Sub-types of Dyslexia in Chinese Writing Systems

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Abstract
The purpose of this project is to explore the underlying mechanisms
involved in students with Chinese reading difficulties. Based on
dual-route model of reading, readers may use either the lexical (words
are recognized as wholes) or sub-lexical (words are recognized through
grapheme-phoneme correspondence) procedure to read. Castles &
Coltheart (1993) have provided evidence for the existence of these two
mechanisms in English reading and they suggest deficits in one and/or
the other mechanism lead to different patterns of reading disability.
Surface dyslexia results from impairment of the lexical procedure with
an intact phonological route to reading. Deep dyslexia results from a
highly selective deficit in the grapheme-phoneme transformation
mechanism. In the case of Chinese reading, some researchers (Makita,
1968; Rozin, Poritzy & Sotsky, 1971) have argued that students in
logographic writing systems are able to derive meaning from print
directly without the need to be aware of the phonological structure
within the characters. Coltheart (1984) maintained that the dual-route
model of reading does not exist in Chinese logographic writing systems.
This study made use of the regularity effect of Chinese characters to
test the existence of the dual-route model of reading and to identify
different patterns of reading disability. It was found that a certain
proportion of Chinese students did use the phonological information
within the characters to read, and this indicates that the dual-route
model of reading exists in Chinese reading. Surface and deep dyslexic
reading patterns were found in the Chinese reading disabled subjects.

Over 70% of students with learning disabilities have reading problem as their primary deficit in the United States of America (Kavale, Forness, & Bender, 1987). The proportion of all children in schools in the United Kingdom, affected to some degree by reading difficulties, is at 10% (Peer, 1994).

In comparison with the high percentage of reading disability in school children of Western countries, researchers (e.g., Makita, 1968; Rozin, Poritsky, & Sotsky, 1971) in "the sixties and seventies" claimed that reading disability was rare in countries of logographic writing systems. This phenomenon was attributed to the difference between alphabetic and logographic writing systems. As Makita and Rozin et al. believed that knowing the rule of symbol-sound correspondences in alphabetic writing systems was considered to be an obligatory stage for children to learn to read, students who were unable to abstract symbol-sound correspondences from printed words therefore faced difficulty in reading. The phonological awareness rule in alphabetic writing systems, however, is irregular, abstract and complex, and difficult to learn. In contrast, Makita and Rozin et al. thought that characters in logographic writing systems were mainly picture drawings. Children were able to extract meaning from print directly without the need to recognize the phonetic structure of words. Thus, there was a rarity of reading disability in countries of logographic writing systems.

The view that phonological difficulty leading to a failure to master symbol-sound correspondences is a primary source of word recognition difficulties among dyslexics in alphabetic writing systems is now generally accepted by reading researchers (e.g., Bradley & Bryant, 1985; Bruck, 1988, 1990, 1992; Liberman & Shankweiler, 1985; Olson, Wise, Conners, Rack, & Fulk, 1989; Siegel & Ryan, 1988; Snowling, 1987; Solomon & Stanovich, 1992; Stanovich, 1988; Vellutino & Scanlon, 1987). On the other hand, the belief that children in logographic writing systems do not have a problem in reading has been challenged. Firstly, a cultural comparative study of reading disability conducted by Stevenson, Stigler, Lucker, Lee, Hsu, & Kitamura (1982) found that 2% of 932 Primary Year 5 Chinese students with average intelligence in Taiwan were two or more years below in reading performance. Secondly, the Hong Kong Education Commission Report No. 4 (Education Commission, 1990) estimated that 14% of students from Primary Year 1 to Secondary Year 3 may have learning difficulties in the schools. Students with learning difficulties in Hong Kong are usually placed in resource
classes where they can receive remedial support in Chinese, English, or Mathematics. Although the exact statistic figure showing the proportion of this group of students who have a reading problem is not available, it can be assumed that reading problems are encountered by this particular group of students as Chinese is considered to be a major subject for remediation. It is, therefore, likely to be the case that reading disability exists in Chinese societies.

Although reports have produced evidence that a certain percentage of students in Taiwan and Hong Kong schools face difficulties in Chinese reading, until recently, attempts to identify the major problem of this particular group of students were not common. Whether these students read in the same fashion or whether these students encounter similar reading problem as their counterparts in alphabetic writing systems are still not fully understood. Specifically, the role that phonological awareness plays in Chinese reading has not been evaluated. As information on the nature of reading disability in logographic writing systems is insufficient, it is difficult to locate skills and experiences required by reading disabled children to improve their performance in reading. Diagnostic instruments and intervention programs for this group of children are thus difficult to design.

The focus of this study is to explore the underlying mechanism involved in reading disabled children of Chinese language. Using models of normal and dyslexic reading in alphabetic writing systems as a framework, it is hoped that the strategy of analyzing the reading process of normal and disabled children in English language can be applied to the study of reading in Chinese logographic writing systems.

Based on the dual-route model of reading, some researchers (e.g., Coltheart, 1987; Castles & Coltheart, 1993) thought that readers may use either the lexical or sub-lexical procedure to read, depending on their purposes and skills. When reading aloud through the lexical procedure, words are recognized as "wholes" and their corresponding pronunciation retrieved as "wholes". When readers use the sub-lexical procedure to read, they are reading words through grapheme-phoneme correspondences which specify sub-graphemic orthographic and phonological segments. Castles & Coltheart (1993) have provided evidence for the existence of these two mechanisms in English reading and they suggest deficits in one and/or the other mechanism lead to different patterns of reading disability. Surface dyslexia results from impairment of the lexical procedure with an intact phonological route to reading. Deep dyslexia results from a highly selective deficit in the grapheme-phoneme transformation mechanism.

In the case of Chinese reading, Tzeng & Hung (1988) maintained that symbol-sound mapping in Chinese orthography is at a morphosyllabic level. Chinese characters represent the units of meaning rather than phonemes. Makita (1968) and Rozin, et al. (1971), therefore, believed that readers of Chinese language may bypass the phonological structure to grasp the meaning directly from the print. With this viewpoint,
Coltheart (1984) made an inference that the dual-route model of reading as well as deep dyslexia were not likely to exist in Chinese logographic writing systems. However, it is estimated that over 90% of characters are phonograms (Martin, 1972). Among the phonograms, most of them are formed by two parts, on the right, a phonetic, dictating the sound, and the left, a signific, dictating the meaning (Wang, 1973). Chinese characters give phonetic hinting information as well. Readers may use phonological elements to read Chinese characters aloud. Information on the role of phonetic hinting in Chinese reading is important in determining reading patterns of those students with learning difficulties. The question of whether phonological elements are involved is not yet resolved.

The purpose of this study is to test the existence of the dual-route model of reading in Chinese logographic writing systems and to identify the patterns of students with reading disabilities.

Method

Subjects. A number of 54 reading disabled students (RD) was selected from two primary schools in Hong Kong. The criteria for selection were:
1. Students were attending resource classes with a major problem in Chinese;
2. These students had a normal IQ but scored below the 20th percentile in the standardized Hong Kong Attainment Test (HKAT) in Chinese;
3. Primary Year 3, 4 and 5 students were chosen in this study. All subjects had at least two years of schooling so that poor performance in reading could not be attributed to "late starting." Cunningham & Stanovich (1990) demonstrated that students in their third year or fourth year of schooling are able to use both orthographic and phonological skills in word recognition;
4. Subjects have to be free, according to the judgment of their teachers, from gross emotional or behavior problems; and
5. Subjects have been attending school regularly.

A number of 45 students from Primary Year 3 to 5 in the same schools was chosen as control subjects (AM). These children scored in the top 20% on the Hong Kong Attainment Test in Chinese. Characteristics of two samples are detailed in Table 1.

| Table 1 Characteristics of control and reading disabled subjects |
AM           RD
M  SD  M  SD  t-test

__________________________________________________________________

Age9.851.049.761.12  -.43
HKAT76.6023.9719.529.9515.94*  
___________________________________________________________________

Notes.
n = 45 for AM; n = 45 for RD
* p<.0001
t(97) for t-tests

Stimuli. The test consists of 3 sets of single-character words. Each set contains 30 words of one type. Types of words are regular (words which give phonetic hints), irregular words (words which do not give phonetic hints) and unknown words (difficult words which give phonetic hints but are beyond the reading level of the subjects).

When selecting regular and irregular words, variables such as frequency, syntactic class and number of strokes which may influence the performance of subjects were controlled. Pairs of regular and irregular single-character words were matched as closely as possible for frequency, syntactic class and number of strokes so that the performance of reading recognition skills could then be attributed to the effect of regularity.

Regular and irregular single-character words were chosen from the Chinese Vocabulary Used in Primary Schools in Hong Kong (Educational Research Establishment, Education Department, 1979), Primary School Syllabus in Chinese (Curriculum Development Council, Education Department, 1990), and Two Thousand Most Frequently Used Chinese Characters (Ho, 1993). The selection of regular and irregular characters were based on the following criteria: 1. Regular and irregular characters in the test were matched in radicals, number of strokes frequency, and syntactic class; and 2. The facility value of each pair of those regular and irregular characters is equivalent. The facility value is referred to the difficulty level of writing the character.

As mentioned before, the phonetic (the right component) of the character provides information about pronunciation. However, this type of aid to pronunciation does not occur in every character. For example, the character "  " is pronounced "ching". In this case, the right hand component "  " is also pronounced "ching". However, the character "  " is pronounced 'hoi'. The right-hand component "  " is pronounced "mui". The sound clue given by the right-hand component is not always reliable. In Chinese writing systems, legal pronounceable non-characters are very difficult to construct. An alternative is to use unknown words to replace non-words. However, these unknown words contain obvious phonetic hinting information. Subjects are able to sound out the words correctly if they make use of the phonological structure within the words. In this experiment, the selection of unknown words is based on the vocabulary used in the text.
books of secondary school and university level. It is presumed that these unknown words have no lexical representation in the subjects' lexicon. Unknown words may then be used to reveal the functioning of the sub-lexical procedure in isolation in the same way as those non-words in the Castles and Coltheart's study.

Irregular single-character words are for examination of the lexical procedure, then unknown single-character words are for examination of the sub-lexical procedure and regular words are for comparison with irregular words. As reading irregular words, it is assumed that the only way the pronunciation of these words can be derived is through the use of lexical procedure as these words do not give phonological hinting information. These words are recognized through a direct visual path way. In contrast, the way to pronounce unknown words is through sub-lexical procedure. Unfamiliar words are sounded out by making use of the phonological hinting information within characters.

Patterns of deep dyslexia would be observed if readers make little difference in reading both regular and irregular words but cannot read unknown words. On the other hand, it is supposed that symptoms of surface dyslexia exist when readers find regular words much easier than irregular words to read and are able to read unknown words.

The 90 words were printed on 66 cm white paper and laminated with plastic. This is to enable shuffling, in order that they could be presented to students in random order and one at a time.

Procedure. The testing consisted of two sessions. The first session required subjects to read the lists of regular, irregular and unknown words. The second session required subjects to give a definition of each of the regular and irregular words as these words are presented to them orally by the investigator. The purpose of this session is to make sure that the factor for the poor performance of irregular words is not because of a language deficit. The stimuli appeared one at a time. The test was administered under no time pressure. The investigator recorded any mispronunciations.

Each child was withdrawn from class for individual testing, for a period of approximately 25 minutes. Subjects were asked to sit opposite to the investigator in a quiet room. They were then asked to read out aloud the 90 words on the laminated cards. The following instructions were given to students before testing begins:

I am going to show you some cards. Each card has a word printed on it. I want you to read out loud. You are not expected to know them all. Some of them are really difficult (show them one) as these words are chosen from text books in secondary level. I want you to try and read these just like the other words. OK?

Instructions were repeated if the students appeared confused. The students then proceeded to read aloud the words, presented to them one at a time and in random order. Feedback on correctness of responses was not given and no time limits were placed on the subjects.
The second session required the subjects to define each of the regular and irregular words as the words were presented to them orally by the investigator. The purpose of this section was to make sure that poor performance on irregular words was not because of a general language deficit.

Before testing began, each subject was given the following set of instructions:

I am going to read some words out loud to you. I want you to tell me what each word means. If you can, give me a definition of the word, like what you might find in a dictionary. If you can't, try and make it a sentence. Some of the characters might have more than one meaning and I want you to tell me as many meanings for the word as you can think of when this happens. OK?

If the child appeared confused, the instructions were repeated. After the child had confirmed that he understood the task, words were read out loud to him, one at a time and in random order.

Design. A repeated measurements experimental design was used in which each student experienced all testing conditions. The analyses consist of two parts. The first part is to identify the two sub-types of dyslexia in logographic writing systems. This part of the analyses consisted of simple regression analyses of (a) irregular word reading as a function of chronological age, and (b) unknown word reading as a function of chronological age for both disabled and control subjects. Data between control and disabled subjects were compared so as to identify the two sub-types of dyslexia among disabled readers.

The second part aims at identifying those disabled students who might show a dissociation between irregular and unknown word reading. As in the Castles & Coltheart's study, it was shown that a high percentage of disabled subjects who were not categorized as surface or deep dyslexics also displayed a dissociation between the two tasks. In the second part, simple regression analyses of (a) irregular word reading as a function of unknown word reading, and (b) unknown word reading as a function of irregular word reading were performed for both control and disabled subjects. The analyses would then find those disabled subjects who displayed a dissociation between their irregular and unknown word reading skills on their relative ability to read each type of words.

Results

The classification of dyslexic subjects according to the word reading skill was done in two parts. The first part involved an examination of their irregular and unknown word reading ability based on their age. Subjects who were poor at the irregular word reading for their age, but normal at the unknown word reading, were classified as surface dyslexics. Subjects who showed poor unknown word reading for their age, but normal irregular word reading, were classified as deep dyslexics. The second part of the classification procedure involved finding those subjects who demonstrated a dissociation between their irregular and unknown word reading skills not based on age, but on their relative
ability to read each type of word.

Identification of sub-types of dyslexia based on age. As the major aim in the first part of analyses was to examine different types of dyslexia in Chinese reading, the regression model for identifying those disabled subjects with surface and deep dyslexic reading patterns in the Castles & Coltheart's (1993) study was used. The number of correct responses (/30) in reading aloud each of three types of words, i.e., regular, irregular and unknown, were calculated for each child in both control and reading disabled groups. Simple regression analyses of (a) irregular word reading as a function of chronological age and (b) unknown word reading as a function of chronological age were performed to control subjects. Analyses of control subjects' data were used as the criteria for selecting those reading disabled subjects who fell below the normal development in children of the reading of irregular words and unknown words.

Figure 1 which contains a plot of data, with the line of best fit [slope=1.34; intercept=10.55; standard error of estimate=3.82], showed the relationship of age and irregular word reading for control subjects. The simple regression analysis revealed a significant relationship between age and irregular word reading, [F(1,43)=5.92, P<.05].

FIGURE 1:

Irregular word reading based on chronological age for the control group, with the line of best fit and the 5% lower confidence interval limit shown.

The second simple regression analysis also showed a significant relationship between age and unknown word reading, [F(1,43)=34.50, p<.001]. The data, with their line of best fit [slope=2.73; intercept=-8.80; standard error of estimate=4.62], are presented in Figure 2.

FIGURE 2:

Unknown word reading based on chronological age for the control group, with the line of best fit and the 5% lower confidence interval limit shown.

Similar to the Castles and Coltheart's (1993) study, 90% confidence interval limits set in the control subjects' performance were used as the criteria for selecting abnormal scores in the reading disabled group. Scores were considered abnormal when they fell outside the 5% lower confidence interval limit.
Irregular word reading scores for reading disabled subjects, and confidence boundaries, are plotted in Figure 3. Thirty-five out of 54 reading disabled subjects (65%) fell below the lower confidence interval limit for the irregular word reading. This group of students, thus, could be classified as abnormal for their age in their ability to read irregular words.

FIGURE 3:
Irregular word reading based on chronological age for the reading disabled group, with the 5% lower confidence interval limits shown.

Scores of reading disabled subjects for the unknown word reading are presented in Figure 4. A number of 24 reading disabled subjects (44%) was found to be below the lower confidence interval limit for the unknown word reading.

FIGURE 4:
Unknown word reading based on chronological age for the reading disabled group, with the 5% lower confidence interval shown. Twenty-seven out of 54 subjects (50%) fell below the 5% lower confidence interval limit for one of the tasks, but within confidence interval limits for the other. Nineteen out of these 27 subjects scored within confidence interval limits for the unknown word reading but fell outside limits for the irregular word reading. The other 8 subjects showed precisely the reverse pattern. Their scores fell within the range for the irregular word reading, but outside it for the unknown word reading. Based on the previous description of two sub-types of dyslexia, the former group of students, thus, could be classified as "pure" surface dyslexics and the latter group as "pure" deep dyslexics. Dyslexic subjects in this study were termed as "pure" surface dyslexics and "pure" deep dyslexics for avoiding the confusion with subjects who were identified as having a surface or deep dyslexic pattern in the second part of analyses.

The data also revealed that 16 out of 54 disabled subjects (30%) were poor at reading irregular and unknown words for their age while 9 out of these disabled subjects (20%) were normal at both tasks for their age. Table 2 presents the distribution of various sub-types of reading.
disabled subjects in the Castles & Coltheart's study and the present study.

Table 2 Distribution of various sub-types of reading disabled subjects

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<thead>
<tr>
<th></th>
<th>SF</th>
<th>DP</th>
<th>BH</th>
<th>NL</th>
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</thead>
<tbody>
<tr>
<td>Castles &amp; Coltheart's study</td>
<td>10 (19%)</td>
<td>8 (15%)</td>
<td>30 (57%)</td>
<td>5 (9%)</td>
</tr>
<tr>
<td>present study</td>
<td>19 (35%)</td>
<td>8 (15%)</td>
<td>16 (30%)</td>
<td>11 (20%)</td>
</tr>
</tbody>
</table>

Notes.
SF: Surface dyslexic subjects
DP: Deep dyslexic subjects
BH: Reading disabled subjects with deficits at both tasks for their age
NL: Reading disabled subjects with normal reading in both tasks

Results showed that two sub-types of dyslexia were found in both studies. It can be seen that the ratio of surface to deep dyslexics is larger in the present study than that in the Castles & Coltheart's study. Fifty-seven percent of disabled subjects in the Castles & Coltheart's study were considered to be poor at both reading tasks and only 30% of disabled subject in the present study had the same reading patterns. It is also found that the percentage of disabled subjects who had normal reading skills in both tasks is higher in the present study. In summary, these results supported the existence of two sub-types of dyslexia among reading disabled subjects in Chinese logographic writing systems. Their reading patterns were found to be similar to those dyslexic subjects in English alphabetic writing systems. The surface dyslexics were poor at reading irregular words whereas the deep dyslexics were poor at reading unknown words.

Confirmation for the poor performance of surface dyslexics in reading irregular words. As argued by Castles & Coltheart, to conclude that the poor performance of surface dyslexic subjects in the whole word recognition resulted from their distinct reading patterns had to control another factor, i.e., the language deficit. The purpose was to make sure that surface dyslexics were able to comprehend irregular words in their spoken language but unable to read them aloud. To avoid the problem that the poor whole word recognition was attributed a general language deficit rather than to their distinctive reading patterns, the second experiment in the Castles & Coltheart's study was to ask subjects to give a meaning to the same sets of regular and irregular words used in the first experiment. The experimenter at this time read out the words to students while presenting the word cards. It was assumed that a language deficit might play a role in their poor irregular word reading if there was a difference for the auditory comprehension performance of regular and irregular words as well as for the reading aloud performance of both types of words. The
implication was that surface dyslexics might have problems in understanding those irregular words so that they were not able to read the irregular words. Their deficits in irregular word reading might thus partly be accounted for by the poor auditory comprehension instead of solely on their deficit in reading aloud performance. On the other hand, if there was a difference between regular and irregular word reading but no difference between the auditory comprehension performance for both types of words, then distinctive reading patterns of surface dyslexia could be attributed to their specific reading problems.

In the Castles & Coltheart's study, the comprehension scores for regular words did not differ from those for irregular words for their surface dyslexic subjects. On the other hand, the reading aloud performance for regular words differed significantly from that for irregular words. The dyslexic subjects in the Castles & Coltheart's study could understand both regular and irregular words equally well but they performed poorer at reading aloud irregular words than regular words. It could thus be confirmed that these surface dyslexic subjects' deficit in irregular word reading was not due to a auditory language problem. Instead, their deficit might thus be explained by their reading patterns in which their "whole" recognition of words was poor.

Similarly, the present study also requested reading disabled subjects to give a meaning to regular words and irregular words. After identification of two types of dyslexic subjects, scores of regular and irregular words in the auditory comprehension and the reading aloud performances for surface dyslexic subjects (subjects with specific problems in irregular word reading) were analysed. Results showed that there was no significant difference for the comprehension of regular and irregular words for surface dyslexic subjects, t(18)=1.11, p>.05. However, regular word reading was significantly differed from irregular word reading for surface dyslexic subjects, t(18)=12.00, p<.0001. These results indicated that surface dyslexic subjects had no problem in their auditory comprehension of presented irregular characters. They were able to comprehend irregular characters as well as regular characters when they were presented in spoken language. Surface dyslexic subjects in this study did not have a problem in their listening comprehension of irregular words. On the hand, they were not able to perform well in reading aloud irregular words. These results confirmed that the surface dyslexics' poor performance in irregular word reading in the present study was mainly due to the impairment with their lexical procedure which gave troubles to them to read aloud irregular words.

Identification of dyslexic patterns based on relative ability to read each type of words. In the Castles & Coltheart's study, in addition to identified "pure" surface and "pure" deep dyslexic subjects, a proportion of the remaining disabled subjects also showed a dissociation between the irregular word reading and the unknown word
reading even though some of them might be regarded as disabled subjects with deficits in both tasks for their age. In their study, it was found that 45 out of 53 disabled subjects (85%) showed a dissociation between the irregular word reading and the unknown word reading. Twenty-nine of this group disabled students (55%) showed a deep dyslexic reading pattern while 16 disabled subjects (30%) displayed a surface dyslexic pattern.

Similarly, the second part of analyses in the present study also aims at isolating those subjects with a dissociation between the irregular and unknown word reading. However, age would not be used as predictor for the performance of the irregular and unknown word reading this time. Specifically, it is hoped that these analyses would further confirm the existence of two sub-types of dyslexia and the role of the lexical procedure played in Chinese logographic writing systems.

In doing so, the estimation of the expected number of correct responses for the irregular word reading and the unknown word reading was not based on the chronological age as in previous two sets of regression analyses. Instead, correct responses for the irregular word reading were predicted from varying levels of unknown word reading and vice versa. Again, results of control subjects were used as criteria for selecting those reading disabled subjects who fell below the performance of normal children.

Simple regression analyses of (a) irregular word reading scores on unknown word reading scores and (b) unknown word reading scores on irregular reading scores were performed for control subjects. Analyses revealed a significant relationship between the irregular word reading and the unknown word reading, \[ F(1,43)=14.39, p<.001 \]. The result of the former analysis \[ \text{slope}=.37; \text{intercept}=16.99; \text{standard error of estimate}=3.52 \] is presented in Figure 5 whereas the latter \[ \text{slope}=.67; \text{intercept}=-2.17; \text{standard error of estimate}=4.71 \] is shown in Figure 6.

FIGURE 5:
Irregular word reading based unknown word reading for the control group, with the line of best fit and the 5% lower confidence interval limit shown.

FIGURE 6:
Unknown word reading based on irregular word reading for the control group, with the line of best fit and the 5% lower confidence interval limit shown.
Ninety percent confidence interval limits were again established for both (a) unknown word reading based on irregular reading scores and (b) irregular word reading based on unknown word reading scores. The 5% lower confidence interval limits and the distribution of scores for reading disabled subjects in both analyses are presented Figure 7 and Figure 8.

**FIGURE 7:**

Irregular word reading based on unknown word reading for the reading disabled group, with the 5% lower confidence interval limit shown.

**FIGURE 8:**

Unknown word reading based on irregular word reading for the reading disabled group, with the 5% lower confidence interval limit shown.

Results of these analyses revealed that 28 out of these 54 subjects (52%) were below the lower confidence interval limit for the irregular word reading, when prediction was made from their unknown word reading performance. These subjects were much poorer at their irregular word reading than would have been expected on the basis of their unknown word reading scores. This outcome indicated that, in addition to 19 identified "pure" surface dyslexic students in previous age-based analyses, nine more reading disabled students showed similar reading pattern even though their performance at both tasks were below average. When predictions were made from their irregular word reading scores, seven subjects (13%) fell below the lower confidence interval limit for the unknown word reading. These subjects were much poorer at reading unknown words than would have been expected on the basis of their irregular word reading performance.

In summary, 35 out of 54 dyslexic subjects (65%) appeared to show a dissociation between their irregular word reading and their unknown word reading performance. Twenty-eight out of 54 dyslexic students (52%) showed a surface dyslexic pattern while 7 students (20%) displayed a deep dyslexic pattern. Results again confirmed that deep and surface dyslexic reading patterns existed in Chinese logographic writing systems. The existence of two sub-types of dyslexic reading patterns among Chinese disabled subjects was another indication of the availability of the dual-route model in Chinese reading. In addition, the proportion of children with a surface dyslexic pattern was greater than that of children with a deep dyslexic pattern. Deficit in lexical procedure could, thus, be seen as a more major cause in Chinese reading disability. Results found in the second part of analyses were consistent with those in the first part. Table 3 presents the findings in the second part of analyses for the Castles & Coltheart's study and
the present study.

Table 3  Distribution of reading disabled subjects with surface dyslexic and deep dyslexic patterns in the Castles and Coltheart's study and the present study

<table>
<thead>
<tr>
<th>SF</th>
<th>DP</th>
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<tbody>
<tr>
<td>Castles &amp; Coltheart's study</td>
<td>16 (30%) 29 (55%)</td>
</tr>
</tbody>
</table>

Notes.
SF: reading disabled subjects with a surface dyslexic pattern
DP: reading disabled subjects with a deep dyslexic pattern
In comparison with the Castles & Coltheart's study, disabled subjects had similar reading dyslexic patterns in Chinese writing systems. However, the proportion of subjects with a deep dyslexic pattern in English writing systems was much higher than that with a surface dyslexic pattern. This result was different to the finding of the present study that subjects with a surface dyslexic pattern had a higher proportion.

Discussion
Results for the first part of simple regression analyses showed that 27 out of 54 reading disabled subjects (50%) were normal for their age for one task while falling below the 5% confidence interval limit on the other task. Nineteen of this particular group of students could be classified as "pure" surface dyslexics and 8 students as "pure" deep dyslexics according to the definition of two sub-types of dyslexia given by Castles and Coltheart (1993).

As surface dyslexic and deep dyslexic reading patterns were found in the present study, it could, therefore, be inferred that students of Chinese logographic writing systems might make use of both of the lexical procedure and the sub-lexical procedure to read. A certain proportion of Chinese readers specifically relied on either the sub-lexical procedure or the lexical procedure to read.

In sum, reading characteristics of two sub-types of dyslexia found in this study were consistent with the general description of two sub-types of dyslexia in English reading (e.g., Castles and Coltheart, 1993). On the other hand, evidence for the existence of two sub-types of dyslexia in logographic writing systems disagreed with Coltheart's
(1984) suggestion that the dual-route model was not found in Chinese reading. According to the Coltheart's (1984) argument, phonetic clues in Chinese characters were unreliable. Chinese readers perceived words as "wholes" and they only used the lexical procedure for word identification. However, findings in the present study suggested that the dual-route model of reading was found in Chinese logographic writing systems just as it was in English alphabetic writing systems. It could be claimed that the dual-route model of reading is a universal phenomenon and innate to human beings.

It is true that not all the phonetic clues within Chinese characters gives readers the proper pronunciation. The fact is that over 90% of Chinese characters are phonograms and a high proportion of characters do give correct phonetic hinting information to readers. If the sub-lexical procedure is innate to human beings, it is natural for some Chinese readers to make use the phonological route to read.

The dual-route model of reading exists in both alphabetic and logographic writing systems. In alphabetic writing systems, there is a consensus that the sub-lexical procedure is important in reading. Readers with the deficit in the sub-lexical procedure would inevitably face difficulties in reading. In addition, Castles and Coltheart (1993) found that 85% of reading disabled subjects in their study displayed a dissociation between the irregular word reading and the non-word reading. Fifty-five percent of reading disabled students had a phonological dyslexic pattern whereas 30% showed a surface dyslexic pattern. The proportion of students with a deep dyslexic pattern was much higher than that with a surface dyslexic pattern. It was believed that the deficit in the sub-lexical procedure was considered to be a major problem in English reading.

In the present study, results of the second part of regression analyses indicated that 35 out of 54 of the dyslexic subjects (65%) had a dissociation between the irregular word reading and the unknown word reading where unknown words carried the similar function as non-words in the Castles and Coltheart's (1993) study. Twenty-eight of this particular group of students (52%) showed a surface dyslexic pattern and 7 students (13%) displayed a deep dyslexic pattern. Results appeared to provide the evidence that the surface dyslexic pattern dominated the reading problem in the reading disabled group with a dissociation in the irregular and unknown word reading in Chinese logographic writing systems.

With inspection of the analyses of two sub-types of dyslexia in the Castles & Coltheart's study and the present study, it could be claimed that the sub-lexical procedure played the crucial role in English reading whereas the lexical procedure was important in Chinese reading. The phenomenon of this opposite direction might be due to the difference in the basic structure of Chinese logographic writing systems and English alphabetic writing systems.

As indicated before, the rule of symbol-sound correspondences in English writing systems is abstract and complex. It is common to have
more than two or three sounds in an English word. The rule is very complex as well. In Chinese, the characters are mono-syllabic. The pronunciation of the right component which provides phonological clue is also the pronunciation of the whole character. Phonological clues within characters might be processed differently from those in alphabetic and logographic writing systems. As demonstrated by Patterson & Morton (1985) and Shallace, Warrington, & McCarthy (1983), the number of sounds blended in a pronunciation influence the performance in reading. Fewer sounds in a pronunciation means a reduction in the load of phonological processes. English readers with the deficit in the sub-lexical procedure would therefore encounter much more difficulties in reading than those with the problem in the lexical procedure.

On the other hand, Chinese writing systems are complex in their graphic structure. Characters would alter their meaning when the size of strokes is not properly written. For example, "" means "last" and "" means "not yet". Also, some of characters are complex in their combination of strokes, e.g., "" (a total number of 17 strokes) for "turtle" and "" (a total number of 13 strokes) for "lion". The demonstrated Chinese characters are actually some common words of frequent use. The complexity in graphic appearance of Chinese characters would be likely to present the major difficulties in learning to read.

In conclusion, the dual-route model of reading existed in Chinese logographic writing systems. Surface and deep dyslexic patterns of reading were found in Chinese readers. A certain proportion of readers did use sub-lexical procedure to read Chinese characters. However, the central mechanism for reading disability in Chinese was the deficit in the lexical procedure whereas for reading disability in English it was the deficit in the sub-lexical procedure.

References


Educational Research Establishment, Education Department (1979). A study of the Chinese vocabulary used in primary schools in Hong Kong. Hong Kong: Education Department.

Ho, K.C. (1993). A comparison of the 2,000 most frequently used Chinese characters found in three frequency counts carried out in China, Taiwan and Hong Kong. Hong Kong: Institute of Language in Education.


