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Verbal Working Memory Deficits in Children with Chinese Developmental Dyslexia

Cecilia Yuet Hung Chan[1]

Abstract:

Previous research indicated the association of working memory deficits and English developmental dyslexia. This study investigates whether verbal working memory deficits also associate with Chinese developmental dyslexia. Verbal working memory involves storing and processing of verbal information. In the study, Chinese dyslexic children were compared with their non-dyslexic counterparts in sentence listening and sentence reading tests that measured working memory capacity and assessed sentence processing ability. The results of the study show that Chinese dyslexic children performed significantly worse than their controls in word recall, sentence recall and sentence comprehension in both spoken and written forms. The findings of the study reveal that Chinese developmental dyslexia, similar to English developmental dyslexia, is connected with weak verbal working memory. It is suggested that training of verbal working memory needs to be considered in language education for Chinese dyslexics.

Key words.: *Chinese dyslexia, verbal working memory, working memory capacity, sentence comprehension*

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I. INTRODUCTION

Dyslexia is defined as a specific language disorder which is neurobiological in origin and exhibited by deficiency in word recognition, spelling and decoding abilities. It induces consequences in difficulties in reading comprehension (Lyon, Shaywitz & Shaywitz, 2003).

Previous research revealed the association of difficulties in reading comprehension characteristic of dyslexia and deficits in working memory, either verbal or non-verbal (Brady 1991; Gathercole, Alloway, Willis & Admans 2006; Jeffries & Everatt, 2004; Kibby, Marks, Morgan & Long, 2004; Schuchardt, Maehler & Hasselhorn, 2008; Smith-Spark & Fisk, 2003). Working memory is defined as having both of the two components of processing and storage of information (Baddeley & Hitch, 1974). Verbal working memory1 refers to the temporary maintenance and manipulation of verbal information (Baddeley, 1986). The research concerning the relationship of reading disabilities characteristic of dyslexia and verbal working memory focuses on English developmental dyslexia, with very few studies on Chinese developmental dyslexia. The present study aims to fill this gap.

II. THE STUDY

The present study intends to investigate whether the association of reading difficulties and verbal working memory shown in English developmental dyslexia exists in Chinese developmental dyslexia.

Aims of the study

This study aims to find out whether Chinese dyslexic children are comparable with their typically developed peers in:

(1) Storing verbal information when listening to sentences;

(2) Storing verbal information when reading sentences;

(3) Processing verbal information when listening to sentences;

(4) Processing verbal information when reading sentences.

Research Methods

Participants

The study involved an experimental group and a control group, with 38 primary school students in each group. The experimental group included Year 3 to Year 5 Chinese dyslexic children who received a formal diagnosis, while the control group consisted of age-, educational year-, and IQ-matched non-dyslexic counterparts. The participants were from five primary schools in Hong Kong. The information about the participants is given in Table 1.

Table 1: Participant Information

Year of study/ Age range (year; month)	Number of children in the dyslexic group	Number of children in the non-dyslexic group
Year 3 / 8;4 – 8;7	11	11
Year 4 / 9;1- 9;9	17	17
Year 5 /10;3-11;5	10	10
Total number of children in each group	38	38

In the selection of the students involved in the study, the IQ of the participants was the control variable. The students involved in this study had to complete a standardized non-verbal IQ test, Raven's Standard Progressive Matrices (Raven 2008), which was used to assess the IQ of all the participants. This test required the participants to identify the missing element that completed a pattern in each test item. There were 64 test items in the test. The students did the test at their own pace, spending 25 to 30 minutes to complete it. Only those students whose IQ scores fell within the average score range were selected to be involved in the study.

The IQ mean scores in each age group of the dyslexic and non-dyslexic students were compared by conducting a t-test.

[1] Department of Linguistics and Translation, City University of Hong Kong, Tat Chee Avenue, Kowloon, Hong Kong, Email: ctcyhc@cityu.edu.hk.

The IQ mean scores of the dyslexic students were not significantly different from those of the non-dyslexic students in each age group, which ensured that the differing performance of dyslexic and non-dyslexic students which might appear in this study is not due to any differing IQ of the two groups of students. The descriptive and t-test results of the IQ scores of the two groups of students selected for this study are given in Table 2.

Age range (year; month)/ Year of study	Dyslexics / non-dyslexics	Mean scores of Raven's SPM	S. D.	T-test result of the comparison of the IQ scores of dyslexics and non-dyslexics
8;4 – 8;7/ Year 3	Dyslexics Non-dyslexics	34.56 35.60	7.002 7.892	p>0.05 (No significant difference)
9;1- 9;9/ Year 4	Dyslexics Non-dyslexics	36.72 36.43	8.259 8.382	p>0.05 (No significant difference)
10;3-11;5/ Year 5	Dyslexics Non-dyslexics	41.75 42.89	6.751 7.271	p>0.05 (No significant difference)

Test Instruments

A verbal working memory test was designed for this study. This test was adapted from a memory span task in Chinese constructed by Leong, Tse, Loh and Lau (2008), which was originally developed from the reading span test designed by Daneman and Carpenter (1980) which proposed thatboth storage and processing components are required in working memory tasks.There were four subtests in the whole test, with two subtests (i.e. subtests 1 and 2) requiring students to listen to sentences, and two subtests (i.e. subtests 3 and 4) asking students to read sentences. In subtest 1, the students were required to listen to a group of pre-recorded unrelated sentences, then verbally recall the last word of each sentence, and finally answer a comprehension question related to a sentence in the group. There were eight groups of sentences in this subtest, with each two of them consisting of two, three, four, and five sentences. In subtest 2, there were 5 sentences. The students listened to each sentence in a group and then repeated it word by word. At the end of the repetition of the final sentence, the students were required to answer two comprehension questions related to two sentences. In subtest 3, the students were required to read a group of pre-recorded unrelated sentences shown on the screen one by one, then recall the last word of each sentence, and finally answer a comprehension question related to a sentence in the group. There were eight groups of sentences in this subtest, with each two of them consisting of two, three, four, and five sentences. In subtest 4, there were five sentences. The students read each sentence, and then repeated it word by word. At the end of the repetition of the final sentence, the students were required to answer two comprehension questions related to two sentences. All students did the four subtests in the same order, from subtests 1, 2 and then 3 and 4.

The test was self-paced and conducted with the students with the use of computers. The students were required to recall words or sentences and answer comprehension questions at the end of each group of sentences or at each individual sentence or question. The recalls of words and sentences measured the students' storage capacity, and the comprehension questions were related to sentence processing and comprehension. The overall results of the test could reflect the verbal working memory of the students.

An example of a word recall and sentence comprehension test item (with English translation added) is given below. In this test item, students listened to a group of three sentences, and then recalled the last word (as underlined). The order of the words recalled could be flexible.

Sentence 1:小美的妹妹有一張圓圓的臉孔。

(Little Mei's sister has a round face.)

Sentence 2: 小強的姐姐在家中養了十一隻可愛的松鼠。

(Little Qiang's elder sister keeps twelve lovely squirrels at home.)

Sentence 3: 哥哥在童年時希望長大後當一名出色的獸醫。

(When my elder brother was in his childhood, he wanted to be a famous vet.)

After word recall, the students were required to answer a comprehension question they listened to:

A comprehension question: 小強的姐姐養了多少隻松鼠？

(How many squirrels does Little Qiang's elder sister keep?)

An example of a sentence repetition and comprehension test item is given below. In this test item, the students read each sentence in the group and then repeated the sentence. After reading and repeating all the five sentences in the group, they answered two comprehension questions.

Sentence 1: 家庭主婦清潔衣服。

(Housewives are washing clothes.)

Sentence 2: 幾名鋼琴家正在台上演奏。

(Several pianists are performing on the stage.)

Sentence 3: 寂寞的鸚鵡在鳥籠裏靜靜地站著。

(A lonely parrot is standing quietly inside the cage.)

Sentence 4:一大群學生放學後**跑到運動場練習跳遠。**

(A big crowd of students ran to the playground to practice long jump after school.)

Sentence 5: 建築師在去年設計了一座三十層高的商業大廈。

(Architects designed a thirty-floor tall commercial building last year.)

Comprehension questions:

(1) 甚麼鳥在鳥籠裡站著？(What bird is standing in the cage?)

(2) 建築師設計了甚麼？(What was designed by the architects?)

Administrative procedures

At the beginning of each sub-test, two trials were used to make sure that the students understood how to complete the test with the instructions provided. There was a break of at least 5 minutes between the subtests. All the subtests were self-paced. The time, on average, students spent on doing the whole test was one hour and fifteen minutes.

Methods of scoring and data analysis

One was scored for each accurate recall of word or sentence2, and for each correct answer for the comprehension question. Zero was scored for each inaccurate recall of word or

sentence, and for each incorrect answer for comprehension questions. The descriptive results of the mean scores of the four subtests were calculated. An independent t-test was conducted to investigate whether the results of the dyslexic students were significantly different from those of their non-dyslexic counterparts in each subtest.

III. RESULTS

Word recall and sentence comprehension

As described above, subtests 1 and 3 required students to listen to and read a group of sentences respectively, and then orally recall the last word of each sentence and answer a comprehension question. The results of these two subtests are shown in Fig 1. It was found that both groups of students did better in word recall than in question answering; and better in reading than in listening. As indicated in the independent t-test results, dyslexic students performed significantly more poorly than non-dyslexic students in these two subtests (sentence listening and word recall: $t=-3.35$, $df=74$, $p<0.01$; sentence reading and word recall $t= -4.45$, $df=74$, $p<0.01$; answering a comprehension question after listening $t= -4.65$, $df=74$, $p<0.01$; and answering a comprehension question after reading: $t=-3.96$, $df=74$, $p<0.01$).

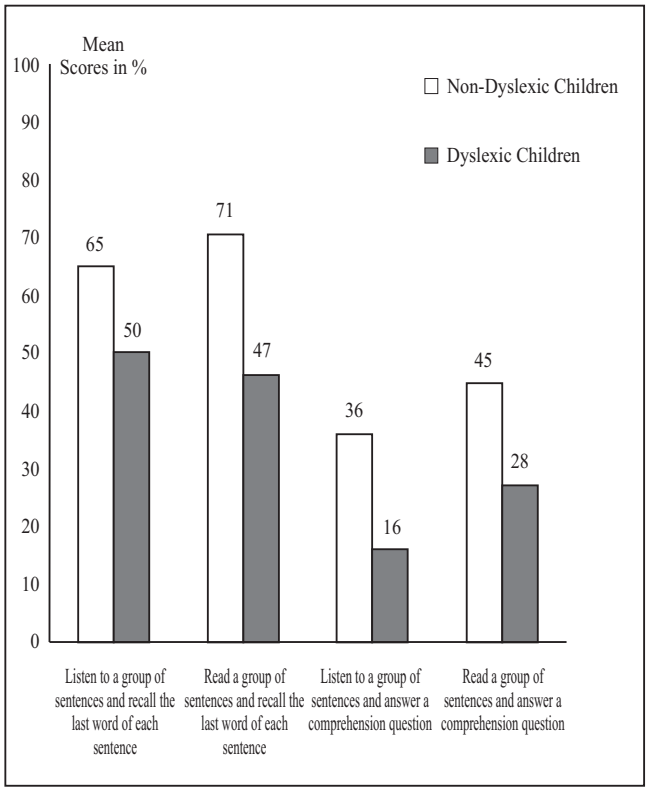

Fig. 1: Results of the verbal working memory subtests requiring word recall and sentence comprehension

Sentence recall and comprehension

In subtests 2 and 4, the students were asked to listen to and read sentences respectively. The two sub-tests required sentence repetition and answering comprehension questions. As shown in Fig. 2, both two groups of students did worse in listening than in reading, and worse in recalling sentences than in answering comprehension questions.

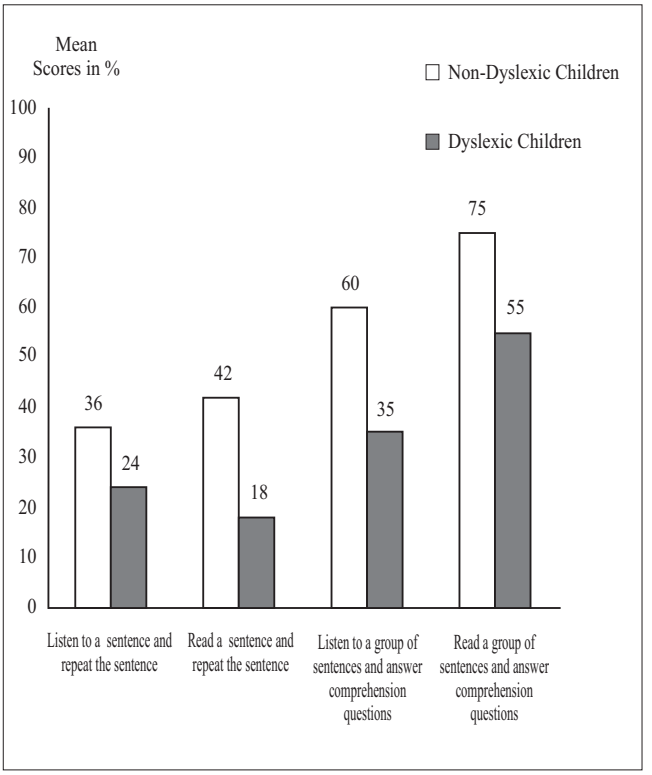

Fig. 2: Results of the verbal working memory subtests requiring sentence recall and comprehension

Similarly, the independent t-test results indicate that dyslexic students performed significantly worse than non-dyslexic students in these two sub-tests (sentence listening and repetition: $t=-4.26$, $df=74$, $p<0.01$; sentence reading and repetition: $t= -3.84$, $df=74$, $p<0.01$; answering comprehension questions after listening: $t= -2.68$, $df=74$, $p<0.01$; and answering comprehension questions after reading: $t=-2.16$, $df=74$, $p<0.05$).

IV. DISCUSSION

As presented above, the dyslexic children performed significantly worse than non-dyslexic children in all the verbal working memory subtests. On the one hand, compared with non-dyslexic children, Chinese dyslexic children were significantly weaker at storing verbal information when listening to or reading sentences, which were shown in their poorer performance in word recalls and sentence recalls. In the word recall subtests, the children paid attention to the ending word of each sentence and stored them in the working memory until they had listened to or read all the sentences, and recalled all the ending words orally. An increase of the number of sentences requires a higher working memory capacity to store the ending words to be recalled. Besides, sentence recalls are much more cognitively demanding than word recalls. For sentence recalls, the children needed to remember all the words in each sentence, and if children did not understand the meaning of the sentence, they found it difficult to recall the sentence.

On the other hand, dyslexic children were not comparable with non-dyslexic children in processing verbal information when listening to or reading sentences, which was revealed in

their poorer results on answering comprehension questions. When dyslexic children were listening to or reading sentences in a group, they had to process each sentence to understand its meaning and remember the information given, so as to prepare for answering (a) comprehension question(s)after recalling all the ending words or sentences. The disability of comprehending the meaning of each sentence in a group and/or insufficient memory capacity to keep all the information included in the sentences led to poor performance in answering comprehension questions.

Moreover, dyslexic children did worse than non-dyslexic children not only in the subtests requiring sentence reading, but also in the subtests involving sentence listening. This result demonstrates that dyslexic children's poor performance in word recall, sentence recall, and answering comprehension questions is not related to language modality, but is associated with underlying weak verbal working memory involving information storage capacity and language processing ability.

The present research focusing on children with Chinese developmental dyslexia replicates the findings of previous research concerning English developmental dyslexia as mentioned earlier. Both sets of research reveal a connection between verbal working memory and developmental dyslexia. As we know, the writing system of Chinese is logographic and English is alphabetical. The present study provides evidence to show that the association of verbal working memory and developmental dyslexia is not language specific, but is language universal.

V. CONCLUSION

Based on previous research on the relationship of working memory and English developmental dyslexia, the present study investigated the verbal working memory of Chinese dyslexic children. The results indicate that verbal working memory deficits associate with Chinese developmental dyslexia. The findings of the present research have implications for teaching Chinese to dyslexics.

It is proposed that verbal and non-verbal working memory practices could be introduced to enhance dyslexic children's information storage capacity and verbal processing ability. Future research on the effect of the training of verbal working memory on the reading comprehension of dyslexics is desirable.

Footnotes

[1]Cowan (2008) summarizes the definitions of working memory and tries to make a distinction between working memory and short-term memory. According to Cowan, working memory is defined as: (1) short-term memory applied to cognitive tasks; (2) a multi-component system that holds and manipulates information in short-term memory; and (3) the use of attention to manage short-term memory. Compared with short term memory, working memory seems to be more attention demanding and to correlate well with cognitive aptitudes.

[2]Different scoring methods were used for the recalls in previous studies. Friedman & Miyake (2005) demonstrated that the scoring method of counting total recalled words is reliable and correlated with reading comprehension measures.

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