacters was affected by the manipulated variable of the number of logographemes (two-logographemes and three-logographemes), it could be concluded that processing the pseudocharacters was accomplished via the processing of the logographemes (Taft & Zhu, 1997). This number of logographemic effect would be similar to the "word length effect" in varying the number of letters in words. If logographemes existed as an independent psychological entity as that of letters, it was expected that more logographemes in a pseudocharacter would require more time to process each logographeme one by one. The time for starting rehearsal would be delayed until all the information had been processed. Without adequate re-activation of the memory trace of the whole pseudocharacters, the trace of the pseudocharacters with more logographemes would be more vulnerable to decay (C.H. Lee, 1999). Thus, the accuracy of the level of pseudocharacters with three-logographemes would be expected to be less than pseudocharacters with two-logographemes. However, if the pseudocharacters were processed as a whole, with balanced stroke complexity (number of strokes) and orthographic frequency of logographemes across levels (two-logographemes and three-logographemes), similar outcome accuracy rate should be obtained in the two levels.

For the result of qualitative analysis, it was predicted that four types of logographemic errors, namely substitution, deletion, addition and transposition, could be found in the spelling errors if the logographemes really existed as an independent psychological entity. This was based on Caramazza & Miceli's (1990) logic that if a unit existed as an independent psychological entity, these four types of errors should occur at the same processing unit.

For the developmental issue, it was predicted that children at higher grade would have better result than that of the lower grade counterparts due to more literacy experience in reading and spelling.

Method

Participants

There were 72 grade 2 (P2), 73 grade 3 (P3) and 76 grade 4 (P4) students from two primary schools recruited for screening at the end of the first semester after the mid-term examination. Four standardized tests were administered in the screening process. Raven's Standard Progressive Matrices (Raven, 1986) which estimated the non-verbal cognitive skills; the Hong Kong Test of Specific Learning Difficulties in Reading and Writing- the Chinese Word Reading subtest (Ho, Chan, Tsang & Lee, 2000); the Test of Visual-Perceptual Skills Revised- a Visual Memory subtest (Gardner, 1996) and the Test of Visual-motor Skills (Gardner, 1995), were carried out in the screening process.

A total of 36 grade 2 (mean age 7; 06, ranged 7; 01- 8; 04), 36 grade 3 (mean age 8; 05, ranged 7; 11- 9; 10) and 32 grade 4 (mean age 9; 05, ranged 9; 00- 10; 00) students with normal nonverbal intelligence (i.e., with standard score of 90 or above), reading achievement within –0.67 SD to +1.33 SD, visual memory and visual-motor abilities of or above –1.25 SD and –1.07 SD respectively, were selected as our participants for the experiment. An independent one-way ANOVA, 1 (results of a screening test) X 2 (students from the two different schools) was done on each screening test. The two groups of students were the independent variables and the results of a screening test were the dependent variable. This was to ensure that the two groups of students were matched. No significant difference was found in all the four screening tests.

Materials

A database of logographemes with frequency breakdown across grades was derived from the Hong Kong Corpus of Primary School Characters (HKCPSC) (Leung, 2002). HKCPSC was established based on Chinese characters collected from Chinese and General Sciences textbooks and workbooks in Hong Kong. One of the major difficulties for investigating spelling was to examine the word frequency effect on spelling (Brown & Ellis, 1994). Although HKCPSC could be used to represent the reading frequency, it might not reflect the writing frequency. A questionnaire (see Appendix A) about the writing frequency was sent to 50 randomly selected from 800 local primary schools in Hong Kong. This was to find out how much of the students' written works were derived from their textbooks and workbooks that constituted the basis of the HKCPSC. Nineteen primary schools replied the questionnaire. These primary schools were evenly distributed in Hong Kong Island, Kowloon and the New Territories. Based on these schools' replies, 90 percent of students' written words originated from their textbooks and workbooks. Therefore, the corpus of logographemes derived form HKCPSC was assumed to be reflecting the frequency of written output.

Principles in identifying logographemes were mainly adopted from Law & Leung (2000). There were three major principles in identifying logographemes in a character: I) Spatial separation of components. This meant components could be spatially isolated from the chunk. II) Replaceability of components. This referred to both or either one of the components in a character being free to combine with other components to form another character. III) Co-occurrence. For example, the character 發 /fat$_8$/ (prosperous) were broken down into four logographemes (癶, 弓, 几, 又) based on the above principles. These four logographemes were spatially separable and 弓 could be replaced by 言 to form the character 設 /ts^{h}it$_8$/ (establish); 又 could be replaced by 口 to form the left part of the character 鉛 /jyn$_4$/ (lead); 癶 was considered as one logographeme as the two parts must co-occur.

There were 2018, 2582 and 3108 different characters found in the character corpus of grade 2, 3 and 4 levels respectively. By adopting the decomposition principle of logographemes aforementioned, there were 311, 320 and 322 different logographemes at grade 2, 3, 4 levels respectively. The logographemes could be categorized into three units size, namely, a stroke (e.g., 一, |), a graphical form (e.g., ユ, 䒑) and a character (e.g., 人 /jɐn$_4$/ [human]) (Law & Leung, 2000).

The frequency of logographeme was estimated by the family size of the characters it generated. For example, logographeme ユ occurred in characters 候, 猴 and 緱. Its frequency was counted as three. The logographeme 䒑 occurred in characters 綘, 偉, 瞵, . Its frequency was counted as four. In the case of characters in which the same logographeme occurred more than once, the frequency was counted accordingly. For example, the character 林 was made up of two 木 s, therefore, the frequency of the logographeme 木 would be counted as two.

Only logographemes that posed no semantic and phonological information were chosen as stimuli to control for the lexical factors (e.g., syllable frequency). There were 129, 136 and 146 logographemes chosen for grade 2, 3 and 4 levels respectively. At each grade, the values of logographemic frequencies of different logographemes were arranged in order of magnitude. The value of the frequency of the central number of logographeme was taken as the median frequency for that grade. For example, at grade 2 level, there were 129 different logographemes. The logographeme in the middle was the 65th logographeme which had a corresponding frequency of seven. Seven was taken as the median frequency for grade 2 level. The median frequency computed for grade 3 level was eight and for grade 4 level was ten.

Twenty-seven different logographemes were selected for the construction of 20 different pseudocharacters at each grade. All of the logographemes selected were neither strokes nor characters themselves. The mean stroke number of pseudocharacters at each grade was controlled at 12 which was the mean stroke number of real characters across grades according to the HKCPSC (Leung, 2002). The mean frequency of the 27 different logographemes at each grade was controlled at the median frequency. Table 1 showed the characteristics of the logographemes in the study.

Table 1

Characteristics of logographemes used for constructing stimuli

Grade	Number of pseudocharacters	Number of logographemes	Logographemes frequency Mean (range)	Pseudocharacters' Stroke number Mean (range)	Example
P2	10	2	7 (5- 9)	12 (10-13)	
	10	3	7 (4- 11)	12 (9-15)	
P3	10	2	8 (5- 13)	12 (9-14)	
	10	3	8 (5- 13)	12 (11-15)	
P4	10	2	10 (6- 14)	12 (9-15)	
	10	3	10 (7-15)	12 (9-14)	

In order to retain the positional specificity of the logographemes and to obey the orthographic rules, all the component logographemes were at their legitimate positions when constructing the pseudocharacters. Two types of stimuli were constructed. They were pseudocharacters consisting of two- logographemes with top-down configurations of "  " like  and pseudocharacters consisting of three- logographemes with top-down and left-right configurations of "" like  or "" like .

Three different sets of stimuli lists (see Appendix B) were used for the three different grades of students. A total of 25 stimuli in each list were constructed for each grade, with 10 stimuli in each level (two-logographemes and three-logographemes) and five fillers of real characters. All the fillers did not contain those logographemes used in the stimuli to avoid additional activation of the logographemes. Fillers were used to minimize the frustration that might cause with the use of pseudocharacters that students had not yet encountered before. Due to the limited number of different logographemes available under the consideration of other variables like logographemic frequency and stroke complexity, each logographeme was repeatedly used for one to three times in each list. In order to balance the practice effect of repeated exposure of the same logographeme, an ABBA design, with set A consisted of stimuli numbered 1 to 12 and set B comprised stimuli numbered 13-25, were adopted in the presentation for each grade. For example, set A was presented prior to set B to students Group One and vice versa to students Group Two. In such way, each logographeme in different pseudocharacters would receive the same chance in benefiting from the practice effect, thus, counterbalancing the practice effect if any. The stimuli were constructed with logographemes in ‘sing shi ming’ font (新細明體) by using CorelDraw 6.0.

Design

A 2X3 experimental design with a delayed copying paradigm of pseudocharacters was adopted. The number of component logographemes making up pseudocharacters (two- logographemes and three- logographemes) and grade (P2 to P4) were the independent variables while the correct rate of delayed copying of pseduocharacters was the dependent variable. Logographemes employed were not characters themselves, thus, avoiding confounding factors like syllable frequency. Also, the pseudocharacters complexity was controlled at 12, avoiding effect contributed to the variation of stroke numbers. Furthermore, the orthographic frequency of logographemes was manipulated at their median frequencies across grades, preventing any possible frequency effect.

The accuracy in delayed copying across the two types of pseudocharacters (pseudocharacters with two- logographemes and three- logographemes) formed a within-subject design while that across grades (P2 to P4) was a between-subjects design.

Apparatus & Procedure

On average, about 20 students in a group attended the task at a time with five clinician supervisors monitoring their behaviors. This was to avoid the students from copying the work of their classmates as well as dictating the words prior to the pre-setting time stated below. All the students had to put their hand on the hand mats, to ascertain that no one would write prior to the pre-setting time. After the instruction (see Appendix C), a total of 25 stimuli with 20 pseudocharacters and five fillers of real characters were tested in each grade. The stimuli were presented one by one onto a classroom screen by a projector. Each character was presented for six seconds controlled by a computer program (PowerPoint 2000). Then, there were displays of three pages of dots on the screen (i.e., a page with three dots, followed by two dots and then one dot), with each page of dot (s) presented for one second. At the same time of viewing the dots, the students had to perform backward counting from three to one. This was to refrain students from having any verbal production of associated characters, leading to activation of representations at character level which might contaminate the experiment. The students were required to write down the stimulus just shown on the screen once a picture signifying the allowance of writing appeared. The students were required to put back their hands on the hand mats again once after writing. Turning pages to the previous one, as well as reading aloud any words during the experiment, were not allowed. Three practice items were preceded the testing to let the students get familiar with the instruction of the task. No feedback in terms of the accuracy of their response was given. After the tasks, all of the students received a snack as reinforcement.

Results

Quantitative analysis

The accuracy of pseudocharacters in delayed copying was used as the dependent variable for the purposes of analysis. In scoring pseudocharacters accuracy, correct recall of the whole pseudocharacter was given one mark. Incorrect delayed copying of any component of the pseudocharacter got no mark. Fillers were disregarded in the accuracy calculation. The accuracy data were presented in figure 1.

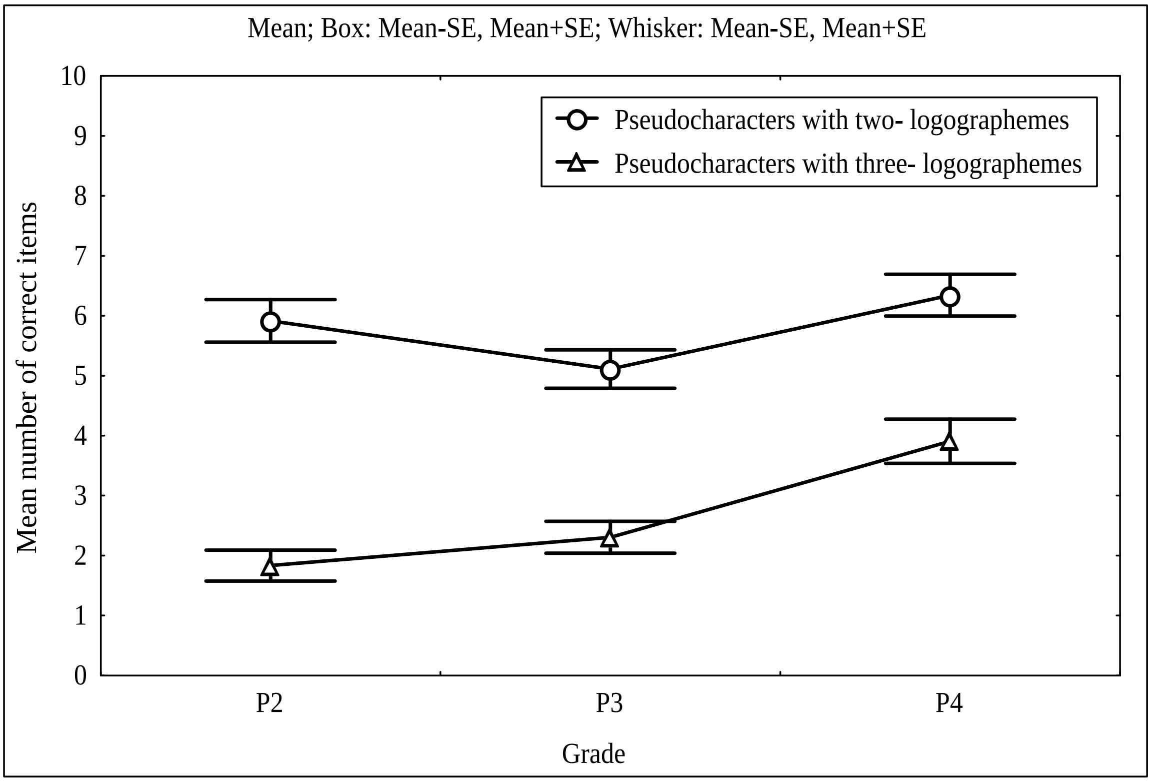


Figure 1. Results of the delayed copying task across levels (logographemes) and grades

The data were analyzed using ANOVA, comprising the factorial combination of levels (two- logographemes and three- logographemes) and grades (P2 to P4). The analyses showed significant main effects of number of logographemes, F (2, 101) = 278, p < 0.01; and grade, F (2, 101) = 7.53, p < 0.01; and significant interaction effect between levels and grades, F (2, 101) = 7.19, p < 0.01. Simple main effect of number of logographemes was significant in all grades with p < 0.01.

The interaction effect was analyzed by a post hoc inspection using Tukey HSD test. The results showed that at the level of two- logographemes, there was significant difference between the third-graders and the fourth-graders, p < 0.01. No significant difference was found between the second-graders and the fourth-graders, as well as between the second-graders and the third-graders.

At the level of three- logographemes, there were significant differences between the second-graders and the fourth-graders as well as between the third-graders and the fourth-graders, each with p < 0.01. No significant difference was found between the second-graders and the third-graders.

Qualitative analysis

The distribution of spelling errors was charted in two different dimensions, namely errors across different processing levels (e.g., the stroke, the logographemic and the character levels) and within the logographemic level (e.g., substitution, deletion, addition and transposition errors).

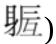
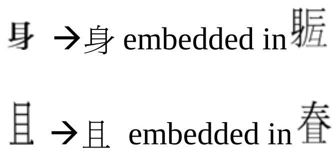
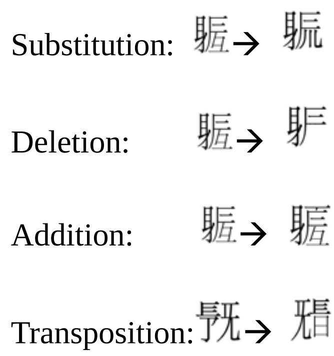
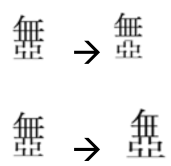
Each error type was counted as one token regardless they occurred in the same pseudocharacter. The target  misspelled as  was used to illustrate the charting criteria. In the example, the logographeme 身 (on the left of the target ) was spelled as a character 身 /sɐn$_1$/ (body), then one token was counted at the character level. Also, one token was counted at the logographemic level for the logographeme  (at the left bottom of the target ) was substituted by another logographeme 丰. Within the logographemic level, one token for this substitution error was counted. The charting criteria of errors across processing levels and within the logographemic level were shown in table 3.

Table 3

Charting criteria and example of errors across different processing levels and within the logographemic level

Processing Unit	Criteria	Example
Character	Addition /deletion a stroke resulting a character	
Logographemes	Substitution/deletion/addition/transposition of logographemes but with at least one logographemes in the response same as the stimulus.	
Stroke	Addition/ deletion of a stroke resulting in a non-logographemes but with similar orthographic configuration as the stimulus	
Uncategorized	Substitution/deletion of the logographemes, resulting in no common logographeme shared between the stimulus and the response or substitution of an irreverent character	
No response	Leaving a blank page	

The errors distribution was 20 percent at the stroke level, 49 percent at the logographemic level, 19 percent at the character level, eight percent at the uncategorized one and four percent at the no response category. At the logographemic level, the distribution was 43 percent for substitution errors, 53 percent for deletion errors and four percent for addition and transposition errors.

Discussion

The hypothesis that logographemes existed as an independent psychological entity was tested using a delayed copying task of pseudocharacters on grade 2 to grade 4 students. Significant number of logographemic effect was found in each grade.

The existence of logographemic level in Chinese characters

The data revealed significant number of logographemic effect across grades. One might argue that the significant number of logographemic effect could be attributed to the effect at other processing levels, apart from the logographemic level. As the mean number of stroke was balanced across the two levels (two- logographemes and three-logographemes), stroke complexity effect was ruled out. The logographemes used and pseudocharacters mapped into no preexisting orthographic, phonological and semantic information in the long-term memory representation, lexical effect (e.g., syllable frequency) was unlikely. Since the mean orthographic frequency of logographemes was the same across the two levels, the orthographic frequency effect of logographemes was eliminated. Therefore, all these alternative arguments could not stand. The number of logographemic result suggested that the pseudocharacters were not processed holistically, but were processed in a componential way via the logographemic level.

Qualitatively, 50 percent of errors at the logographemic level and the presence of four types of errors, namely substitution, deletion, addition and transposition, further supported our hypothesis that logographemes existed as an independent psychological entity. The presence of these four errors implied that logographeme was processed as a unit (Caramazza & Miceli, 1990). If there were insufficient processing at the logographemic level, errors within this unit would occur.

Another supportive evidence of the presence of logographemes as an abstract representation was the presence of cursive scripts transformed from the printed logographemes (e.g., → ;  → ). This transformation suggested delayed copying of pseudocharacters in the task was not simply copying of complex line drawing. This transformation suggested that the input logographemes had been processed and recognized in the abstract logographemic representation. The output logographemes could reflex the one stored in the long-term memory (Kay & Hanley, 1994).

The insufficient processing aforementioned concerning the number of logographemic effect was speculated as follows. When the logographemes were processed in a serial manner, the time for re-activating each logographeme in a pseudocharacter during the rehearsal would be longer for pseudocharacters with three-logographemes than those with two- logographemes. The trace of pseudocharacters with three-logographemes would be more vulnerable to decay (C.H. Lee, 1999), resulting in the retrieval failure. This could explain why the accuracy of delayed copying of pseudocharacters with three-logographemes was significantly less than that of pseudocharacters with two- logographemes.

Development of the metalinguistic awareness of logographemes in spelling

Concerning the development of the metalinguistic awareness of logographemes in spelling, results indicated that it was established as early as in the second-graders, supported by the significant number of logographemic effect in this grade. The results were compatible with those found by C.Y. Lee (2003) who stated that children at their kindergarten third year (K3) had developed the metalinguistic awareness of logographemes as reflected in a recognition task. Therefore, it was not surprising that the second-graders were found to have the logographemic awareness.

The significant number of logographemic effect in all the three grades, implied that all the students had developed the metalinguistic awareness of logographemes in their spelling. However, the findings that the second-graders had similar performance to the fourth-graders at the level of two-logographemes but had significantly poor performance at the level of three-logographemes warranted some explanations.

Since the students were screened using a cutoff line of – 1.25 SD in the visual memory test (Gardner, 1996), it might be possible that the students across grades had different levels of visual memory ability above the cutoff level. As success in the delayed copying task required substantial visual memory ability, the difference in the visual memory ability might lead to the discrepant performance between the second-graders and the fourth-graders. An analysis on the visual memory ability of the students across the three grades was done. By doing a factorial ANOVA, 1 (results of the visual memory test) X 3 (grades) on the visual memory test, a significant difference across grades with F (2, 101) = 6.58, $p < 0.01$ was found. The Tukey HSD post hoc test showed that in the visual memory test, the second-graders' average performance was significantly better than that of the third-graders and the fourth-graders both with $p < 0.01$. The superior visual memory ability of the second-graders could possibly explain why they got similar results to that of the fourth-graders at the level of two- logographemes. The better visual memory ability probably favored the second-graders in doing the delayed copying test which required considerable visual memory load.

However, such information could not explain why the fourth-graders got a better result than that of the second-graders at the level of three- logographemes, even though the second-graders got better visual memory ability in average. Assuming pseudocharacters with three-logographemes were more difficult to be retrieved than pseudocharacters with two-logographemes, the fourth-graders must possess certain skills that enabled them doing better on stimuli with three- logographemes which could not be retrieved solely relying on visual memory.

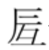
To trace out why the fourth-graders had significantly better result at the level of three-logographemes, the written errors at three- logographemes level were analyzed once again. A phenomenon was observed. The higher the grade, the higher the frequency for both of the logographemes on the same side was written down (i.e., “ $\genfrac{}{}{0pt}{}{B}{C}$ ” in the configuration of “$A\genfrac{}{}{0pt}{}{B}{C}$” or “$\genfrac{}{}{0pt}{}{B}{C}A$.”). Example of the error pattern would be  → . Objectively, the proportion of the error which the two logographemes on the same side being written down (i.e., “ $\genfrac{}{}{0pt}{}{B}{C}$ ” was correctly spelled out like  → ) and the error which only one of the logographemes on the same side being written down (i.e., either **B** or **C** were correctly spelled out like  → or  → ) was calculated. The result was shown in table 4.

Table 4

Distribution of error types in the condition of three logographemes.

Grade	Error in "  " configuration	Error in "**B**" or "**C**" configuration
P2	19%	81%
P3	21%	79%
P4	35%	65%

Results in table 4 showed that the fourth-graders had higher percentage of writing down the two- logographemes on the same side of the pseudocharacters (e.g., "" or "" → "  "). Based on these error patterns, it was speculated the fourth-graders had a better use of the chunking strategy which promoted their performance in delayed copying pseudocharacters with three-logographemes. According to Solso, (1988), chunking strategy facilitated the processes of storage and recalling in the short-term memory (STM). In order to employ the chunking strategy, representation stored in the long- term memory (LTM) must be activated through mapping between the incoming stimulus and the representation stored in LTM (Solso, 1988). Once the stored representations were chunked, not only the memory load was reduced, the items could also be retrieved more easily by looking up the mental representation (Solso, 1988). By analogy, the retrieval of characters stored in the LTM would be activated if they posed the same logographemes or had similar framework as that of the stimuli pseudocharacter with three-logographemes. For example, for the stimulus , possible representation being activated in the LTM could be 辰 /sɐn4/ (morning). The two logographemes 厂 and 𧘇 in the stimulus would then be chunked up based on this character framework of 辰 /sɐn4/ (morning). After chunking, the memory load would reduce from three (e.g., 身, 厂 and 𧘇) to two (e.g., 身, 辰). The latter which consisted of two units would start rehearsal in a shorter time than the former which consisted of three units. In turns, the success in retrieval of the stimuli in the latter case in the delayed copying task would increase due to more chance in re-activating the memory trace.

One of the possibilities for the fourth-graders had a better use of the chunking strategy than the lower grade counterparts might be that the fourth-graders had more exposure to literature, equipping them with better literacy skills. With better literacy skills, the metalinguistic awareness of the possibility of chunking up the internal structures could be promoted. Also, the fourth-graders who had more literacy exposure probably gained the benefit of getting greater number of character frameworks that facilitated chunking and thus recalled the pseudocharacters with three-logographemes better. This could probably explain the fourth-graders had significant better performance at the level of three-logographemes than that of the second-graders even though the second-graders had better visual memory ability.

To attest our hypothesis on the development of chunking strategy in spelling, further research in this area was recommended. If the success in using the chunking strategy was based on prior knowledge of character framework, the accuracy in the condition of pseudocharacters with three- logographemes in a legitimate position (i.e., obey the orthographic rules) should be higher than that of pseudocharacters with three-logographemes in a non-legitimate position. In the latter case, the chunking strategy using character framework could not be applied. Each component structure would then be memorized one by one. Then our hypothesis of the presence of chunking strategy upon knowledge of character framework could be verified. If the chunking hypothesis would be supported, it might further imply that the spelling units become larger with development. Logographeme unit would be used as the processing units at the early stage of spelling development. With development, logographemes would be chunked up to become a larger processing unit.

Based on the speculation of forming a larger spelling unit upon chunking strategy, it was further speculated the Chinese writing system would be hierarchical in nature. This phenomenon of forming a larger unit (chunked logographemes) was similar to the spelling errors at the multi-logographemic level (e.g., two or more logographemes were substituted, deleted or inserted at the same time) as reported by Law & Leung (2000). The presence of the chunked logographemes could imply that they might constitute a level on top of the mono-logographemic level (Law & Leung, 2000). Further research on testifying whether the chunked logographemes constituted a higher level of processing would be recommended. A spelling task could be implemented by manipulating the orthographic frequency of the chunked logographemes. At the same time, the syllable frequency and stroke complexity could be kept constant across levels of the variable concerned. If the level with high frequency group of chunked logographemes had higher accuracy than low frequency group, the hypothesis of the presence of a unit with chunked logographemes could be supported.

Conclusions

The present study offered evidence that the logographemes existed as an independent psychological entity in Chinese writing system and the metalinguistic awareness of logographemes in spelling developed as early as in the second-graders. The presence of logographemes suggested that Chinese characters had internal structures, which fulfilled the first criterion for an orthography to be spelt. If logographemes could also be demonstrated to have positional specificity (the second criterion for an orthography to be spelt), spelling in Chinese would be possible. In such case, Chinese spelling could be regarded as the process of putting logographemes in a spatially corrected sequence to form a character.

References

Caramazza, A., & Miceli, G. (1990). The structure of graphemic representations. *Cognition, 37,* 243-297.

Chen, Y. P., Allport, D.A., & Marshall, J.C. (1996). What are the functional orthographic units in Chinese word recognition: The stroke or the stroke pattern? *Quarterly Journal of Experimental Psychology: Human Experimental Psychology*, 1024-1043.

Frost, J. (2001). Phonemic awareness, spontaneous writing, and reading and spelling development from a preventive perspective. *Reading and Writing: An Interdisciplinary Journal, 14,* 487-531.

Gardner, M.F. (1995). *Test of visual-motor skills revised.* Burlingame, CA: Psychological and Educational Publications.

Gardner, M.F. (1996). *Test of visual-perceptual skills (non-motor) revised.* Burlingame, CA: Psychological and Educational Publications.

Ho, C.S., Chan, D.W.O., Tsang, S.M., & Lee, S.H. (2000). *The Hong Kong Test of Specific Learning Difficulties in Reading and Writing*. Hong Kong: Hong Kong Specific Learning Difficulties Research Team.

Kay, J., & Hanley, R. (1994). Peripheral disorders of spelling: The role of the graphemic buffer. In G.D.A. Brown & N.C. Ellis (Eds.), *Handbook of spelling: Theory, process and intervention* (pp. 295 – 318). NY: John Wiley & Sons.

Law, S. P., & Leung, M. T. (2000). Structural representations of characters in Chinese writing: Evidence from a case of acquired dysgraphia. *Psychologia, 43,* 67-83.

Lee, C.H. (1999). A locus of word length effect on word recognition. *Journal of Reading and Psychology, 20,* 129-150.

Lee, C. Y. (2003). *A pure orthographic stage in processing Chinese characters: Evidence from data of sub-morphemic processing in preschool children*. Unpublished bachelor degree's dissertation, University of Hong Kong.

Leung, M.T. (2002). *Hong Kong Corpus of Primary School Characters (HKCPSC).* Hong Kong: University of Hong Kong.

Li, H., & Chen, H.C. (1997). Processing of radicals in Chinese character cognition. In H. C. Chen (Ed.), *Cognitive Processing of Chinese and related Asian Languages* (pp. 141-160). Hong Kong: The Chinese University Press.

Peng, D., & Wang, C. (1997). Basic processing unit of Chinese character recognition: Evidence from stroke number effect and radical number effect. *Acta Psychologica Sinica, 29(1),* 8-16. (In Chinese.)

Longman English-Chinese dictionary of contemporary English (13th ed.). (1993). Hong

Kong: Longman Asia Limited.

Raven, J.C. (1986). *Hong Kong Supplement Guide to the Standard Progressive Matrices*. Hong Kong: Education Department.

Shen, H.H., & Bear, D.R. (2000). Development of orthographic skills in Chinese children. *Reading and writing: An interdisciplinary journal, 13,* 197-236.

Solso, R.L. (1988). Cognitive psychology (2nd ed.). Boston: Allyn and Bacon.

Taft, M., & Zhu, X. (1997). Submorphemic processing in reading Chinese. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23(3),* 761-775.

Taft, M., Zhu, X., & Peng, D. (1999). Position specificity of radicals in Chinese character recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 498-519.

Acknowledge

I would like to express my gratitude to Dr. Leung Man Tak, my honorable supervisor, for his support and guidance during the course of this study. I was especially grateful for his valuable comments and stimulation on my thinking on the topic.

I would like to give special thanks to classmates for their support and help in data collection.

I would like to thank the vice-principal, teachers and the students of T.W.Hs. Tam Shiu Primary School and T.W.Hs. Sin Ci Wan Primary School who participated in this study.

Appendix A

「中文字書寫發展」之問卷

本校 (學校名稱) 二至四年級學生各書寫內容所佔百分比:

1. 有關中文書課文內容 (例如: 作業、詞語抄寫、默書等) 的佔: ____ %

2. 有關常識書課文內容 (例如: 作業、工作紙等) 的佔: ____ %

3. 非中文書及常識書課文內容 (例如: 課外讀物、抄寫聖經金句等的佔: ____ %

(註: 1 ,2, 3, 三項的總和需爲 100 %)

The questionnaire in English was as follows:

Questionnaire on the topic of "Chinese spelling development"

The percentage of the written work of our (school name) primary two to primary four students which:

1. Derived from the Chinese textbook (e.g., workbook, vocabulary copying, dictation) is ____%

2. Derived from the General Science textbook (e.g., workbook, worksheet) is ____%

3. Derived from written materials other than the Chinese and General Science textbook (e.g., unseen dictation, golden sentences copying) is ____%

(Remark: the percentage sum in the three items, 1, 2, 3, should be equal to 100%)

Appendix B

Order of presentation	P2 set A	P2 set B	P3 set A	P3 set B	P4 set A	P4 set B
Trials						
1.	吾	吾	吾	吾	吾	吾
2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Stimuli (number 1-10)						
1.	[illegible]	的	[illegible]	的	[illegible]	的
2.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3.	林	[illegible]	林	[illegible]	林	[illegible]
4.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8.	沁	肥	沁	肥	沁	肥
9.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10.	[illegible]	[illegible]	量	[illegible]	[illegible]	[illegible]

Stimuli (number 11-25)

11.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14.	的	[illegible]	的	[illegible]	的	[illegible]
15.	[illegible]	林	[illegible]	[illegible]	[illegible]	林
16.	[illegible]	[illegible]	[illegible]	林	[illegible]	[illegible]
17.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20.	[illegible]	沁	[illegible]	沁	[illegible]	沁
21.	肥	[illegible]	肥	[illegible]	肥	[illegible]
22.	[illegible]	[illegible]	[illegible]	量	[illegible]	[illegible]
23.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix C

The instruction of the task in Chinese was as follows:

"今日姐姐邀請你地黎係做一個默寫既測驗. 你地而家先將雙手放係掌形枱墊上, 然後再望住熒光幕. 好啦, 等陣你地會係熒光幕度見到一個中文字, 你地要立即記住佢. 因爲個字會好快消失. 當個字消失後, 我地一齊數 "三, 二, 一". 見到個老婆婆幅圖畫出現既時候, 你地就要即刻寫番頭先見度果個字出黎. 記住呀, 如果識個字呢都唔好讀出聲呀. "你地見到既字, 有 d 好會似字, 有 d 唔似, 你地要睇清楚每一筆每一劃先寫出黎呀. 好啦, 望住熒光幕, 開始."

The instruction of the task in English was as follows:

" Today, you are invited to have a delayed copying test. Now, please put your hands on the hand mat stick on your desk and then look at the screen. In the test, you will see a Chinese character shown on the screen. When you see a character, you have to memorize it as much as possible, as the character will disappear quickly. Once the character disappears, you have to perform a backward counting from three to one. You are only allowed to write down the character just seen on the screen until a picture of an old lady appears. Remember, you are not allowed to read aloud the characters. Please also read each character carefully, because some characters look like real characters while some do not. Now, look at the screen again. The test is going to begin."