

Sub-types of Dyslexia in Different Orthographies

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Abstract

The purpose of this project is to compare the underlying mechanisms involved in students with reading difficulties in alphabetic and logographic writing systems. Based on the 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) and Jimenez (2000) provided evidence for the existence of these two mechanisms in English reading and Spanish reading respectively. They suggested that deficits in one and/or the other mechanism would lead to different patterns of reading disability. Surface dyslexia results from impairment of the lexical procedure with an intact phonological route to reading. Phonological dyslexia results from a highly selective deficit in the grapheme-phoneme transformation mechanism. It was found that surface and phonological dyslexic reading patterns were also found in the Chinese dyslexic readers. The ratio of surface to phonological dyslexia in Chinese orthography was similar to that of Spanish. A higher percentage of surface dyslexia was observed.

The principles of generalized phonological activation in English language can be realized in various ways. Dual route theories of word identification (e.g., Besner, 1990; Coltheart, 1978; Paap & Noel, 1991) assume that phonological conversion processes occur along one route, while direct access, unmediated by phonology, occurs along the other route. Using Coltheart's terminology, 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-grapheme orthographic and phonological segments.

Castles and 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. Phonological dyslexia results from a highly selective deficit in the grapheme-phoneme transformation mechanism. The result of Castles and Coltheart's study showed that the proportion of phonological dyslexics (55%) was larger than that of surface dyslexics (30%) in their groups of disabled readers.

Jimenez (2000) used Castles and Coltheart's (1993) regression-based procedure to identify dyslexic subtypes in Spanish orthography. It was found that patterns of both the phonological dyslexia and the surface dyslexia were identified also in Spanish readers.

Jimenez (2000) found that 20 out of 89 dyslexic 3rd grade children in their study were identified as phonological dyslexics whereas 48 dyslexics were considered as surface dyslexics. The identification is based on a comparison with chronological-age controls on reaction time and high frequency and pseudoword reading.

Phonological dyslexia is apparently less common in Spanish than in English. The explanation for this phenomenon is the simplicity of the phonological structure of Spanish. Spanish has a very regular orthography; the pronunciation of a string of letters can always be derived from print (Sebastian, 1991). The shallowness of its orthography should foster phonological processing in early reading. A greater proportion of surface dyslexia than that of phonological dyslexia observed in the Spanish study is due to the fact that there was an overreliance of the sub-lexical procedure and the infrequent use of lexical procedure. Genard, Mousty, Content, Alegria, Leybaert, and Morais (1998) also found similar patterns in French as in Spanish, with a greater proportion of surface dyslexics. It is obvious that, in a highly regular orthography, more surface dyslexics were found. Frith's (1985) description of developmental dysgraphia, in fact, supported the above-mentioned explanation of a higher incidence of surface dyslexia in regular orthographies. Readers of developmental dysgraphia apply the alphabetic strategy to spell regular words correctly and experience difficulty reading irregular words. Problems that arise during transition from alphabetic to the orthographic strategy result from overreliance on the alphabetic principle. Because logographic skills remain intact, readers will rely on phoneme-grapheme rules, disregard intraword structures, and tend to regularize the spelling of irregularly spelled words, for example, spelling "cough" as "coff."

The discrepancy found in the relative proportion of phonological and surface profiles in regular and irregular orthographies suggested that evidence of the impairment may be determined by the relative importance of analytical and lexical knowledge in respective writing systems.

If the regularity of different alphabetic orthographies influences the incidence of phonological and surface dyslexia, what does this suggest for Chinese? Coltheart (1984) claimed that dual-route model of reading in Chinese was not plausible. This hypothesis was based on the argument that reading Chinese required the visual route to identify Chinese words without the need to recognize the phonological structure of words. Zhou et al. (1999) also argued that the direct visual route is the major path in reading Chinese characters

In contrast, DeFrancis (1989) believed that any fully developed writing system has to be speech-based. Perfetti and McCutchen (1982) also suggested that, regardless of the writing systems, speech codes are kept activated in working memory in support of comprehension. The implication from these results is that phonological processing of the printed words is a requirement in any writing system. If the latter is true, the sound characteristics of Chinese words should result in activation of phonological processing.

Hung, Tzeng, and Tzeng (1992) found that linguistic information in Chinese character recognition, is automatically activated. In the process of Chinese reading, knowledge of the shape and sound influences the recognition of Chinese characters. Jackson, Lu, and Ju (1994) also pointed out that, although the character as a whole almost always corresponds to a single syllable and morpheme, it might have component parts that, when they stand alone, have a different meaning or sound. For example, "每" could be a component of "梅" as well as an independent character "每". This may hint at the pronunciation of the

characters. Leong (1999) argued that reading Chinese is not just a visual process; it involves phonological processes even before meaning is accessed. He believed that the core deficit in the literacy domain is the language area, and in particular, in phonological processing linking symbols to speech sound.

In summation, Chinese consists of sound components. Phonology plays a role in word recognition. About 25% of the phonological components give the exact pronunciation. It is different from Spanish, in which the relationship between sound and print is direct and transparent. On the other hand, it is similar to English orthography where irregular correspondences between symbol and sound can be found. Furthermore, the Chinese orthography is morphosyllabic; each character represents a morpheme as well as a syllable. It seems that to decode the sound within the characters is less complicated than those in English and in Spanish orthographies. However, the phonological information within the character is unsystematic and unreliable. Whether readers of Chinese language make use of the lexical or the sub-lexical route as their major pathway in reading still requires further investigation.

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

Phonology in Chinese may play a different role from that played in alphabetic orthographies. The present investigation, therefore, focused on testing the existence of the two sub-types of dyslexia in the Chinese writing system. Given that the surface and phonological dyslexic readers could be found in Chinese, the relative proportion of these two sub-types was also of interest.

METHOD

Subjects

Fifty-three reading disabled students were selected from two primary schools in Hong Kong. The mean age of the reading disabled students was 10.11 and the standard deviation was 1.08. The criteria for selection were:

1. Students were attending resource classes and had a major problem in Chinese reading. Students who were eligible for entering the resource classes had deficits in two or more of the three basic subjects, i.e. Chinese, English and Mathematics. (The resource classes have been renamed the Intensive Remedial Teaching Programme since September, 2000);
2. These students had to score below the 20th percentile in the Hong Kong Attainment Test in Chinese;
3. These students had average IQ scores;
4. Primary Year 3, 4 and 5 students were chosen for 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 and Stanovich (1990) demonstrated that students in their third or fourth year of schooling are able to use both orthographic and phonological skills in word recognition;
5. Subjects had to be free, according to the judgment of their teachers, from severe emotional or behavior problems; and
6. Subjects must have attended school regularly.

In the same schools, forty-four Primary Year 3 to 5 students who scored above the 20th percentile in the Hong Kong Attainment Test in Chinese were randomly chosen as a comparison. The average age of the comparison group was 10.00 and the standard deviation was 1.16.

Stimulus materials

The test consisted of 3 sets of single-character words. Each set contained 30 words of one type. Types of words were regular (words which give phonetic hints), irregular (words which do not give phonetic hints) and pseudowords (words which followed the Chinese word formation rule and gave phonetic hints but did not contain any meaning).

When selecting regular and irregular words, variables such as the frequency, the radical and the number of strokes, which might influence the performance of subjects, were controlled. Pairs of regular and irregular single-character words were matched as closely as possible for the frequency, the radical and the 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 "A Study of High Frequency Words Used in Chinese Elementary Reading Materials" (National Institute for Compilation and Translation, 1967), and "the Chinese Vocabulary Used in Primary Schools in Hong Kong" (Educational Research Establishment, Education Department, 1979). 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, and number of strokes; and
2. The rank of frequency of each pair of regular and irregular characters was equivalent.

The legal pronounceable non-characters were constructed upon the principle that the pseudowords contained obvious phonetic hinting information. Subjects were able to sound out the words correctly if they made use of the phonological structure within the words. In this experiment, the list of pseudowords was constructed to be consistent with the lists of regular and irregular words, in terms of radicals and number of strokes. It was presumed that these pseudowords had no lexical representation in the subjects' lexicon.

Irregular single-character words were for examination of the lexical procedure, the pseudowords were for examination of the sub-lexical procedure and regular words were for comparison with irregular words. As reading irregular words, it was assumed that the only way the pronunciation of these words could be derived was through the use of the lexical procedure, as these words did not have any phonological information that could serve as a hint to their pronunciation. These words were recognized through a direct visual pathway. On the contrary, the way to pronounce pseudowords is through the sub-lexical procedure. The pseudowords were sounded out by making use of the phonological hinting information within the characters.

Patterns of phonological dyslexia would be observed if readers demonstrated little difference between reading both regular and irregular words but could not read pseudowords. On the other hand, it was supposed that symptoms of surface dyslexia existed when readers found regular words much easier, than irregular words, to read and were able to read pseudowords.

The 90 words were printed on 6×6 cm white paper and laminated with plastic. This enabled shuffling, so that they could be presented to students in random order and one at a time.

Design

A repeated measurements experimental design was used in which each student experienced all testing conditions. The analyses consisted of two parts. The first part was to identify the two sub-types of dyslexia as well as to investigate the relative importance of the lexical and sub-lexical procedures in logographic writing systems.

The second part aimed at identifying those disabled students who might show a dissociation between irregular and pseudoword reading. As in the Castles and Coltheart's (1993) study, in which it was shown that a high percentage of disabled subjects who were not categorized as surface or phonological dyslexics also displayed a dissociation between the two tasks. In this second part, the simple regression analyses of (a) irregular word reading as a function of pseudoword reading, and (b) pseudoword reading as a function of irregular word reading were performed for both comparison and disabled subjects. The second part of the analyses would then find those disabled subjects who displayed a dissociation between their irregular and pseudoword reading skills on their relative ability to read each type of words.

Procedure

The testing consisted of two sessions. The first session required subjects to read the lists of regular, irregular and pseudoword words. The second session required subjects to give a definition of each of the regular and irregular words as these words were presented to them orally by the investigator. The purpose of this session was to make sure that the factor for the poor performance with irregular words was not 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 began:

"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 response 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 cannot, try and make it a sentence. Some of 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 children had confirmed that they understood the task, words were read out loud to them, one at a time and in random order.

RESULTS

The classification of the dyslexic subjects, according to word reading skill, was conducted in two parts. The first part involved an examination of their irregular and pseudoword reading ability based on their age. Subjects who were poor at irregular word reading for their age, but normal at pseudoword reading, were classified as surface dyslexics. Subjects who showed poor pseudoword reading for their age, but normal irregular word reading, were classified as phonological dyslexics.

The second part of the classification procedure involved finding those subjects who demonstrated a dissociation between their irregular and pseudoword 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 the analyses was to examine the existence of different sub-types of dyslexia in Chinese reading, the regression model for identifying those disabled subjects with surface and phonological dyslexic reading patterns in the Castles and 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 pseudowords, were calculated for each child in both comparison and reading disabled groups.

Firstly, the simple regression analyses of (a) irregular word reading as a function of chronological age and (b) pseudoword reading as a function of chronological age were performed for comparison subjects. The analyses of comparison subjects' data were used as the criteria for selecting those reading disabled subjects who fell below the normal development in children in the reading of irregular words and pseudowords.

Figure 1, which contains a plot of data with two sets of the line of best fit, shows the relationship of age and irregular word reading for the comparison and the reading disabled subjects respectively. The simple regression analysis revealed a significant relationship between the age and the irregular word reading for the comparison subjects, [$F(1,42)=10.37$, $p<.05$].

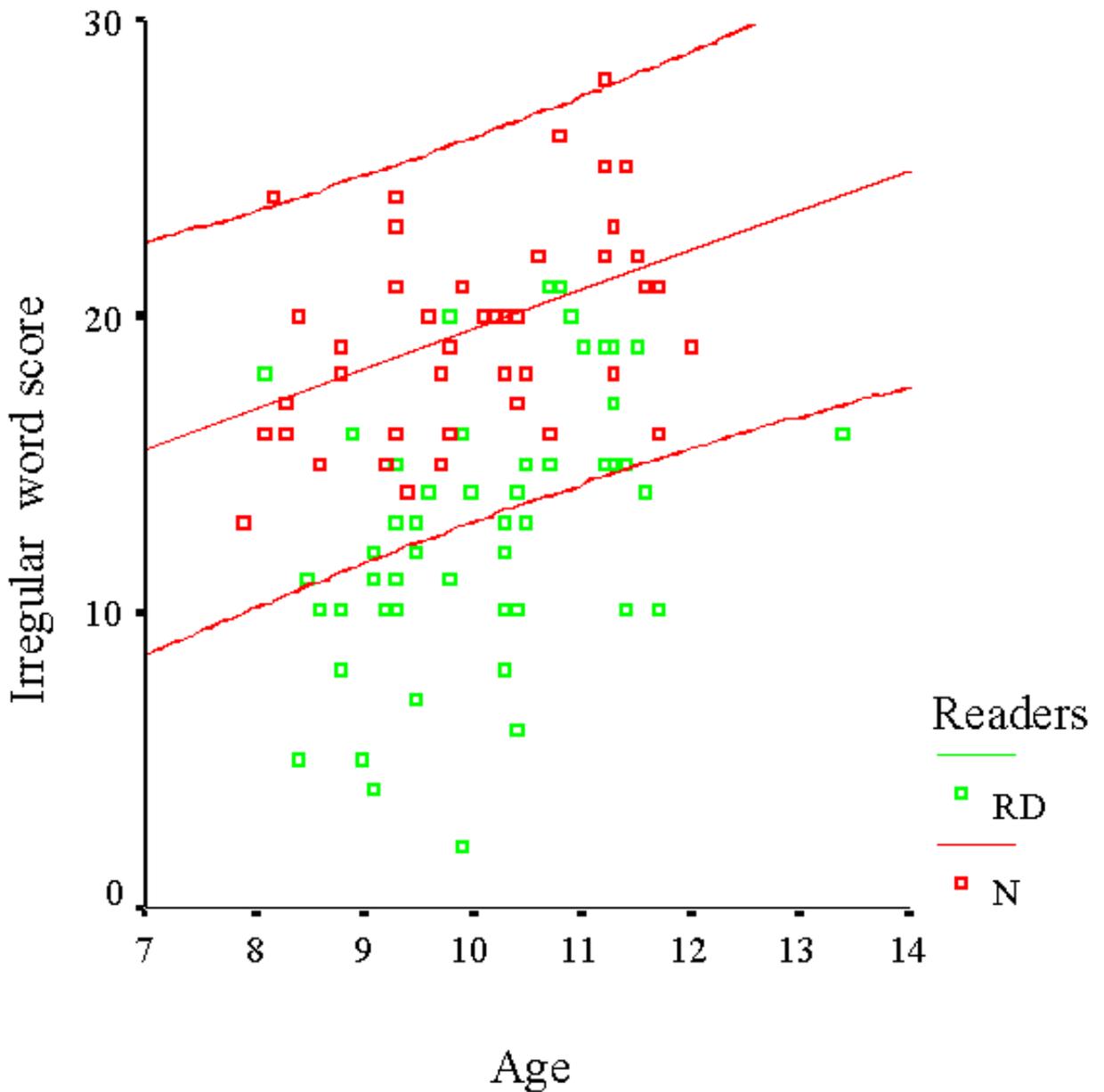


Fig 1. 90% confidence interval limits for irregular word reading based on age

Notes.

RD: Reading Disabled

N: Normal

The second simple regression analysis also showed a significant relationship between age and pseudoword reading for the comparison group, $[F(1,42)=20.86, p<.0001]$. The data are presented in Figure 2.

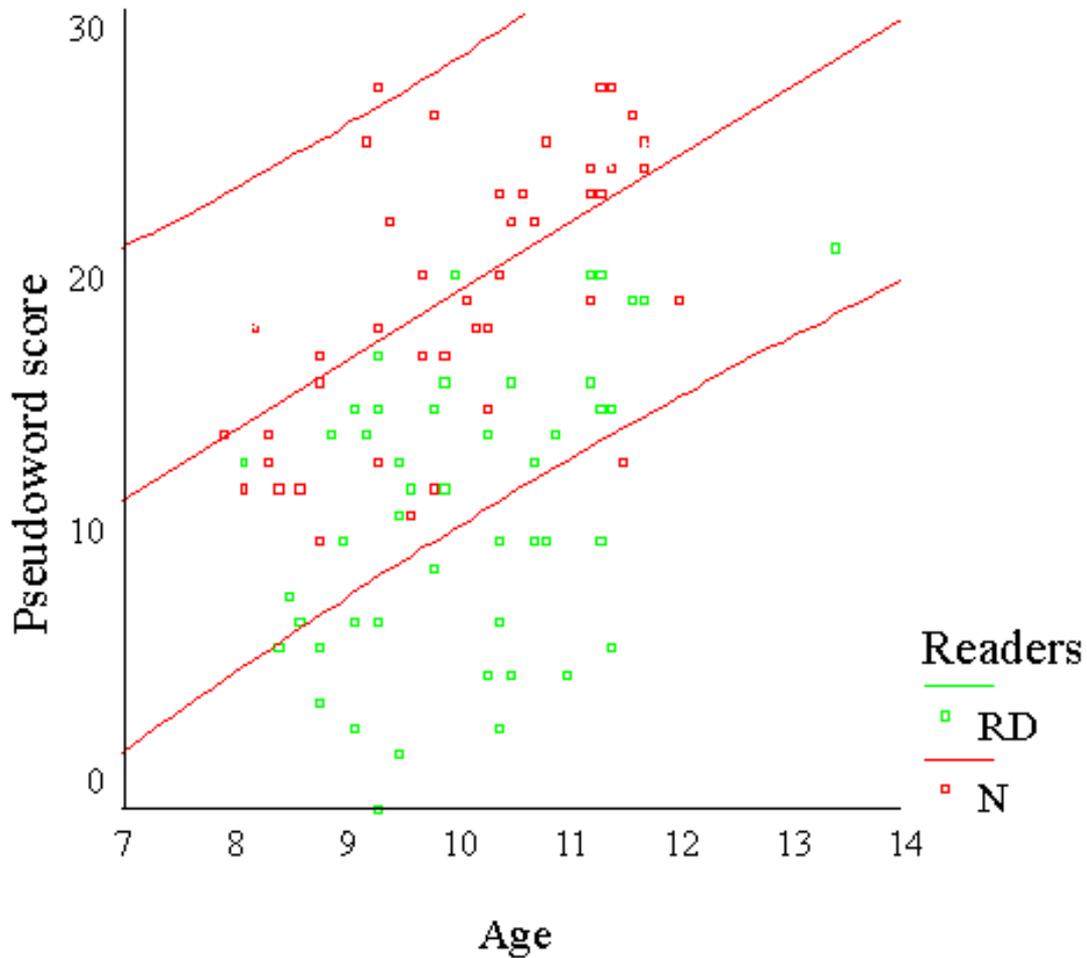


Fig 2. 90% confidence interval limits for pseudoword reading based on age

Notes.

RD: Reading Disabled

N: Normal

Similar to the Castles and Coltheart's (1993) study, 90% confidence interval limits set for the subjects' performance of the comparison group 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 both comparison and reading disabled subjects, and confidence boundaries, are plotted in Figure 1. Twenty-four out of 53 reading disabled subjects (45%) 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.

Scores of reading disabled subjects for the pseudoword reading are presented in Figure 2. A number of 21 reading disabled subjects (40%) were found to be below the lower confidence interval limit for the pseudoword reading.

Twenty-seven out of 53 subjects (51%) fell below the 5% lower confidence interval limit for one of the tasks, but within confidence interval limits for the other. Fifteen (28% of disabled readers) out of these 27 subjects scored within confidence interval limits for the pseudoword reading but fell outside limits for the irregular word reading. The other 12 subjects (23% of disabled readers) showed precisely the reverse pattern. Their scores fell within the range for the irregular word reading, but outside it for the pseudoword 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" phonological dyslexics. Dyslexic subjects in this study were termed as "pure" surface dyslexics and "pure" phonological dyslexics to avoid confusion with subjects who were identified as having a surface or phonological dyslexic pattern in the second part of the analyses.

The data also revealed that 9 out of 53 disabled subjects (17%) were poor at reading irregular words and pseudowords, for their age, while 17 out of these disabled subjects (32%) were normal at both tasks for their age. Table 1 presents the distribution of various sub-types of reading disabled subjects in the Castles & Coltheart's study and the present study.

Table 1. Distribution of various sub-types of reading disabled subjects

| | Normal | Surface | Phonological | Both |
|--|----------|----------|--------------|----------|
| English Alphabetic Orthography (Castles & Coltheart, 1993) | 5 (9%) | 10 (19%) | 8 (15%) | 30 (57%) |
| Chinese Logographic Orthography (Present study) | 17 (32%) | 15 (28%) | 12 (23%) | 9 (17%) |

Notes.

Normal: Normal subjects

Surface: Surface dyslexic subjects

Phonological: Phonological dyslexic subjects

Both: Both dyslexic subjects

The results showed that two sub-types of dyslexia were found in the present study. Fifty-seven percent of disabled subjects in the Castles and Coltheart's study were considered to be inferior in both tasks and only 17% of disabled subject in the present study had the same reading problems. It was also found that the percentage of disabled subjects, with normal reading skills at both tasks, was higher in the present study.

Similarly, the second part of the present study also requested reading disabled subjects to provide a meaning to regular words and irregular words. After identification of two types of dyslexic subjects, scores of regular and irregular words in auditory comprehension and reading aloud, for surface dyslexic subjects (subjects with specific problems in irregular word reading) were analyzed. The statistical analyses showed that there was no significant difference between the comprehension of regular and irregular words, [$t(14)=.88, p>.05$], but that there was a significant word reading difference, [$t(14)=9.18, p<.0001$]. These results indicated that the surface dyslexic subjects had no problem in 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.

Identification of dyslexic patterns based on a dissociation between irregular and pseudoword reading

In the Castles and Coltheart's study, in addition to identified "pure" surface and "pure" phonological dyslexic subjects, a proportion of the remaining disabled subjects also showed a dissociation between irregular word and pseudoword 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 irregular word and pseudoword reading. Twenty-nine of this group of disabled students (55%) showed a phonological dyslexic reading pattern while 16 disabled students (30%) displayed a surface dyslexic pattern.

Similarly, the second part of the analyses in the present study also aimed at isolating those subjects with a dissociation between irregular and pseudoword reading. To do this, correct responses for irregular word reading were predicted from pseudoword reading and vice versa. Again, the results of comparison subjects were used as criteria for selecting those reading disabled subjects who fell below the performance of normal children.

The simple regression analyses of (a) irregular word reading scores on pseudoword reading scores and (b) pseudoword reading scores on irregular reading scores were performed for comparison and reading disabled subjects. The analyses revealed a significant relationship between irregular word reading and pseudoword reading for comparison subjects, [$F(1,43)=14.39, p<.001$]. The result of the former analysis is presented in Figure 3 whereas the latter is shown in Figure 4.

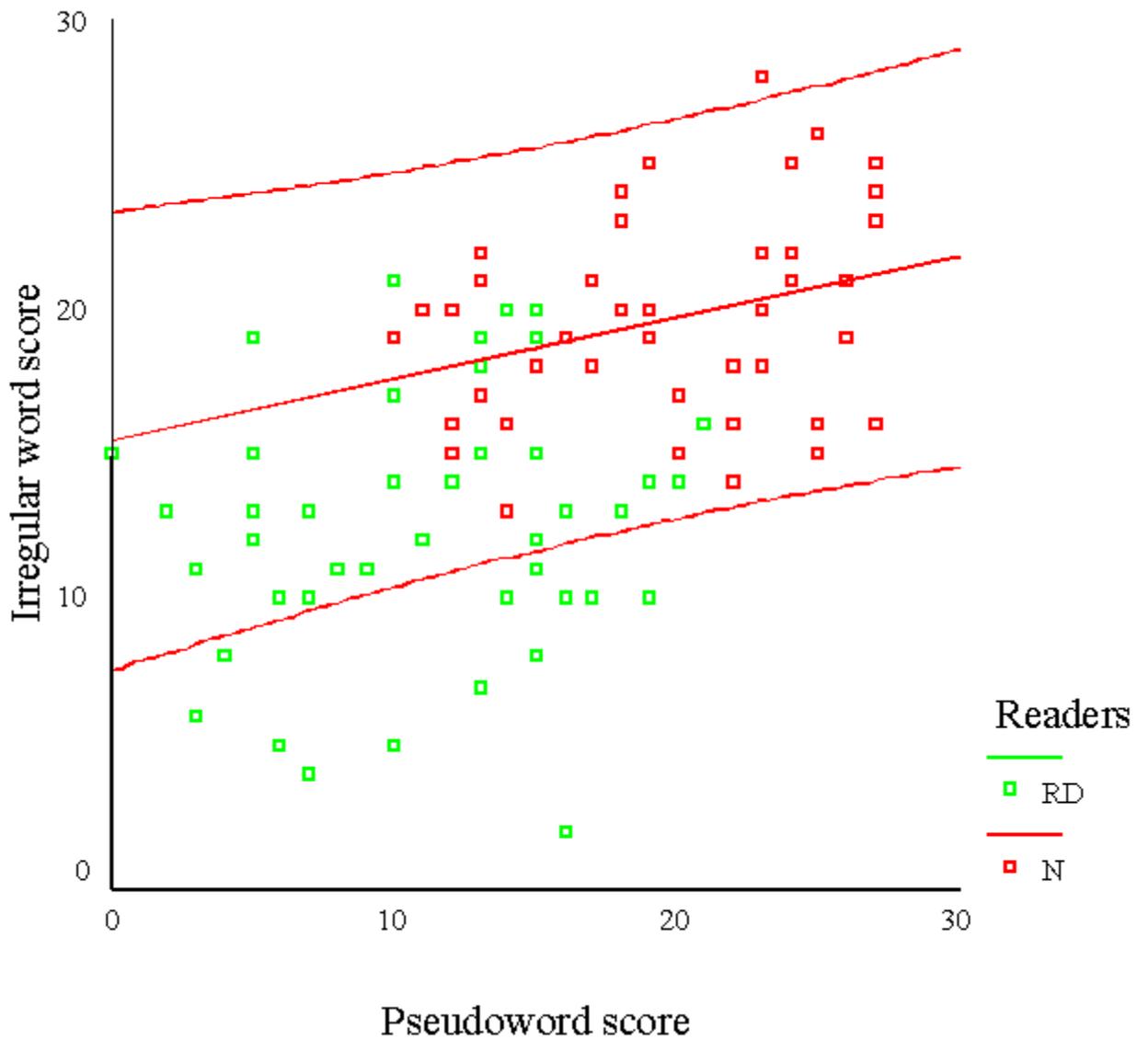


Fig 3. 90% confidence interval limits for irregular word reading score based on pseudoword reading score

Notes.

RD: Reading Disabled

N: Normal

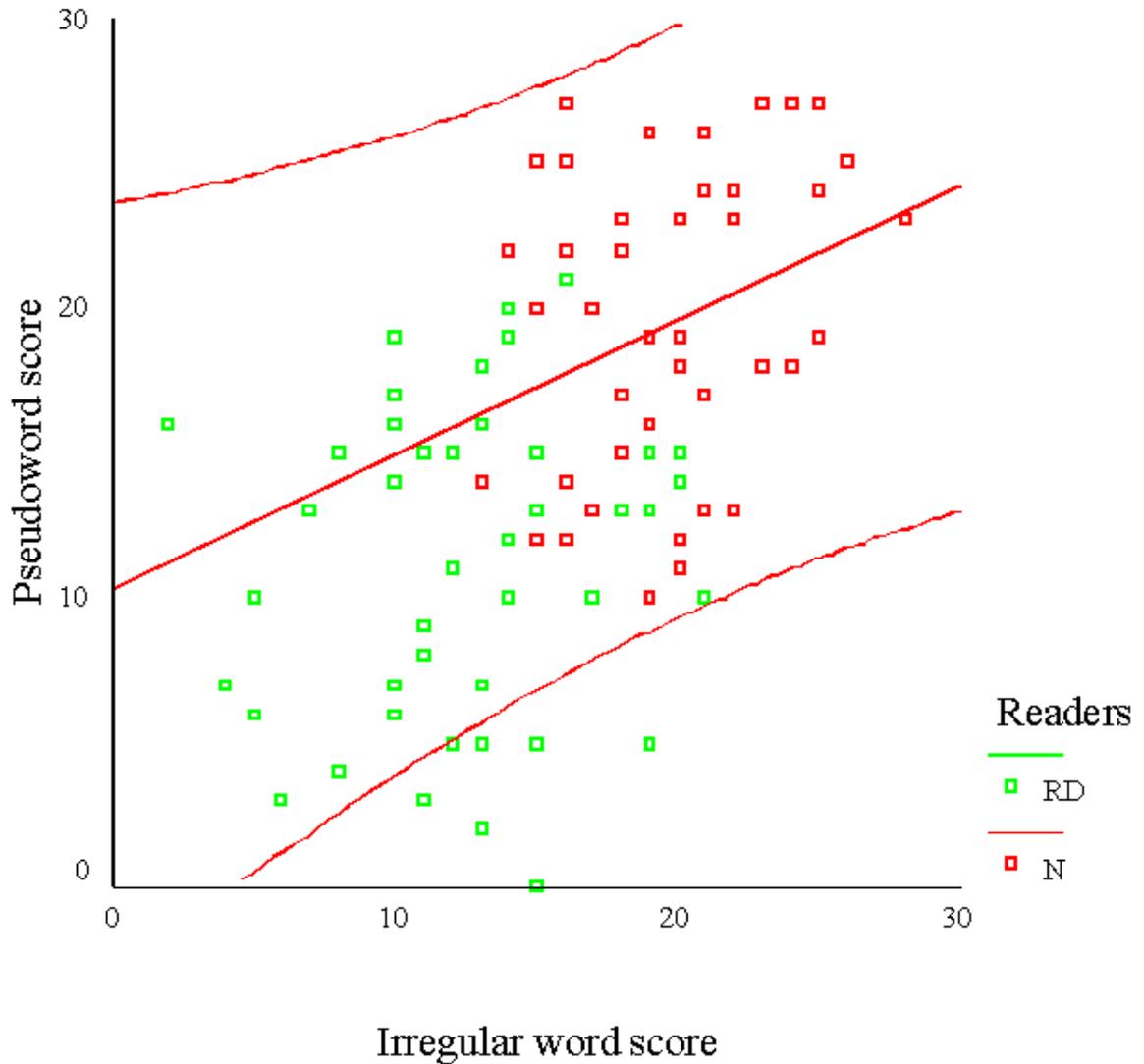


Fig 4. 90% confidence interval limits for pseudoword reading score based on irregular word reading score

Notes.

RD: Reading Disabled

N: Normal

Ninety percent confidence interval limits were again established for both (a) pseudoword reading based on irregular reading scores and (b) irregular word reading based on pseudoword reading scores. The boundaries of 90% confidence interval limits and the distribution of scores for reading disabled subjects in both analyses are presented in Figure 3 and Figure 4.

As can be seen in Figure 3 and Figure 4, fourteen of these 53 reading disabled subjects (26%) were below the lower confidence interval limit for irregular word reading, when predicting their pseudoword reading performance. These subjects were much poorer at irregular word reading than would have been expected on the basis of their pseudoword reading scores.

When predictions were made from their irregular word reading scores, seven subjects (13%) fell below the lower confidence interval limit for the pseudoword reading. These subjects were much poorer at reading pseudowords than would have been expected on the basis of their irregular word reading performance.

In summary, 21 out of 53 dyslexic subjects (40%) appeared to show a dissociation between their irregular word reading and their pseudoword reading performance. Fourteen out of 53 dyslexic students (26%) showed a surface dyslexic pattern while 7 students (13%) displayed a phonological dyslexic pattern. The results again argued for the existence of phonological and surface dyslexic reading patterns in Chinese logographic writing systems.

The existence of two sub-types of dyslexic reading patterns among Chinese disabled subjects indicates the applicability of the dual-route model to Chinese reading. It is interesting to note, however, that the proportion of children with a surface dyslexic pattern was greater than the proportion with a phonological dyslexic pattern. This is the reverse of Castles and Coltheart's (1993) findings in English reading where phonological dyslexia is the more common classification, and it suggests that surface or lexical dysfunction is more damaging to reading performance in Chinese. It is in fact of similar degree of disability as was found in the regular alphabetic orthography of Spanish (see the results of the three orthographies in Table 2).

Table 2. Distribution of reading disabled subjects with surface dyslexic and phonological dyslexic patterns in three studies

| | Surface | Phonological |
|---|---------|--------------|
| English Alphabetic Orthography (Castles & Coltheart's study) | 30% | 55% |
| Spanish Alphabetic Orthography (Jimenez's study) | 53% | 18% |
| Chinese Logographic Orthography (Present study) | 26% | 13% |

Notes.

Surface: reading disabled subjects with a surface dyslexic pattern.

Phonological: reading disabled subjects with a phonological dyslexic pattern.

DISCUSSION

The results for the first part of the simple regression analyses showed that 27 out of 53 reading disabled children (51%) were normal for their age for one task while falling below the 5% confidence interval limit on the other task. Fifteen of this particular group of students (28%) could be classified as "pure" surface dyslexics and 12 children (23%) as "pure"

phonological dyslexics according to the definition of two sub-types of dyslexia given by Castles and Coltheart (1993).

As surface dyslexic and phonological dyslexic reading patterns were found in the present study, it could, therefore, be inferred that students of Chinese logographic writing systems probably make use of both the lexical procedure and the sub-lexical procedure to read. The presence of two sub-types of dyslexia in Chinese orthography contrasts with the perception that Chinese readers perceive words as "wholes" and that they only use the lexical procedure for word identification. As the dual-route model of reading was found in both alphabetic and logographic writing systems, it might be claimed that the dual-route model of reading is common to existing writing systems.

In English orthography, it has been shown that the proportion of phonological dyslexia is higher than that of surface dyslexia. Castles and Coltheart (1993) found that 85% of reading disabled subjects in their study displayed a dissociation between irregular word reading and non-word reading. Fifty-five percent of reading disabled children had a phonological dyslexic pattern whereas 30% showed a surface dyslexic pattern; the proportion of students with a phonological dyslexic pattern being much higher than that with a surface dyslexic pattern. This is not a surprising result as skills in phonological awareness in English reading are important in the acquisition of reading proficiency, and these skills are complex, abstract and difficult to acquire.

In the present study, the results indicated that 21 out of 53 of the dyslexic subjects (40%) had a dissociation between the irregular word reading and the pseudoword reading. Fourteen of this particular group of students (26%) showed a surface dyslexic pattern and 7 students (13%) displayed a phonological dyslexic pattern. The number of surface dyslexic students in the present study were double the number of phonological dyslexic students. That is, this study showed a different dyslexic reading pattern from that of English reading and a similar dyslexic pattern to that of Spanish reading. Genard, et al. (1998) suggested that the proportion of phonological and surface dyslexics, in different orthographies, depends on the nature of the impairment in the analytic and lexical knowledge, in the course of reading development. Based on this assumption, causes of different dyslexic patterns in Spanish, English and Chinese were discussed.

Causes of the identified dyslexic reading pattern in Spanish orthography

Frith (1985) argued that overreliance on the alphabetic principle may cause problems during transition from alphabetic to orthographic strategies, because alphabetic strategies remain intact, the child will rely on phoneme-grapheme rules, disregard intraword structures, and tend to regularize the spelling of irregularly spelled words, for example, "cough" as "coff". Frith (1985) described this condition as developmental dysgraphia. The larger percentage of surface dyslexia in Spanish orthography may be due to the fact that the Spanish orthography is transparent and the phoneme-grapheme correspondence rules are straightforward. The Spanish dyslexic children relied too much on using the phonological analytic skills to read. This might cause a trade-off effect that the children would infrequently use the lexical procedure to read. The infrequent use of the lexical procedure would, thus, cause difficulties for the Spanish readers in mastering the direct visual route to read. The consequence is that the transition from alphabetic to orthographic stage might be hindered. This could be an explanation for the greater proportion of surface dyslexia in Spanish reading.

Causes of the identified dyslexic reading pattern in Chinese orthography

Although a greater proportion of surface dyslexics, in comparison with the number of phonological dyslexics, were found in both Chinese and Spanish orthographies, reasons accounting for this condition might be different. In Spanish, it may be due to the infrequent use of lexical knowledge as well as the overreliance on the alphabetic principle. In Chinese, this is probably because of the graphic complexity of the characters. Chinese writing systems are complex in their graphic structure. Chinese characters would alter their meaning when the size of strokes was not properly written. For example, "未" means "last" and "未" means "not yet". Also, some characters are complex in their combination of strokes, e.g., "龜" (a total number of 17 strokes) for "turtle" and "獅" (a total number of 13 strokes) for "lion". The demonstrated Chinese characters are actually some common, frequently used words. The complexity in graphic appearance of Chinese characters would be likely to cause difficulties for children learning to read. Whenever children use their lexical procedure to read, they have to deal with the complexity of the internal structure of Chinese characters. In addition, the phonetic components of Chinese characters are unreliable, although over eighty percent of Chinese characters are phonograms. Children are encouraged to read the Chinese characters in a gestalt manner. Children are trained to perceive the characters as "wholes". They are taught to avoid using the sound components of the characters as the sound hints for pronunciation. It is, therefore, common for children to use the lexical procedure to read. Deficits in the lexical procedure might cause Chinese readers detrimental problems in reading.

Causes of the identified dyslexic reading pattern in English orthography

The phoneme-grapheme correspondence rules of English orthography are abstract and complex. For example, "da" reads differently in "date", "dad", or "dark". The phoneme-grapheme rules are abstract and complex. The transition from logographic phase to alphabetic phase is difficult in English. Frith (1985) described those children who encounter problems during the alphabetic phase as developmental dyslexics. As evidence shows that the alphabetic principle is important for English reading (e.g. Ball & Blachman, 1988; Bradley & Bryant, 1983; Foorman, Francis, Novy, & Liberman, 1991; Vellutino, 1979, 1991), it is therefore an obstacle for children to learn to read if their sub-lexical procedure does not function efficiently and effectively.

In addition, it is common for an English word to have more than two or three sounds. As argued by Patterson and Morton (1985), the number of sounds blended in a pronunciation influence the performance in reading. Fewer sounds in a pronunciation mean a reduction in the load of phonological processes. English readers with the deficit in the sub-lexical procedure would therefore encounter many more difficulties in reading than those with the problem in the lexical procedure.

In conclusion, the current results support dual-route model of reading in Chinese logographic writing systems. Surface and phonological dyslexic patterns of reading were found in Chinese readers. A certain proportion of readers did use the sub-lexical procedure to read Chinese characters. In comparison, the relative proportion of surface and phonological dyslexia in Chinese is different to that in English. A higher percentage of surface dyslexia was observed in Chinese and Spanish, and phonological dyslexia in English. It is suggested that a child with a deficit in the lexical procedure is more disadvantaged than one with a sub-lexical procedure deficit in Chinese. As evidence shows, segmentation of sound components in English is crucial for fluent reading. The sub-lexical procedure is, therefore, the major route for reading. The impairment of sub-lexical procedure presents a problem to English readers.

In fact, the present experiment was to detect the level of severity of dyslexia in the population of students who were considered as reading disabled in Hong Kong primary schools. The chosen disabled subjects were not clinically diagnosed as dyslexics. This gave an explanation for a higher percentage of disabled subjects who did not fall into surface, phonological or both dyslexics category. The importance of identifying the level of severity of dyslexia in Chinese reading disabled children was to assist teachers to understand that children with reading difficulties may face different problems in their reading process. It was shown that some children might have their major problems in reading irregular words and some in pseudowords. In this study, the sub-types of dyslexia are referred to different levels of severity in reading irregular or pseudowords. In the following three experiments, the aim was to investigate the effectiveness of different teaching approaches in dealing with different sub-types of dyslexia in Chinese.

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