Title	The effects of phonological regularity on writing of Hong Kong school-aged children
Other Contributor(s)	University of Hong Kong
Author(s)	Lee, Yee-wa, Fecilia
Citation	
Issued Date	2005
URL	http://hdl.handle.net/10722/56203
Rights	Creative Commons: Attribution 3.0 Hong Kong License

The Effects of Phonological Regularity on Writing of Hong Kong School-aged Children

Lee Yee Wa, Fecilia

A dissertation submitted in partial fulfillment of the requirements for the Bachelor of Science (Speech and Hearing Sciences), The University of Hong Kong, May 6, 2005.

Abstract

The study investigated effect of phonological regularity of phonetic compound characters on writing and its development. Students from grade 2, 4 and 6 with normal non-verbal IQ, Chinese reading ability and visual-spatial perceptual abilities were recruited. Writing to dictation on 16 characters, embedded in compound words, with phonological regularity, character frequency and stroke number controlled was implemented. Correct percentage was analyzed using 2-way ANOVA. Results showed regularity effect in grade 6. Error patterns suggested second graders processed at logographeme level while students from grade 4 onwards processed at radical level for writing. Sixth graders mastered regularity rule more proficiently than fourth graders as they had larger proportion of phonetic radical accessing error in regular than in irregular condition.

In English, an alphabetic language, both reading and writing processes employ a dual route model and they are similar processes (Caramazza, Miceli, Silveri, & Laudanna, 1985; Goodman & Caramazza, 1986). According to Caramazza, et al. (1985), in reading known words, phonological representations could be extracted from graphemic representations directly as the phonological representations for known words were already stored in one's lexicon. In nonword reading, it involved converting letters or letter clusters into phonological segments for speech output, and this process was called Grapheme-Phoneme Conversion (GPC rule). Goodman and Caramazza (1986) hypothesized that the same phenomenon could be employed in English writing. In writing known words, lexical process was used as the graphemic representations for known words were stored in one's lexicon; in nonword written spelling, GPC rule was employed to convert segments of phonemic representations into graphemic code for written output.

Both English reading and writing use GPC rule for processing nonwords and the basic unit for both reading and writing is letter. In applying GPC rule, one could convert graphemic representations to phonological output in reading nonwords and one could convert phonological representations into graphemic written output. Both English reading and writing have the same basic processing unit, this implies that English reading and writing are similar processes and so dual route model could be applied to both of them.

Spelling is to construct one word from its sub-lexical unit. Spelling is allowed when there is a sub-lexical unit and which is assigned with corresponding phoneme in order to make up one word. Basic unit in English writing, letter, is smaller than an English word, and each letter is assigned to corresponding phoneme. The existence of this sub-lexical unit, letter, allows one to spell one English word from its sub-lexical unit.

Chinese system was described as a logographic system, where the basic orthographic units correspond directly to one morphemic meanings and one pronunciation in isolation.

(Zhou & Marslen-Wilson, 1999). Does Chinese script behave the same as an alphabetic script like English? Do Chinese reading and writing share the same processing unit, as the case in English reading and writing?

According to the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002), 72% (2781/3844) of modern traditional Chinese characters used in Primary School are phonetic compound characters. Each of these characters consists of two components: The semantic radical gives hint to the meaning of and the phonetic radical gives hint to the pronunciation of the character.

Many studies investigated the effects of different factors of phonetic and semantic radicals on reading (Chan & Siegel, 2001; Ho & Bryant, 1997; Peng & Yang, 1997; Shu, Anderson, & Wu, 2000). Three major factors were being studied in these studies. The first one was phonological regularity effect of phonetic radical. Phonetic radicals represent pronunciations of characters containing them in varying degree. A phonetic radical which has pronunciation identical to the pronunciation of the character containing it, the character is said to be phonologically regular. For example, the character '榕' */ju.˙4/*, meaning 'banyan', is a phonologically regular character because its phonetic radical '容' */ju.˙4/*, meaning 'appearance', has pronunciation identical to the pronunciation of the character containing it. The character '滑' */wat6/*, meaning 'to slip', is a phonological irregular character as its onset, rime and tone are different from its phonetic radical '骨' */kwat1/*, meaning 'bone'.

Ho and Bryant (1997) found out that first and second graders in Hong Kong read phonologically regular characters more accurately than phonologically irregular ones in a character reading task. Their results suggested that Chinese children would make use of the phonological cues provided by the phonetic radicals (Orthography-Phonology Correspondence rule [OPC rule]) in reading Chinese characters. Peng and Yang (1997) asked third and sixth graders to name regular and irregular Chinese characters in their study. It was

found that phonologically regular characters were named faster than phonologically irregular ones, showing that regularity of a phonetic compound character plays an important role in the reading of elementary school children. Chan and Siegel (2001) asked first through sixth graders to read aloud phonetic compound characters and pseudocharacters. The results indicated that older and normally achieving readers made more phonological-related errors and performed better on pseudocharacter recognition than younger normal and poor readers. It implied that older and normally achieving readers rely more on the use of phonetic information provided by phonetic radicals when reading a character.

The second factor being studied was the phonological consistency of phonetic radical. Characters containing the same phonetic radical were considered to be within one family, but they might have different pronunciations. Characters containing the same phonetic radical with one pronunciation only are considered as phonological consistent; while those with more than one pronunciation are considered as phonological inconsistent. Shu et al. (2000) asked fourth and sixth graders, secondary and university students to participate in a homophone judgment task. Subjects were asked to give 'yes-no' response and results showed that subjects made fewer 'no' response for pairs of characters with consistent than for those with inconsistent phonetic radicals, indicating that subjects' judgment was influenced by the consistency of phonetic radicals in providing cues to the pronunciation of characters.

The third factor was semantic regularity of semantic radical. Semantic radical represents the meaning of the characters containing them in different degree. Characters share the same meaning with the semantic radicals represent are semantically regular. For example, since the character '軀' */keoi1/*, meaning 'body', shares the same meaning with the semantic radical '身' */san1/*, meaning 'body', it is a semantically regular character. Since the character '嗅' */ts^{h}au3/*, meaning 'smelling', is not closely related to the meaning the semantic radical '口' */hau2/*, meaning 'mouth', represents, it is a semantically irregular character.

All of the above mentioned investigations studied the effect of factors of radicals, in order to reflect the relationship between sub-character component, either phonetic radical or semantic radical, and the character containing it. The above studies showed that the effect of these factors of radicals were significant, suggesting that there was a sub-character level, radical, of processing during reading. However, it was hypothesized that it was not the same for Chinese writing.

Law and Leung (2000) argued that the basic unit of processing in writing was logographeme, a unit larger than a stroke, but smaller than a character. A stroke is a line made between the points at which the pen touches and leaves the paper (Zhang, 1992). Phonetic and semantic radicals can also be broken into smaller components, either logograheme or stroke. Law and Leung (2000) investigated writing errors of a Chinese brain-damaged patient with acquired dysgraphia. They found that the patient's errors could not be analyzed using semantic and phonetic radicals as the basic processing unit., but involved errors at level of logographemes (Law & Leung, 2000). It showed that when logographemes was used as the basic unit of processing, it served to explain a large percentage of error made by the client. It supported the notion that the basic unit for writing was logograheme rather than radicals.

As logographeme is the basic unit in Chinese writing, which is a sub-lexical unit for writing Chinese characters, Chinese words can be constructed from logographemes and spelling in Chinese words is possible.

Chinese reading and writing might be two different processes, as they might have different basic units. The basic unit for reading is radical and there is possibility that the basic unit of writing is likely to be logographeme (Law & Leung, 2000). The relative importance of semantic cue in Chinese reading and writing might further support Chinese reading and writing are two different processes. Chinese writing depends on semantic cue provided by the

graphical representation much for writing to dictate homophone while Chinese reading does not. It was mentioned that there was phonological regularity effect in reading Chinese characters, so does it also exist in Chinese writing as their basic units are different?

There were two previous studies on the effect of phonological regularity on Chinese writing. Shu, Zhou, D.C. Zhang, and H.C. Zhang (1999) asked sixth graders to do writing to dictation on a list of target characters embedded in two-character words. The target characters were either phonologically regular or phonologically irregular and they were of high to mid-low frequency according to the corresponding grade and average number of stroke was similar. There was no significant difference in the percentage of correctness between phonologically regular and phonologically irregular characters. The authors concluded that phonological regularity had no effect on writing.

Similarly, Meng, Shu, and Zhou (2000) used writing to dictation task to study children's structural awareness on the process of character production. They recruited fourth graders to do a writing to dictation task on phonologically regular and irregular characters embedded in two-character words. The frequency and number of stroke of all the target characters were controlled. Contrary to Shu et al. (1999) study, they found significantly higher percentage accuracy for phonologically regular characters than that for phonologically irregular characters and they concluded that there was phonological regularity effect on writing.

A detail look into the studies revealed that the two studies were using stimuli of different character frequency. Shu et al. (1999) used characters of high to mid-low frequency while Meng et al. (2000) used characters of low frequency based on the frequency information obtained from adult study. The use of high frequency characters by Shu et al. (1999) was likely to produce ceiling effect in the task and the phonological regularity effect would be masked. This suggestion was supported by the fact that their subject got an average of 82% accuracies. In writing to dictation of high frequency characters, the association between

phonological, semantic and orthographic representations was stronger due to repeated exposure. Subjects could employ a holistic approach and there was no need to decompose the characters into their sub-lexical units in the process (Shu & Zhang, 2001). Therefore, effect of phonological regularity might not be shown.

In Meng et al.'s (2000) study, they used characters of low frequency according to adult frequency and they claimed that the character frequency in grade four was highly related to that in adult. However, a search at the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002) indicated that it might not be always true. For example, the character, '蒜' */syun3/*, meaning 'garlic', is a low frequency character in grade six, but an unfamiliar character in grade four. It showed that low frequency character for adult could either be a low frequency character or an unfamiliar character for fourth graders, therefore, the use of adult exposure frequency as a reference for frequency control could be misleading.

Furthermore, the two studies mentioned above did not control for other possible confounding factors, like phonological consistency, syllable frequency, semantic regularity and concreteness of meaning of compound words in which the target characters were embedded, which might affect the result they got. Yang & Peng (1997) found that the processing time of characters with high phonological consistency were shorter than low consistency character. If writing requires processing of phonological information for retrieving orthographic representation of characters, it will be necessary to control phonological consistency of target characters.

Regarding the syllable frequency, the pronunciation of characters with higher syllable frequency will activate its homophones at the same time when phonological information is input during writing to dictation, these characters may require longer processing time which may affect the retrieval of their motoric representation in written output.

Shu and Anderson (1997) had illustrated that subjects performed better in radical identification task for semantic regular characters than those with irregular semantic radicals. It implied that children would employ information provided by semantic radicals in reading Chinese. In writing to dictation, one will have more reliance on orthographic semantic information than for reading aloud. The meaning of two-character compound word where the target character embedded will give cues to the semantic radical when it is a semantic regular character. It was hypothesized that semantic regular characters would provide extra information other than phonological regularity and this could be a confounding variable.

Concreteness was referred to things which human can see and touch (B.Y. Zhang & Q. Zhang, 1997). Chen and Peng (1998) found that subjects responded faster when recognizing compound words with high concreteness and they concluded that concreteness of compound words has a significant effect on compound word recognition. In doing writing to dictation task, compound words would be presented auditorily and subjects were required to write one of the component characters. Concreteness of compound words may affect the processing of the compound word and it may affect the orthographic output of the target character.

Another possible explanation for the different conclusions drawn about phonological regularity effect in studies of Shu et al. (1999) and Meng et al. (2000) was about the development of the awareness of phonological regularity across elementary grades. According to the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002), there was a trend in the distribution of phonetic compound characters across grades in primary school. Forty eight percent (217/452) of the characters learnt in grade one are phonetic compound characters while 72% (2781/3844) of the characters learnt in grade six were phonetic compound characters. Children were exposed to larger proportion of phonetic compound characters as they moved up the grade. It was hypothesized that there should be a developmental trend in awareness of phonological regularity in writing and it was

hypothesized that higher graders should have more proficient awareness of phonological regularity in Chinese writing. The conclusions of the previous studies of Shu et al. (1999) and Meng et al. (2000) were contradictory to this hypothesized development.

In order to know the exact relationship between phonological regularity and writing, the study of effect of phonological regularity on Chinese writing will be repeated. The dictation study should select only low frequency characters corresponding to the grades in question, with proper control of other confounding variables such as concreteness of the two-character words in which target character is embedded, phonological consistency, semantic regularity and number of stroke.

The present study aims at investigating: (1) the phonological regularity effect in Chinese writing (2) the developmental trend of phonological regularity effect across primary grades on writing.

If subjects make use phonological information of radical in writing, better writing performance on phonologically regular characters when compared with phonologically irregular characters would be expected. Otherwise, there would be no significant phonological regularity effect on writing detected in the present study.

The interaction between phonological regularity and grade plus the error analysis would inform us on the developmental pattern of applying phonological regularity rule on writing.

Method

Subjects

A total of 183 children from a local elementary school in Hong Kong: 64 second graders, 52 fourth graders and 67 sixth graders were recruited in a screening procedure at the initial stage of the study. Raven's Standard Progressive Matrices (SPM) (Raven, 1956), a standardized non-verbal intelligence test, the Chinese word reading sub-test of the Hong Kong test of specific learning difficulties in reading and writing (Ho, Chan, & Education

Department., HKSAR Government, 2000), visual motor (Gardner, 1995), visual perceptual skills test (Gardner, 1996) were administered to each of the 183 students to select subjects with normal intelligence, Chinese reading ability, visual motor skills and visual perceptual skills. Since Shu et al. (1999) recruited sixth graders and Meng et al. (2000) recruited fourth graders, fourth and sixth graders were chosen to for a comparison between the previous studies and the present study. Second graders were also chosen to trace the developmental trend in employing phonological information of phonetics from low graders to high graders in primary school.

Ninety-two children, 30 second graders, 32 fourth graders and 30 sixth graders, who obtained an IQ score above -1 *SD* in SPM, a reading score between +1.33 *SD* and -1 *SD* in the Chinese word reading test, a score above -1 *SD*. in visual motor and visual perceptual skills tests were selected as the subjects of the present study. The age, intelligence, reading abilities, visual motor and visual perceptual skills were summarized in Table 1.

Table 1

Age, Intelligence, Reading Ability, Visual Motor and Visual Perceptual Skills of the Three Groups of Subjects

Grade	No. of subjects	Age	Raven's Progressive Matrices	Chinese word reading test	Visual Memory Test	Visual Spatial Relation-ship Test	Test of Visual Motor Skills
		Range	Standard score (*SD*)	Standard score (*SD*)	Standard score (*SD*)	Standard score (*SD*)	Standard score (*SD*)

2	30	7;02 – 8;02	116.53 (12.36)	11.53 (2.12)	117.47 (10.72)	122.34 (6.74)	114.23 (11.64)
4	32	9;00 – 10;02	108.75 (14.08)	10.72 (1.79)	117.06 (9.86)	114.74 (7.69)	110.63 (8.82)
6	30	11;01 – 12;02	99.17 (13.12)	9.70 (1.70)	106.90 (11.35)	112.03 (6.82)	107.60 (10.17)

Written consent (see Appendix A) was obtained from caregivers of subjects before they participated in the experiment.

Stimuli

All the stimuli were selected from the Hong Kong Corpus of Primary School Chinese Character. The characters in the corpus were taken from the primary school Chinese textbooks (Leung & Lee, 2002).

Three sets of 16 phonetic compound characters, one set for each grade, were prepared for the present study. Within each set of 16 phonetic compound characters, half of them was regular and the other half was irregular. In the present experiment, those phonetic compound characters which have the same onset, rime and tone with their phonetic radicals were considered as regular characters, whereas, characters with onset and/or rime different from their phonetic radicals were considered as irregular characters. Only characters with low frequency of occurrence were used in the present study to avoid ceiling effect as well as the masking effect of the use of holistic approach in writing that might exist. Character frequencies and syllable frequencies of stimuli for each grade were calculated in a cumulative fashion. For example, the character frequency of a character in sixth grade would be equal to the total of frequencies of occurrence of that character in grade one, two, three, four, five and six. The character frequencies of the stimuli in the two regularity conditions were controlled

within grade. All phonetic compound characters were ranked in ascending order by the character frequency according to each grade. The characters at the lowest extreme of the ranked list were classified as low-frequency characters. For example, the frequency of occurrence of character '嗅' */tsʰau3/*, meaning 'smelling', in grade one, two, three, four, five and six were 1, 0, 0, 9, 2 and 1, respectively. The cumulative character frequency of this character at grade six was 13 (1 + 0 + 0 + 9 + 2 + 1). Character frequencies of all stimuli were controlled to be within the lowest 30% of the total number of characters in each grade.

The syllable frequency of a character in one grade would be the total number of different characters (token frequency) that have the same onset, rime and tone as that particular character in that grade. For instance, the syllable frequency of character '廊' */l□.·4/*, meaning 'corridor', in grade four and six were four and five respectively. The low frequency characters chosen were controlled to have comparative syllable frequency. Due to limitation of stimuli for grade two, the syllable frequencies of all stimuli were controlled between 2.69 and 3.56 for each grade.

All the stimuli were controlled for their semantic regularity. Six out of eight target characters were within the range of rating point 4 to point 6 while two of them were within the range of rating point 1 to point 3 for semantic regularity. The semantic regularity of each phonetic compound character in the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002) was rated on a six-point scale, in which point one is given to regular character and point six to irregular characters. Due to limitation of stimuli, characters fell within rating 1 to rating 3 were classified as semantic regular characters while characters fell between rating 4 and rating 6 were called semantic irregular characters. Stimuli with controlled ratio of semantic regular to semantic irregular, 6:2, were used.

All the target characters used in present study were embedded into compound words of concrete objects, action and feeling, which could be seen, touched or had been felt by the

subjects from each grade. Compound words were used as there were homophones for single characters and semantic context was necessary to specify which target character was targeted. The list of compound words for each grade was presented to two students from that grade to confirm the compound words were concrete in meaning. The students were asked whether they understand what the compound words mean and all students reported they understood and felt the representations of each compound word of their grade.

The position of the target component character was controlled. Eight target component characters were at the word initial position while eight of them were at the word final position and this was controlled across three grades. Within the eight target component characters at word initial position, four of them were phonologically regular character and the other four were phonologically irregular characters. This was the same for the eight target component characters at word final position.

Phonological consistency value for a particular phonetic radical was defined as one over the number of different realizations of members in that family (regardless of tonal discrepancy) while a larger value indicated that the phonetic radical was more consistent and vice versa. The phonological consistency value of the stimuli was controlled between 1.50 and 1.81 across the grades.

Examples of component characters, compound word in which characters were embedded and all controlled factors for the three subject groups were shown in Table 2. The full list of stimuli for each grade was included in the appendix (see Appendix B).

Table 2

Example of Stimuli and Details of Controlled Factors in the Two Regularity Conditions for 3 Subject Groups

	Grade

	2	4	6
Regular character/ Compound word	蛛/ 蜘**蛛**	幣/ 金**幣**	嗅/ **嗅**覺
Irregular character/ Compound word	牌/ 金**牌**	漬/ 污**漬**	眺/ **眺**望
Cumulative character frequency/ Mean (*SD*)	6.31 (2.44)	9.31 (2.21)	11.50 (1.79)
Syllable frequency/ Mean (*SD*)	2.69 (1.62)	2.87 (1.88)	3.56 (1.41)
Phonological consistency/ Mean (*SD*)	1.81 (1.28)	1.75 (0.93)	1.50 (0.73)
Stroke number/ Mean (*SD*)	12.75 (1.69)	12.81 (1.56)	12.50 (1.63)

Three pilot tests, one for each grade, were conducted. The percentage accuracy for the second, fourth and sixth graders were 43.82%, 37.50% and 43.82% respectively and this indicated that no ceiling or floor effect was associated with the stimuli.

Procedures

Candidates who met all the screening criteria mentioned above for each grades were randomly separated into two groups. The stimuli for each grade were divided into two equal parts (Part A & B), each part consisted of eight character in randomized order. Two groups of the same grade took the test at the same time. One group was administered the writing to dictation task on Part A stimuli before Part B stimuli while another group of subjects from the same grade were administered Part B stimuli before Part A stimuli.

The subjects were seated in rows in one classroom. There were two examiners responsible for the administration of the task in each class. After dictation booklets were distributed to the subjects, the chief examiners explained to the subjects the procedures of the test by reading aloud a standard instruction (see Appendix C). Then the examiner went through three practice trials with the whole class to familiarize the subjects with the task and to ensure that they understood the procedure clearly.

Writing to dictation task was administered and subjects were asked to dictate component character of two-character word, for example, instruction of ‘柑桔 (two-character word) 個 (classifier) 桔 (target character)’, meaning ‘write down the second component character of the two-character word’, was given to instruct subjects to write down the target component character ‘桔’ of the compound word ‘柑桔’.

Measurement

One mark was awarded to the correct written production of each target character and no mark was given to incorrect production of target characters. Percentage accuracy for phonological regular and irregular characters will be calculated for measurement and error analysis will be implemented to confirm results obtained.

Ten percent of the data collected was randomly selected to evaluate inter-judge reliability. Data were rated by two independent raters who were native Cantonese-speaking final year university students who studied Speech and Hearing Sciences. Inter-judge reliability was computed based on the agreement between two.

Results

Accuracy

The mean percentage scores and standard deviations of the subjects’ performance in different regularity conditions and the overall performance were summarized in Table 3.

Table 3

Mean Percentage Scores of Subjects’ Overall Performance and the Individual Performance in Different Regularity Conditions

Grade	Overall percentage score (%)	Mean scores (%) in different conditions	
		Regular	Irregular

	Mean (*SD*)	Mean (*SD*)	
2	21.46 (12.04)	17.10 (15.64)	25.00 (12.91)
4	37.11 (17.74)	39.84 (21.30)	35.94 (17.33)
6	26.46 (13.08)	33.33 (14.55)	19.58 (17.29)

The mean overall percentage accuracy of grade four was the highest and that for grade two and grade six were similar. Second and fourth graders had comparable mean percentage accuracy for both phonologically regular and irregular characters while sixth graders had higher mean percentage accuracy for phonologically regular characters than that for phonologically irregular characters.

The data collected were analyzed by a three (grade) x two (phonetic regularity), two-way ANOVA with repeated measures, in which grade (three levels: grade two, grade four and grade six) was the between-subject factor and phonetic regularity (two levels: regular and irregular) was the within-subject factor.

The main effect of grade was found to be significant, F (2, 89) = 9.99, p = .000083, but the main effect of regularity was not significant. A Tukey Honestly Significant Difference (HSD) test was done to investigate what contribute to this main grade effect. Results showed that fourth graders performed significantly better than subjects from grade two, $p < .001$ and grade six groups, $p < .01$.

The interaction between grade and regularity was found to be significant, F (2, 89) = 12.22, p = .000016 (see Figure 1). To investigate what contribute to the significant interaction, a Tukey HSD test was conducted. The results revealed that the difference between regular and irregular character was only significant in grade six. Accuracy of grade six on writing regular characters was significantly higher than that on writing irregular characters, $p < .001$, but no significant difference was observed between regular and irregular phonetic compound

characters in grade two and four. This suggested that children from grade two and grade four did not benefit from the regularity whereas grade six children performed better on regular characters.

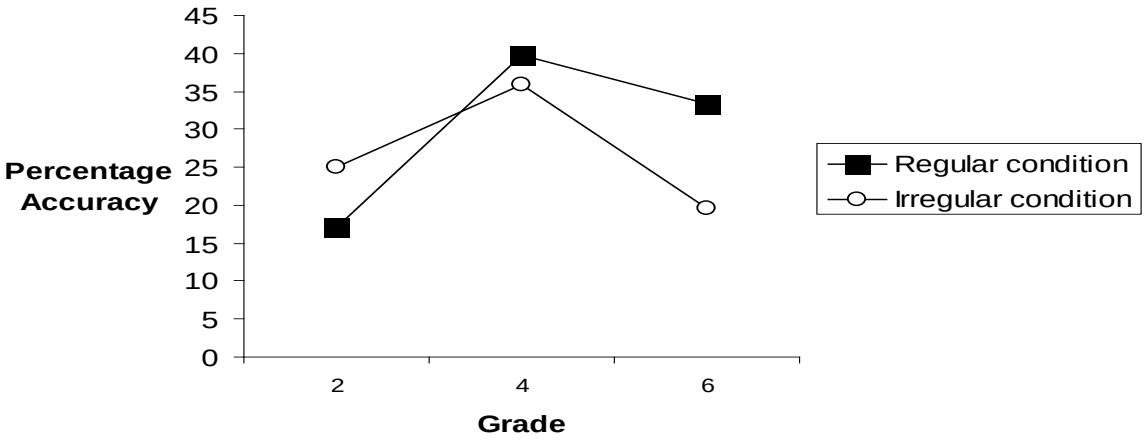

Figure 1. Interaction between phonological regularity and grades.

Error Analysis

Errors of each subject were also analyzed. Errors were classified into six categories: whole character access errors, radical level access errors, logographeme level access errors, stroke level access errors, word level access errors and no response. The errors across regularity levels of each grade were further investigated and to compare the error patterns.

A whole character level processing error occurred when the whole target character was substituted by another unrelated character. For example, '雲' */wan4/*, meaning 'cloud' was produced in place of the target character '混' */wan6/*, meaning 'not clear' of '混亂' */wan6/ /lyun6/*, meaning 'chaos'.

A processing error at radical level occurred when either phonetic or semantic radicals of the target character was substituted by another radical. An example of the radical level access error was when the target character '餒' */n□i5/*, meaning 'dispirited' of '氣餒' */hei3/ /n□i5/*, meaning 'to be frustrated', was substituted by '食女', a pseudo-character. The error character

was orthographically similar to the target and the radical being substituted was phonologically similar to the target character.

A processing error at logographeme level occurred when there was a competition between the logographeme of the target character and related entries at logographeme level. It was the same for stroke level processing error, such an error was resulted when there was a competition between the stroke of the target character and related entries at stroke level.

Last type of error occurred when the target character was substituted by the character also embedded in the word, for example ‘魄’ */pak3/*, meaning ‘soul’, was produced when dictating the target ‘魂’ */wan4/*, meaning ‘spirit’, of ‘魂魄’ */pak3/ /wan4/*, meaning ‘soul’.

The percentage of error types according to the above mentioned categories across regularity levels of different grades are summarized in the following table.

Table 4.

The Percentage of Each Error Type in Phonologically Regular and Irregular Compound Character Groups of Corresponding Grades

Grade	Regularity	The Percentage of each error type in phonologically regular and irregular compound character groups of corresponding grades					
		Character (*SD*)	Radical (*SD*)	Logographeme (*SD*)	Stroke (*SD*)	Word (*SD*)	No Response (*SD*)
2	Regular	40.19 (19.00)	11.87 (11.72)	9.22 (9.57)	2.63 (6.37)	0.56 (3.04)	35.19 (23.52)
	Irregular	17.70 (19.49)	12.78 (16.81)	7.46 (10.27)	1.31 (5.18)	0.48 (2.61)	60.27 (32.73)

	Total	29.82 (13.30)	12.25 (11.43)	7.89 (7.70)	2.41 (4.37)	0.57 (2.21)	44.06 (24.97)
4	Regular	37.76 (20.25)	26.40 (23.36)	10.05 (13.27)	1.88 (5.09)	3.97 (8.87)	19.94 (27.01)
	Irregular	37.37 (21.01)	28.41 (20.18)	13.44 (15.33)	0.91 (3.63)	0.52 (2.94)	16.22 (22.66)
	Total	39.22 (16.07)	27.41 (13.85)	11.81 (11.83)	1.36 (2.95)	2.26 (4.49)	16.18 (19.89)
6	Regular	24.15 (19.60)	44.93 (22.35)	14.39 (14.41)	0.28 (1.52)	1.39 (5.40)	14.87 (18.28)
	Irregular	47.17 (27.64)	16.39 (16.38)	3.65 (9.09)	0.00 (0.00)	1.40 (4.34)	30.72 (28.91)
	Total	36.16 (17.72)	28.67 (13.08)	8.91 (8.59)	0.14 (0.76)	1.56 (0.00)	24.63 (22.83)

Further analysis on the results of error analysis was performed and it showed developmental trend in awareness of stroke, logographeme and radicals in writing across the three grades. Comparisons on percentage of these three levels of error across three grades were shown in Figure 2 (see below).

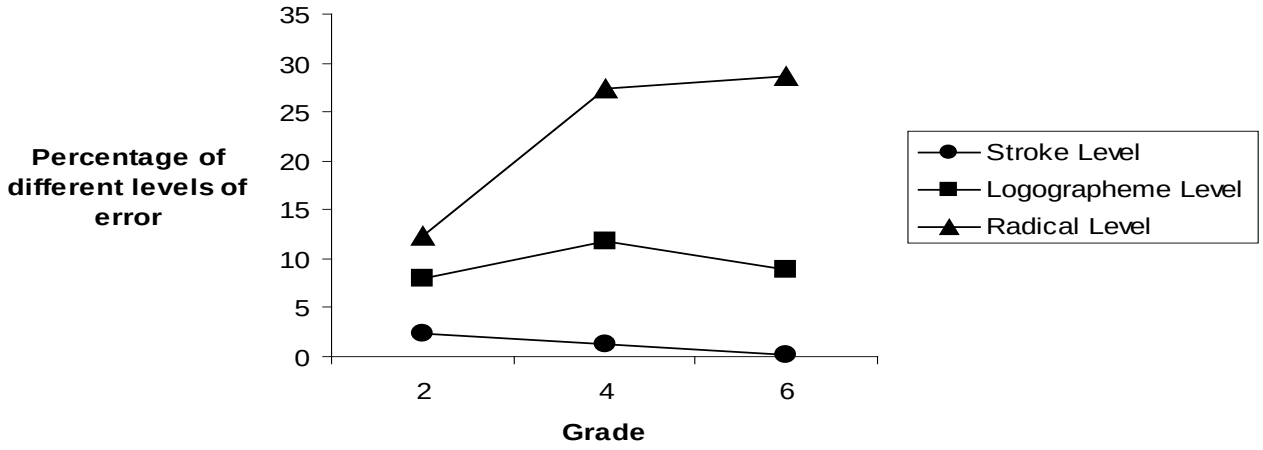

Figure 2. Comparisons on percentage of these three levels of error across three grades.

The percentage of radical level accessing error was increasing across the three grades, the percentage of logographeme level accessing error was comparable while that of stroke level accessing error was decreasing among the three grades. Comparison between the percentage of radical level accessing errors of regular and irregular conditions for each grade was performed to investigate subjects' use of phonological information carried by phonetic radical (see Figure 3).

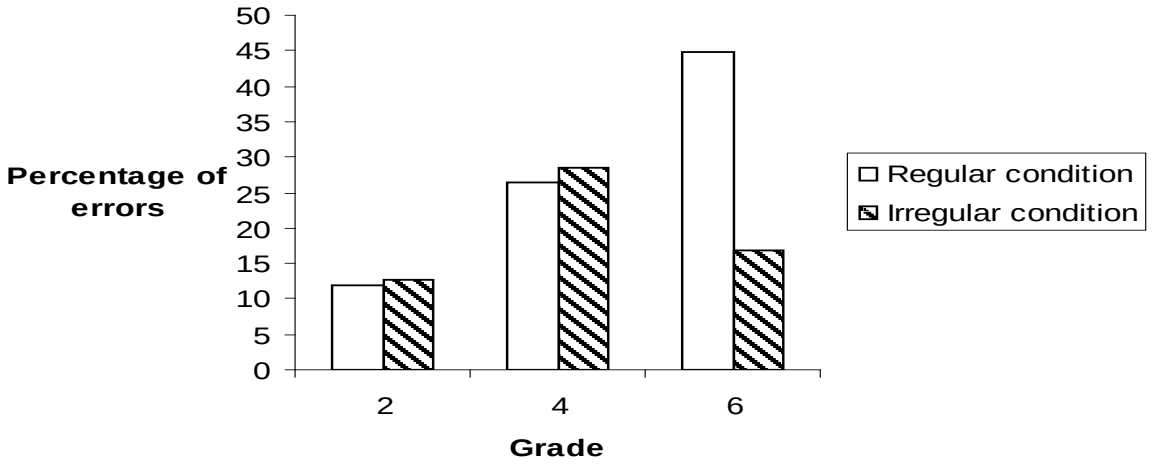

Figure 3. Comparison between the percentage of radical level accessing errors of regular and irregular conditions for each grade.

Discussion

Results of the present study showed that there was a phonological regularity effect in writing Chinese characters, and it only appeared in sixth graders as there was only significant difference between the percentage accuracy of regular and irregular conditions in grade six. It supported the hypothesis of the present study that sixth graders would use phonological information carried by phonetic radical in writing phonetic compound characters. The phonological regularity effect in writing emerged later than that in reading Chinese characters, which emerged as early as second graders (Ho & Byrant, 1997; Shu et al., 2000; Wu, Zhou, & Shu, 1999). The comparison between the present study and the two studies of Shu et al. (1999) and Meng et al. (2000) will be discussed first. The developmental trend of phonological regularity effect in writing Chinese characters will be explained later.

The results of the present study indicated that when syllable frequencies, phonological consistency, semantic regularity, concreteness of the compound words the target component characters are embedded, position of the target component characters and stroke number were controlled, phonological regularity effect in writing Chinese occurred at grade six.

In contrast to the findings of Meng et al. (2000), there was no significant regularity effect found in grade four. The results of Meng et al.'s study would be correct if phonological regularity effect was significant for fourth and sixth graders, but the phonological regularity effect for sixth grade was masked by ceiling effect and the use of high frequency stimuli in Shu et al.'s study (1999). On the contrary, Meng et al.'s conclusion would be incorrect. The test stimuli were controlled according to adult frequency, and not all target character was of low frequency to fourth graders. The phonological regular target characters might be of low frequency, but the phonological irregular target characters might be unfamiliar to fourth graders and this might lead to a significant phonological regularity effect in writing for fourth graders, but not the true phonological regularity effect. For example, '笆' */pa1/*, meaning

‘fence’, a phonological regular character, is a low frequency character for both fourth and sixth graders, while ‘屠’ */tou4/*, meaning ‘slaughter’, a phonological irregular character, is a low frequency character to sixth graders, but an unfamiliar character to fourth graders.

The conclusion on a developmental trend in using phonological information of Chinese writing was further supported by the error patterns obtained from error analysis. Based on the data of the Hong Kong Corpus of Primary School Chinese (Leung & Lee, 2002), non-phonetic compound characters made up the majority of learnt characters in low grades and higher graders were exposed to larger proportion of phonetic compound characters. Since higher graders encountered larger proportion of phonetic compound characters, they would learn to decompose the phonetic compound characters into their phonetic and semantic radicals in processing, and would have developed awareness of phonological regularity. Walley (1993) stated that holistic representation of phonological information in infants or toddlers would be restructured as vocabulary size grows, from holistic representation of phonological information of a whole word, to representation of smaller unit of grapheme. It was hypothesized that a hierarchical representation analogy to English was also applied to Chinese character writing system, from largest processing unit, whole character, to smallest processing unit, stroke. For lower graders, no phonological regularity effect was expected since their processing level was at smaller unit than radical while a significant phonological regularity effect was expected in higher graders as they had promoted to larger processing level within the hierarchical representation of a Chinese character, radical, in writing.

It was mentioned in introduction section that there were five hierarchy of accessing errors. They were word level accessing error, character level accessing error, radical, logographeme and stroke level accessing errors. The relative proportion of error at different levels reflected the dominant level processing. By revealing the percentages of different level accessing errors across grades, the development of processing unit across grades could be

visualized and this would inform us on the development of awareness of phonological regularity in writing.

The percentage of stroke-level errors decreased across grades (see Figure 2) indicating that higher graders relied less on a smallest processing unit, stroke, in writing. In contrast, the percentage of logographeme-level errors remained at a comparable level across grades (see Figure 2). It indicated that students from grade two onwards relied on processing unit of logographeme in writing with the same extension. The fact that percentage of radical-level errors increase across grades (see Figure 2) showed that higher graders relied more on a larger processing unit, radical, in writing. In summarizing results of error analysis, higher graders tended to do writing to dictation at a larger processing unit, radical, and were more affected by phonological regularity of phonetic radical in writing phonetic compound characters. It reflected that normal children were able to use logographeme proficiently as young as grade two and subjects from grade four onwards tended to decompose phonetic compound characters into their semantic and phonetic radicals, and have developed the awareness of phonological regularity of phonetic radicals in writing. This conclusion was consistent with that in the studies of Meng et al. (2000) and Shu and Zhang (2001).

Meng et al. (2000) reported that there were large proportion of homophonic error and radical accessing error in fourth graders' writing to dictation and so they only studied the interaction of these types of errors, implying that there was few errors of smaller processing units. Shu and Zhang (2001) reported that apart from homophonic errors, radical-accessing errors made up the largest proportion of errors in writing to dictation of sixth graders. These two studies together with the present study demonstrated the development of ability to decompose phonetic compound characters into their component radicals and the awareness of phonological regularity as children are promoting to higher grades of primary school.

Percentage of radical-level errors in grade four and six was comparable (see Figure 2). The percentage of radical-level errors under phonological regular and irregular conditions within grade four was similar while the percentage of radical-level errors in phonological regular condition was much higher than that in phonological irregular condition (see Figure 3). It implied that both fourth and sixth graders were processing at radical level in writing Chinese, but sixth graders had a comparatively more proficient in the use of the awareness of phonetic radical in writing than fourth graders.

Sixth graders seemed to have mastered the phonological regularity rule and realized that this rule could only be applied to phonologically regular characters, therefore, they tended to substitute homophone for the whole character when they faced with an irregular phonetic compound character.

Different from Walley (1993), who stated that as children was growing up and their vocabulary size was increasing, children tended to process phonological information of English words with larger processing unit. The present study showed that the processing unit of Chinese in writing to dictation is shifting from the larger processing unit, character, and smaller processing units, like logographeme and stroke, and is converging towards a middle size processing unit, radical. On one hand, it lent support to the claim that Chinese could be spelled and their writing processing was affected by phonological information carried by sub-character units, and on the other hand, the development of processing unit in writing in Chinese is different from an alphabetic script like English.

In conclusion, lower graders are less proficient in making use phonological regularity of phonetic radicals of phonetic compound characters, while higher graders were more proficient in making use of the phonological regularity rule of phonetic compound characters in writing. Second graders did not have apparent difference in accessing error among

processing levels of stroke, logographeme and radical while fourth and sixth graders had significant large proportion of radical-level error.

Acknowledgement

I would like to deliver my most sincere gratitude to my dissertation supervisor, Dr. Leung Man Tak, for his kind guidance, valuable comment in helping me to go through different phases of this study.

I would like to give special thanks to Elaine, Bonnie, Ronnie, Elizabeth, Jovy and Jacky for their unconditional help and support in subject selection and data collection.

Finally, many thanks were devoted to the Principal, teachers, social workers and students of the primary school that participated in this study.

References

Caramazza, A., Meceli, G., Silveri, M. C., & Laudanna, A. (1985). Reading mechanisma and the organization of the lexicon: Evidence from acquired dyslexic. *Cognitive Neuropsychology, 2*, 81-114.

Chan, C. K., & Siegel, L. S. (2001). Phonological processing in reading Chinese among normally achieving and poor readers. *Journal of experimental child psychology, 80*, 23-43.

Chen, B., & Peng, D. (1998). The influence of concreteness of words on word recognition. *Acta Psychologica Sinica, 30*, 387-393 (in Chinese).

Gardner, M. F. (1995). *Test of Visual-Motor Skills Revised*. United States of America: Psychological and Educational Publications, Inc.

Gardner, M. F. (1996). *Test of Visual-Perceptual Skills (non-motor) Revised Manual*. United States of America: Academic Therapy Publications.

Goodman, R. A., & Caramazza, A. (1986). Dissociation of spelling errors in written and oral spelling: The role of allographic conversion in writing. *Cognitive neuropsychology, 3*, 179-206.

Ho, C. S., & Bryant, P. (1997). Learning to read Chinese beyond the logographic phase. *Reading research quarterly, 32*, 276-289.

Ho, C. S. -H., Chan, D. W. -O., & Education Department, HKSAR Government. (2000). *The Hong Kong Test of Specific Learning Difficulties in Reading and Writing.* HK: E.D., HKSAR Government.

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.

Leung, M. -T., & Lee, A. (2002). *The Hong Kong corpus of primary school Chinese*. Paper presented at the 9th Meeting of the International Clinical Phonetics and Linguistics Association. Hong Kong.

Meng, X. Z., Shu, H., & Zhou, X. L. (2000). Character structural awareness of children in character production processing. *Psychological Science, 23*, 260-264 (in Chinese).

Peng, D., & Yang, H. (1997). The learning and naming of Chinese characters of elementary school children. In H. C. Chen (Ed.), *Cognitive processing of Chinese and related Asian languages* (pp. 323-346). Hong Kong: The Chinese university of Hong Kong.

Raven, J. C. (1986). *Hong Kong supplement to guide to the standard progressive matrices*. Hong Kong: Education Department, H.K.

Shu, H., & Anderson, R. C. (1997). The role of radical awareness in learning characters of Chinese children. *Reading Research Quarterly, 32*, 78-89.

Shu, H., & Zhang, D. C. (2001). The characteristics and factors affecting children character output under the dictation task. *Psychological Development and Education, 1*, 1-5.

Shu, H., Zhou, X. L., Zhang, D. C., & Zhang, H. C. (1999). Character processing in the dictation task. *Applied Linguistics, 29,* 67-70 (in Chinese).

Walley, A. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Development Review, 13*, 286-350.

Wu, N. N., Zhou, X. L., & Shu, H. (1999). Sublexical processing in reading Chinese: A developmental study. *Language and Cognitive Processes*, *14*, 503-524.

Yang, H., & Peng, D. L. (1997). The learning and naming of Chinese characters of elementary school children. In H. C. Chen (Ed.), *Cognitive processing of Chinese and related Asian languages* (pp. 323-346). Hong Kong: The Chinese University Press.

Zhang, J. -X. (1992). *Xiandai hanzi jiaocheng (A course in contemporary Chinese characters).* Beijing: Shidai chubanshe (in Chinese).

Zhang, Q., & Zhang, B. Y. (1997). Concreteness effects of two-character Chinese words. *Acta Psychologica Sinica, 29,* 216-224.

Zhou, X., & Marslen-Wilson, W. (1999). The nature of sublexical processing in reading Chinese characters. *Journal of experimental psychology: learning, memory, and cognition, 25*, 819-837.

Appendix A

Consent Form for Subjects

香港大學言語及聽覺科學系
「中文單字書寫發展」研究

香港大學言語及聽覺科學系現正進行一項有關兒童中文單字書寫發展研究, 目的是為進一步了解兒童中文單字書寫發展的特性, 從而訂出老師向兒童介紹中文單字書寫的特性的次序.

現誠邀 閣下允許貴子弟參與此項研究, 在二零零四年十二月至二零零五年二月期間在學校接受一個約三十分鐘的集體智能評估, 一個約二十分鐘的視象分析測試, 一個約十分鐘的個別中文字詞閱讀能力評估及一個約二十分鐘的集體中文單字書寫作業. 評估完成後, 家長可獲兒童的一份個別報告.

貴子女之個人資料將絕對保密，一切有關資料只會作是次研究之用. 任何有關研究報告及論文寫作亦不會提及 貴子女的名字. 如閣下有任何疑問, 可隨時停止參與此研究.

我們預先感謝 閣下對此項研究的支持, 如有任何疑問, 請致電 92299864 或電郵到 h0149210@hkusua.hku.hk 與本人(李綺華小姐)聯絡.

本人 _____ (家長/ 監護人姓名) 同意 _____ (小孩姓名) 參與是項研究. 而以上有關事項, 研究員已向本人詳細了解釋, 本人証明完全明白一切有關安排.

家長/ 監護人簽署:

_____

聯絡電話: _____

日期: _____

研究員簽署:

_____

研究員姓名: _____

日期: _____

Appendix B

Table B1

Word in which target character being embedded, cumulative frequency, syllable frequency, phonological consistency, stroke number and semantic transparency of stimuli for grade 2

Grade	Word in which target character being embedded	Cumulative Character Frequency	Syllable Frequency	Phonological Consistency	Stroke Number	Semantic Regularity
2	**週**日	3	3	3	10	Irregular
	算**術**	9	2	1	11	Irregular
	蜘**蛛**	9	4	1	12	Regular
	傢俬	4	4	1	12	Irregular
	溜冰	4	1	2	13	Irregular
	慌張	10	4	1	13	Regular
	雜**誌**	3	4	1	14	Irregular
	車**輛**	8	1	1	15	Irregular
	默書	7	2	1	16	Irregular
	標本	6	1	3	15	Irregular
	手**槍**	7	2	4	14	Regular
	犯**罪**	7	3	5	13	Irregular
	細**菌**	10	1	1	12	Regular
	金**牌**	4	2	2	12	Irregular
	移民	6	7	1	11	Irregular
	混亂	4	2	1	11	Irregular
	Mean (*SD*)	6.31 (2.44)	2.69 (1.62)	1.81 (1.28)	12.75 (1.69)	

Note. Bold items are targeted characters

Table B2

Word in which target character being embedded, cumulative frequency, syllable frequency, phonological consistency, stroke number and semantic transparency of stimuli for grade 4

Grade	Word in which target character being embedded	Cumulative Character Frequency	Syllable Frequency	Phonological Consistency	Stroke Number	Semantic Regularity
4	柑**桔**	12	2	1	10	Regular
	萎縮	7	3	2	12	Irregular
	走**廊**	9	4	1	12	Irregular
	誇張	9	1	1	13	Irregular
	嗅覺	10	2	1	13	Irregular
	嘈吵	6	2	2	14	Irregular
	金**幣**	11	2	2	14	Irregular
	榕樹	11	7	1	14	Regular
	回**憶**	10	2	1	16	Regular
	污**漬**	7	7	1	14	Irregular
	骯髒	13	1	4	14	Irregular
	狡**猾**	6	2	1	13	Irregular
	溪水	12	2	2	13	Regular
	廁所	9	4	3	11	Irregular
	木**偶**	10	2	3	11	Irregular
	逝去	7	2	2	11	Irregular
	Mean (*SD*)	9.31 (2.21)	2.87 (1.88)	1.75 (0.93)	12.81 (1.56)	

Note. Bold items are targeted characters

Table B3

Word in which target character being embedded, cumulative frequency, syllable frequency, phonological consistency, stroke number and semantic transparency of stimuli for grade 6

Grade	Word in which target character being embedded	Cumulative Character Frequency	Syllable Frequency	Phonological Consistency	Stroke Number	Semantic Regularity
6	蝌**蚪**	10	5	2	10	Irregular
	惦念	14	3	1	11	Regular
	走**廊**	10	5	1	12	Irregular
	渺小	10	3	1	12	Irregular
	兩**棲**	12	5	1	12	Irregular
	嗅覺	13	3	1	13	Irregular
	魂魄	11	6	1	14	Regular
	紅**磡**	10	2	1	16	Irregular
	氣**餒**	9	2	1	15	Irregular
	反**駁**	11	5	1	14	Irregular
	嗜好	12	5	2	13	Irregular
	跪下	13	2	3	13	Regular
	精**湛**	15	2	1	12	Irregular
	眺望	13	2	3	11	Regular
	崩潰	9	3	2	11	Irregular
	抽**屜**	12	4	2	11	Irregular
	Mean (*SD*)	11.50 (1.79)	3.56 (1.41)	1.50 (0.73)	12.50 (1.63)	

Note. Bold items are targeted characters

Appendix C

Instruction for Administration of Dictation Task

In the answer booklet, please ask the children to write down their personal information, including name, class, date of birth and age.

今日姐姐請你地嚟做一個默寫測試. 你地而家先係答案簿封面寫低你地嘅名, 班別, 出生日期同埋年齡.
好啦, 等陣, 我會講出一個詞語, 你地要聽清楚, 因為你要幫我係本答案簿度默番個詞語嘅其中一個字出嚟. 我會將個詞語重複三次, 例如, 足球個球, 足球個球, 足球個球. 你地要聽哂三次先好默出嚟, 每個詞語會重複講三次, 如果都聽唔清楚的話, 你可以舉手叫我重複. 咁我地而家試吓先, 例如: 努力個力, 努力個力, 努力個力, 默.

係啦, 就係咁樣啦. 記住要聽哂三次先好默出嚟. 好似平時默書咁, 你識寫嘅話,就寫出嚟, 如果唔識, 你覺得個字點樣寫, 就寫出嚟, 盡量唔好漏空.
每頁只可以默一個字, 默完之後, 就要揭去下一頁. 明白嗎？ 我地試多一個啦. 樹木個木, 樹木個木, 樹木個木, 默.

After dictating the first eight characters, collect all the answer booklets and distributed

another answer booklet for dictating the remaining eight characters.