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Effect of Different Memorization Methods of Chinese Characters among Beginner-level Middle School Students in Australia

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Abstract: *We conducted a one-year longitudinal study of middle school beginner Chinese learners in Australia about how they memorize Chinese characters to figure out the effect of different memorization methods. Based on the test, questionnaire and interview, we found: The effect of memorization method is relatively stable in different memory stages. Form-pronuciation-meaning associative mnemonics, Stroke mnemonics and Characters-associative mnemonics have the better effect of all the memorizing stages. Different memorization methods cause different type of errors. The method of repetitive practice mainly cause stroke missing while Characters-associative mnemonics mainly lead to the confusion in strokes between characters. The main reason for the poor performance of Components-associative mnemonics is the stroke errors in the inner component. Therefore, the teaching suggestion is proposed: Teachers should guide students to make good use of Components-associative mnemonics, pay attention to the effectiveness of Stroke mnemonics and the diversity of memorization methods.*

Keywords: *Chinese character mnemonics; memory effects; error analysis; beginner-level Chinese learners; middle school students in Australia*

1. Introduction

As the international promotion of Chinese culture advances, an increasing number of overseas primary and middle schools are offering Chinese language courses, with more and more students in the schools learning Chinese language and Chinese characters in their mother tongue environment. Chinese characters have always been the focus and challenge of Chinese language learning for non-Chinese learners, and the learning and memorization methods of Chinese characters reflect their exploration on how to solve the difficulties in learning Chinese characters. Throughout the existing research results, many scholars have discussed the usage patterns of Chinese character learning strategies of learners from different native language backgrounds and learning environments with respect to learning process (e.g., Ma Mingyan, 2007; Liu Yanmei, 2009), and depicted and summarized the common writing errors of foreign students from the perspective of learning outcomes (e.g., Shi Zhengyu, 2000; Zhang Jun 2015). In general, however, there have been many studies on adult international students and relatively few on students from overseas mother-tongue environments, and there lacks sufficient longitudinal studies combining Chinese character learning strategies with memory effects and Chinese character writing errors. Therefore, in this study, questionnaires and interviews were both used to carry out a one-year follow-up study on the memory of 18 Australian middle school students who learned Chinese from scratch. 1,836 entries of reflective materials were collected on how the learners memorized the Chinese characters, which were combined with the results of multiple dictation tests. Discussions were oriented at following questions: (1) By using dictation test accuracy as an indicator, how effective are different mnemonics at different stages of memory? (2) What are the characteristics of writing errors that arise when learners use different mnemonics? (3) What are the implications of the different effects of different mnemonics for teaching Chinese characters?. By combining the learning process and learning outcome of Chinese characters, and integrating "learning" and "teaching", we hope this study can offer valuable suggestions and references for the study, teaching and research of Chinese characters for Chinese beginners in their native environment.

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2. Dictation Accuracy of Different Memorization Methods

Based on the analysis of learners' reflections in the Chinese character memory questionnaire, we categorized the Chinese character mnemonics into the Repetitive practice method, Stroke mnemonics, Symbol mnemonics, Components-associative mnemonics, Characters-associative mnemonics, and Form-sound-meaning associative mnemonics. Among that, the Form-sound-meaning associative mnemonics refers to the method of memorizing Chinese characters by associating the grapheme of a character with its sound or meaning (Feng Liping & Guo Jia, 2018).

To provide a more comprehensive and accurate portrayal of the memory effects of different mnemonics, in this study, learners' memory of Chinese characters was divided into four different stages for dictation tests.

(1) **Immediate memory:** A learner's memory of the characters after the class on new characters has ended.

(2) **Short-term memory:** A learner's memory for a Chinese character after a week of study; "short-term memory" is used here to distinguish it from the psychological term "short-time memory".

(3) **Long-term memory:** A learner's memory of a Chinese character two to three weeks after learning it.

(4) **Consolidation of memory:** A learner's memory of a Chinese Character after reviewing it he or she had previously learned under the pressure of examinations, i.e., consolidation of his or her memory of the Chinese Character after learning.

To investigate the memory effect of each mnemonic method at each stage, we counted all the students who used one of them and all the Chinese characters they memorized. On top of that, we compared the test results of the specific memory stage corresponding to a method, counted the scores of the memorized characters in the test of the students who used the method, and averaged the scores to get the average correct rate of the learners who used the method to memorize the Chinese characters at the specific memory stage. In doing so, the learners' memory effect was represented with respect to memorizing Chinese characters at the stage using the method. See Table 1 for examples.

Table 1: Statistical example of the average correct rate of memorizing Chinese characters in the immediate memory stage using the Characters-associative mnemonics

Chinese character	**Characters-associative mnemonics- immediate memory stage**										
火	0	0									
灭	1	1	1	1	1	1	0				
……	……	……									
犬	1	1	1	1	1	1	1	1	1	1	1
Average correct rate	75.34%										

Note: In the above Table, 1 indicates that learners who used the Characters-associative mnemonics correctly wrote the new character in the dictation at immediate memory stage; 0 indicates the opposite; each row of the table records the correctness of the dictation of the new character by learners who used this method.

2.1. Comparison of dictation accuracy between different mnemonics at different memory stages

In order to comprehensively investigate the memory effect of each mnemonics at different memory stages, we selected the dictation accuracy data of different mnemonics at different memory stages and performed the chi-square test using SPSS22.0. The results of the statistical test are shown in Table 2.

Table 2: Chi-square test of the effect of mnemonics at each memory stage

Mnemonics	Immediate memory		Short-term memory		Long-term memory		Consolidation of memory	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
Repetitive practice method	68	43	78	33	67	46	79	38
Stroke mnemonics	80	18	64	9	80	20	65	11
Symbol mnemonics	58	22	62	23	63	19	63	22
Characters-associative mnemonics	55	18	46	7	64	17	53	7
Form-pronunciation-meaning associative mnemonics	143	29	153	18	151	29	158	20
Components-associative mnemonics	107	42	103	47	109	53	106	47
χ^2	20.518		32.804		29.143		33.590	
P-value	0.001**		<0.001***		<0.001***		<0.001***	

Note: Each mnemonics in the table is followed by the number of "correct" or "incorrect" ones in dictation tests at each stage. P-values with statistically significant differences are marked with *.

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The statistical test results show that the $\chi 2$ values were 20.518, 32.804, 29.143 and 33.590 in the immediate memory, short-term memory, long-term memory, and memory consolidation stages, respectively, and the p-values were all less than 0.05, signifying that the differences in the accuracy of different mnemonics in these stages were statistically significant. The above results provide a basis for us to discuss the differences in the effects of different mnemonics on different memory stages. To compare the overall pattern of memory effect of different mnemonics at each memory stage, we present the average correct rate of different mnemonics at different memory stages in Table 3 and Figure 1.

Table 3: Average correct rate of different mnemonics at different memory stages (%)

Mnemonics \ Memory stage	Average correct rate				
	Immediate memory	Short-term memory	Long-term memory	Consolidation of memory	Average correct rate for different mnemonics
Repetitive practice method	61.26	70.27	59.29	67.52	64.60
Stroke mnemonics	81.63	87.67	80.00	85.53	83.29
Symbol mnemonics	72.50	72.94	76.83	74.12	74.10
Characters-associative mnemonics	75.34	86.79	79.01	88.33	81.65
Form-pronunciation-meaning associative mnemonics	83.14	89.47	83.89	88.76	86.31
Components-associative mnemonics	71.81	68.67	67.28	69.28	69.29
Correct rates at different memory stages	74.82	78.69	74.37	78.33	-

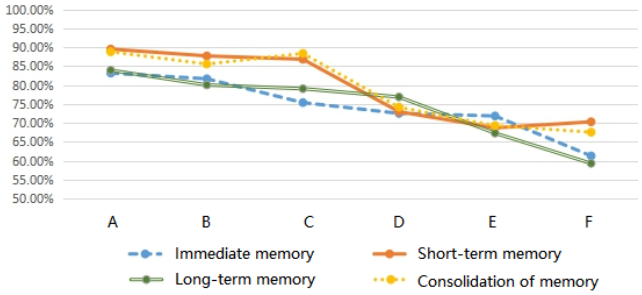

Figure 1: Average correct rates of different mnemonics at different stages of memory

A. Form-pronunciation-meaning associative mnemonics; B. Stroke mnemonics; C. Characters-associative mnemonics; D. Symbol mnemonics; E. Components-associative mnemonics; F. Repetitive practice method

With the above chart, we can see the following rules:

(1) The effect of short-term memory and consolidation of memory is better, while the effect of long-term memory is the worst. According to the Ebbinghaus forgetting curve, the amount of forgetting is positively correlated with the duration, the longer the duration, the greater the amount of forgetting, and the forgetting rate after one week reaches 74.6% (Feng Zhongliang, Wu Xinchun, Yao Meilin, Wang Jianmin, 2010), so the short-term memory stage where the mnemonics contributes the most has the best memory effect, while the long-term memory stage, after one week to two weeks of forgetting, has the poorest memory effect. Since the consolidation memory stage of the test was directly related to learners' performance, learners paid more attention to this test and would concentrate on reviewing and consolidating before the test, so the consolidation memory is also more effective. This proves the role of review and consolidation in the learning process, even after forgetting occurs, the concentrated consolidation review can help learners to recover their knowledge to the level when the effect is better.

(2) The trend of performance distribution of different mnemonics at the four stages is approximately the same, which indicates that the role and effect of mnemonics are relatively stable.

(3) The effects of Form-pronunciation-meaning associative mnemonics, Stroke mnemonics, and Characters-associative mnemonics are relatively favorable at all stages. Specifically, Form-pronunciation-meaning mnemonics and Stroke mnemonics are both consistent with the characteristics of Chinese characters; the former reflects the rationality of the meaning constitution of Chinese characters, while the latter reflects the systematicality of the formation of Chinese characters, making they are more advantageous in memorizing Chinese characters. The Characters-associative mnemonics is very much in line with the learning characteristics of learners with Chinese as their second languages. Numerous studies have found that the association between Chinese characters with similar forms and similar sounds is one of the main causes of Chinese character errors (e.g., Zhu Zhiping and Harina, 1999; Chen Qin, Liu Jing, and Zhu Li, 2009). The Chinese-character-associative mnemonics can help learners to consciously distinguish between the Chinese characters they have learned and the characters with similar forms and sounds, and this awareness and ability to identify confusion will also help in the long-term learning of

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Chinese characters.

(4) Stroke mnemonics is significantly more effective than Symbol mnemonics and repetitive practice at all stages of memory. Compared with the symbols that learners associate by themselves, strokes are part of the Chinese character system, the writing element of Chinese characters (Wang Ning, 2015), which are more scientific and systematic, and therefore can help learners achieve better memory effects. On the other hand, there are two main reasons for the big difference between Stroke mnemonics and Repetitive practice method: on the one hand, repetitive practice is only mechanical repetition, and learners' processing of Chinese characters and depth of memory are relatively shallow, and studies on memory by Ebbinghaus, Reed, and Taylor, et al. have all found that mechanically learned materials will be forgotten in large quantities and rapidly without timely review (Feng Zhongliang, Wu Xinchun, Yao Meilin. (Jianmin Wang, 2010); on the other hand, learners mainly use the Stroke mnemonics to memorize relatively simple single characters (pictographs and self-explanatory characters), while the use of repetitive practice is not affected by the type of characters, i.e., many learners still use this method when memorizing compound characters, and the complexity of the characters themselves also affects the memory effect of this method.

(5) The Components-associative mnemonics is not satisfactory at all stages of memory. On the one hand, this is because most of the Chinese characters memorized by this method are compound characters, and many of the errors of the components of single characters are migrated to the compound characters, resulting in "consequential error" (see 2.2); on the other hand, many factors affect the effectiveness of this method, such as the shape, position, and structure of the components.

2.2. Comparison of dictation accuracy between different mnemonics in the short-term memory stage

The dictation test at the short-term memory stage is just after the learners have completed the questionnaire on the mnemonics, so the average correct rate of the stage test can best reflect the memory effect of the mnemonics used by the learners. The average correct rates of Chinese characters memorized by different mnemonics at the short-term memory stage are shown in Figure 2.

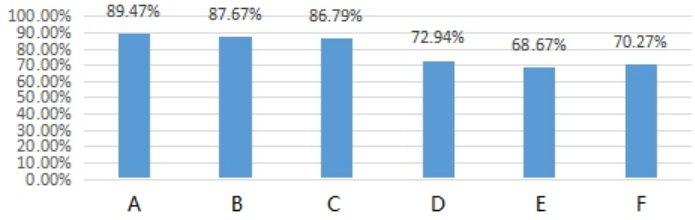

Figure 2: Average correct rates of Chinese dictation in the short-term memory stage for different mnemonics

A. Form-pronunciation-meaning associative mnemonics; B. Stroke mnemonics; C. Characters-associative mnemonics; D. Symbol mnemonics; E. Components-associative mnemonics; F. Repetitive practice method

According to Figure 2, the average correct rate of Chinese characters memorized by different mnemonics at the short-term memory stage can be ranked as follows: Form-pronunciation-meaning associative mnemonics > Stroke mnemonics > Characters-associative mnemonics > Symbol mnemonics > Repetitive practice method > Components-associative mnemonics. Based on this, we can draw the following conclusions.

(1) Form-pronunciation-meaning mnemonics is most effective.

Jiang Xin and Zhao Guo (2001) mentioned the method of "making up some stories about the overall shape of the Chinese characters", and stated that "beginners often try to give a certain meaning to the characters according to their overall shape, that is, to establish some kind of connection with the existing patterns in the brain. This connection is meaningful for them, and can help them memorize Chinese characters. However, this may also be one of the reasons why students often have 'missing parts' and 'miss this and that' when writing Chinese characters", says an evaluation. Zhao Guo and Jiang Xin (2002) mentioned two such grapheme strategies: "S8 I memorize the grapheme of Chinese characters as a whole" and "S11 I imagine the grapheme of Chinese characters in my mind", arguing that they "also lead to the blurring of graphemes and confusion with characters with similar forms". Zhang Yuan (2011) also argues that "learners who prefer to use the memorizing strategy of "constituting patterns according the forms of Chinese characters" have poor handwriting performance and always appear to be 'missing parts' or 'adding unnecessary parts'". These findings are not consistent with the best memorizing effect of the Form-pronunciation-meaning-associative mnemonics in this study; the reason for this may lie in the

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specificity of this method. It is true that learners start from the overall shape of a Chinese character and imagine the grapheme of the character in their minds during the memorization process, using the overall grapheme to make up stories or construct images, but the meaning that learners give to the overall grapheme is associated with the sound or meaning of the character, rather than just a random pattern that learners build up based on their personal experience. Therefore, the Form-pronunciation-meaning-associative mnemonics is actually a special type of mnemonics denied by the predecessors; it can effectively communicate the form, sound, and sense of Chinese characters to each other and the learner will automatically strengthen the association between the three dimensions, so as to achieve a sound memory effect.

Form-pronunciation-meaning associative mnemonics, Stroke mnemonics and character-associative mnemonics are significantly better than Symbol mnemonics, Repetitive practice method and Components-associative mnemonics if terms of memory effect. The effect of Components-associative memory is the worst.

Zhou Jian and Wei Wanchuan (2004) stated that "International students all agreed that the grapheme strategy (including repeated writing, stroke memory, and grapheme association) was the most effective strategy at the beginning of learning Chinese characters (within 200 characters)." This is in line with the findings of this study, where "stroke memory" and "grapheme association" (in this study, this includes both Form-pronunciation-meaning mnemonics and Characters-associative mnemonics are indeed most effective. However, with respect to "repeated writing", the findings of this study support conclusions of Zhao Guo and Jiang Xin (2002) regarding the grapheme strategy of mechanical exercise: "S25 I practice single characters" and S28 I write new Chinese characters over and over again as I learn them". These two strategies are both significantly negatively correlated with Chinese character meaning recognition and performance in Chinese character writing, suggesting that they "may not be an effective strategy for promoting Chinese character learning". In the context of this study, the Symbol mnemonics and Repetitive practice method of mechanical memorization may not be effective in facilitating the memorization of Chinese characters.

Through a self-administered questionnaire, Ke (1998) found that most beginning-level Chinese learners in the United States believe that learning Chinese character components is more effective than learning Chinese character strokes. Jian Zhou and Wanchuan Yu (2004) also suggest that "the components strategy is superior to the strokes strategy and the grapheme-associative strategy". Zhang Yuan (2011) found that "learners who preferred the 'components analysis' memory strategy had better Chinese character recognition and writing scores". However, the analysis in this study is inconsistent with the results of previous studies: compared with other mnemonics, users of grapheme-associative mnemonics did not achieve a rosy effect. We have asked the learners about their views on the "Three Sinogram Verses Using Radicals" (2006) teaching materials and the component mnemonics used. Almost all of the learners said that it was easy to memorize Chinese characters through components and that the textbook was helpful in memorizing Chinese characters because when the first two characters in a set of characters were add up, they became the third character. I thought I memorized the third Chinese character, but sometimes it wasn't a simple sum of the first two, and it was easy to make mistakes in the strokes." The above interviews may partly explain the discrepancy between the real-life effects of Components-associative mnemonics and the general impression of its effects, and the reasons for this discrepancy - mainly due to "consequential error" - will be investigated in the following section through a error analysis. However, the data in this paper also suggest that the Components-associative mnemonics may be useful for memorizing Chinese characters, but it may not be as effective as we think, and learners may overemphasize the combination of components and ignore the details of the strokes.

3. Different mnemonics and grapheme error

3.1. Definition of grapheme error

Based on the definitions of Chinese character errors by Shi Zhengyu (2000), Xiao Xiqiang (2002), Guo Shenglin (2008), and Chen Deyin et al. (2018), the types of errors involved into three main categories: stroke errors, component errors, and wrongly written character errors, taking into account the specific errors of the subjects of this study.

Among them, the **stroke errors** include:

(1) inter-stroke relation error, i.e., learners confuse strokes with strokes that are separated, connected or intersecting, e.g., in the character for "巾", the relationship between the long vertical stroke and

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horizontal turning hook should be intersecting, but learners treat them as connected.

(2) error in the number of strokes, i.e., learners mistakenly add or reduce strokes when writing Chinese characters, causing the corresponding strokes to be mistakenly added or missing, e.g., when writing the character for "白", the learner adds a horizontal stroke in the middle and writes "自". However, during the interview, the author found that the learner did not know the Chinese character "自", so we attributed this kind of error to an error in the addition of strokes; when the learner was writing the character for "毛", the first stroke was missing, resulting in a loss of strokes.

(3) Stroke shape error, i.e. the learner writes the wrong shape of a stroke, e.g. the learner writes the character for '见' with a vertical curved hook written as the right-falling stroke.

(4) Stroke misplacement, i.e. the learner writes a stroke in an incorrect position and the position where it should be written is left vacant, e.g. the learner writes the point of the character for '龙' to the left of the vertical left-falling stroke. Stroke misplacement also includes stroke mirrored misplacement, i.e. the position of the strokes is subject to mirrored inversion, e.g. the learner writes the top and bottom of the two lines of the character for '二' in a way that is short in the top and long in the bottom.

Component error include:

(1) component alternation or replacement, i.e., when the learner writes a composite character, the correct component is replaced by an incorrect one, thus making the composite character into a non-character, e.g., when the learner writes the character for "泉", he writes "白" as "王".

(2) Component misplacement, including structural displacement and mirrored displacement of components. Component structural displacement means that learners confuse the upper and lower structure of a Chinese character with the left and right structure, e.g., learners write the character for "聋" as "龙耳". (2) Mirrored displacement of components, i.e., the positions of components are subject to mirrored inversion, e.g., learners write "明" as "月日".

(3) Component missing, i.e. a component is missing when the learner writes a compound character, but the corresponding position is left vacant. e.g. when the learner writes the character for '泉', the character for '水' is missing and only the character for '白' is left at the top of the writing position.

Errors of wrongly written characters include:

(1) Wrongly written characters in the same group: in the "Three Sinogram Verses Using Radicals", six characters are a group. If learners confuse two of the six characters in a lesson, they will be classified as wrongly written characters in the same group. For example, in the sixth week of the Chinese character lesson, new characters are those for "爪木采舟皿盘", but learners write "木" as "皿".

(2) Wrongly written characters due to similar forms, i.e., learners confuse characters with similar forms, e.g., learners write "穴" as "六".

(3) Wrongly written characters due to similar sounds, i.e., learners confuse characters with similar sounds, e.g., learners write "二" as "儿". Due to the rhythmical nature of the "Three Sinogram Verses Using Radicals", characters with similar sounds summarized by this paper often belong to wrongly written characters in the same group. The author recorded these characters as both wrongly written characters in the same group and wrongly written characters due to similar sounds, but recorded only once when classified as the broad category of "error of wrongly written characters".

3.2. Analysis of grapheme error by different mnemonics

Table 4: Table of chi-square tests for types of error vs. mnemonics

Mnemonics / Type of error	Repetitive practice method		Components -associative mnemonics		Characters -associative mnemonics		Symbol mnemonics		Stroke mnemonics		Form-pronunciation-meaning method		Chi -square	P value
	×	√	×	√	×	√	×	√	×	√	×	√		
Stroke error	20	111	27	155	12	73	12	83	9	99	8	190	16.835	0.005*
Error of wrongly written characters	13	118	3	179	3	82	5	90	5	103	7	191	13.143	0.022*
Component error	9	122	17	165	2	83	1	94	1	107	3	195	24.133	0.000*
Total errors	42	89	47	135	17	68	18	77	15	93	18	180		
Number of times of each method used	131		182		85		95		108		198			

Note: The data in the table represent the number of "×: error" and "√: correct" ones produced by learners for a

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given mnemonics. Statistically significant differences in p-values are marked with *.

Based on the learners' dictation, we collected a total of 157 typical errors. To explore the distribution of different mnemonics in the broad category of error, we tested the following data by type of error using SPSS 22.0 software with cross chi-square analysis (see Table 4).

The statistical test results show that the p-values of the cross-chi-square test for stroke error, error of wrongly written characters, and component error are all less than 0.05, indicating that there are significant differences in the different mnemonics in causing grapheme error. This provides a basis for us to compare the distribution of different mnemonics in different types of error. To facilitate comparative analysis, we prepared Tables 5 and 6 according to the correspondence between different types of error and mnemonics.

Table 5: Distribution of broad categories of error for different mnemonics

Mnemonics / Type of error	Repetitive practice method		Components -associative method		Characters -associative mnemonics		Symbol mnemonics		Stroke mnemonics		Form-pronunciation -meaning associative method	
	Number	Error rate	Number	Error rate	Number	Error rate	Number	Error rate	Number	Error rate	Number	Error rate
Stroke error	20	15.27%	27	14.84%	12	14.12%	12	12.63%	9	8.33%	8	4.04%
Error of wrongly written characters	13	9.92%	3	1.65%	3	3.53%	5	5.26%	5	4.63%	7	3.54%
Component error	9	6.87%	17	9.34%	2	2.35%	1	1.05%	1	0.93%	3	1.52%
Total errors	42	32.06%	47	25.82%	17	20.00%	18	18.95%	15	13.89%	18	9.09%
Number of times of each method used	131		182		85		95		108		198	

Note: "Number" is the number of error produced by learners using the mnemonics; "Error rate" is the quotient of the number of errors of a specific mnemonics divided by the total number of times the method is used, which stands for the probability of a certain type of error when the learner uses this mnemonics, and is used to compare the effects of different mnemonics.

Table 6: Distribution of specific types of error in different mnemonics

Type of error / Mnemonics		Components -associative method	Repetitive practice method	Form-pronunciation-meaning associative method	Symbol mnemonics	Characters -associative mnemonics	Stroke mnemonics	Total
Stroke error	inter-stroke relation error	13	3	3	4	8	2	33
	Stroke count error	9	9	3	5	2	4	32
	(Strokes missing)	7	7	3	4	1	3	25
	(Strokes added by mistake)	2	2	0	1	1	1	7
	Stroke shape error	3	3	1	2	3	0	12
	Stroke misplacement	2	5	1	1	0	3	12
	(Strokes mirrored displacement)	2	4	1	1	0	2	10
	stroke direction error	0	0	1	0	0	0	1
error of wrongly written characters	Wrongly written characters in the same group	1	11	4	3	2	5	26
	Wrongly written characters due to similar forms	0	2	3	2	3	4	14
	Wrongly written characters due to similar sounds	2	5	1	1	0	1	10
Components error	Component alternation or replacement	10	6	2	1	0	0	19
	Component misplacement	5	1	0	0	2	1	9
	(component structure displacement)	2	0	0	0	0	0	2
	(Component mirrored displacement)	3	1	0	0	2	1	7
	Component missing	2	2	1	0	0	0	5

First, we will examine the overall picture of error and the distribution of different mnemonics across specific types of error.

In general, stroke error is the most common type, accounting for 56.05% of all errors. Among which, the inter-stroke relation error is most common, accounting for 21.02% of all errors and 37.5 % of stroke

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error, followed by stroke number error, accounting for 20.38% of all errors and 36.36% of stroke error, with more strokes missing than strokes mistakenly added. By comparing the proportion of stroke error, we found that Repetitive practice method > Components-associative mnemonics > Characters-associative mnemonics > Symbol mnemonics > strokes mnemonics > Form-pronunciation-meaning-associative mnemonics.

There were slightly more errors of wrongly written characters than component errors. As the "Three Sinogram Verses Using Radicals" (2006) aims to establish linkages between characters in a group to facilitate students' memorization, the confusion of characters in a group is the one among its kind hard to avoid in this teaching mode. Among errors of wrongly written characters, Repetitive practice method > Symbol mnemonics > Stroke mnemonics > Form-pronunciation-meaning-associative mnemonics > Characters-associative mnemonics > Components-associative method.

The most common component alternation or replacement error in components errors were 12.03% of all errors and 57.58% of the component errors, and the most common component displacement error was component mirrored displacement. Among component errors, Components-associative method > Repetitive practice method > Characters-associative mnemonics > Form-pronunciation-meaning-associative mnemonics > Symbol mnemonics > Stroke mnemonics.

In the next section, we will examine the characteristics of the errors that learners make when they use specific mnemonics to memorize Chinese characters.

The most common errors that learners make when memorizing Chinese characters through **repetitive practice** were stroke error and error of wrongly written characters, especially the strokes missing error in the error of the number of strokes. This indicates that the Repetitive practice method may not be suitable for memorizing Chinese characters with too many strokes, and learners may inadvertently miss strokes during repetitive practice. However, learners who used the Repetitive practice method had fewer inter-stroke relation errors, which means that through repetitive practice, learners can pay better attention to the relationship between strokes and achieve more accurate writing results. However, the number of errors of wrongly written characters, especially those in the same group, was also far greater than other methods. This shows that the Repetitive practice method does have some effect on the consolidation of character grapheme, but the link between form, sound and sense of the characters established by this method is weaker, and therefore there are more confused wrongly written character or component alternation or replacement errors.

Table 7: Components-associative mnemonics - example of "consequential error" in stroke errors

Serial No.	mnemonics	Chinese character	Type of error	error description
1	Form-pronunciation-meaning - associative mnemonics	水	Stroke shape error	Vertical hook was written as vertical
	Components-associative mnemonics	泉		
2	Repetitive practice method	艮	Stroke shape error	Vertical rising stroke was written as a vertical stroke
	Components-associative mnemonics	眼		
3	Stroke mnemonics	龙	Stroke misplacement	The dot was on the left of the vertical left-falling stroke
	Components-associative mnemonics	聋		
4	Stroke mnemonics	毛	Stroke missing	Left falling stroke was missing
	Components-associative mnemonics	笔		Left falling stroke was missing in "毛"
5	Form-pronunciation-meaning - associative mnemonics	舟	Stroke missing	The first stroke - left falling stroke was missing
	Components-associative mnemonics	盘		
6	Symbol mnemonics	耳	Mistakenly added strokes	An extra horizontal stroke was added in the middle
	Components-associative mnemonics	聋		An extra horizontal stroke was added in the middle of "耳"
7	Characters-associative mnemonics	白	Mistakenly added strokes	An extra horizontal stroke was added in the middle of "白"which therefore became "自"(but the learner did not know the character)
	Components-associative mnemonics	泉		
8	Symbol mnemonics	巾	Inter-stroke relation error	Long vertical stroke met horizontal turning & hook
	Components-associative mnemonics	帘		
9	Repetitive practice method	走	Inter-stroke relation error	The first vertical stroke met the first horizontal stroke
	Components-associative mnemonics	赶		
10	Stroke mnemonics	小	Stroke mirrored displacement	The directions of two dots of "小"
	Components-associative mnemonics	尖		

Stroke errors are the most common among learners who use **Components-associative mnemonics**

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to memorize Chinese characters, especially inter-stroke relation error and number of stroke error. On the one hand, this may be due to the fact that learners use components as the basic unit of memorization and focus on the composite relations between components, lacking attention to details such as the form, position, and inter-stroke relations of strokes. On the other hand, it can also be attributed to the characteristics of the Chinese characters that learners remember using the Components-associative mnemonics. The vast majority of Chinese characters involved in this method are component characters, i.e., composed of two single characters as components. So, if a single character has stroke writing error (e.g., the single character error in the previous line of each serial number of Table 7), the component character with that character as a component will often have corresponding stroke writing error as well (e.g., the next line in each serial number contains a compound character error with the single character as a component). To investigate this phenomenon in more detail, the author named this type of error as "consequential error", summed up all the errors of each learner, and compared the single character and the compound character with the single character as its component. "As many as 24 or 88.89% were found to be "consequential error" in stroke errors, and these errors were clearly influenced more by the way they were memorized, as shown in Table 7.

There are also four "consequential errors" in the component error that learners made when they memorized Chinese characters through Components-associative mnemonics. The existence of "consequential errors" actually indirectly explains the lower-than-expected accuracy in memorizing Chinese characters by the Components-associative mnemonics method we found earlier. In fact, the typical error directly caused by the Components-associative mnemonics is the component-type error that occurs at the level of component combination without the influence of the individual components (e.g., example in Table 8). This process involves the learner consciously memorizing compound characters through Components-associative combinations, but confusion or forgetfulness occurs when memorizing a particular component. This leads to component alternation or replacement and component missing errors; or only approximate graphemes of the components are kept in mind, without remembering the structure or relative position of the components when they are combined, thus leading to component displacement error.

Table 8: Components-associative mnemonics - typical examples of component error

Chinese character	Type of error	error description
眼	Component alternation or replacement	"目" was written as "月"
视	Component alternation or replacement	fell into two components "示" and "见"
尖	Component alternation or replacement	"大" was written as "木"[1]
泉	Component alternation or replacement	"白" was written as "田"
尖	Component missing	"大" was missing
泉	Component missing	"泉" was written as "水"
聋	Component structure displacement	became the left -right structure
帘	Component structure displacement	became the left -right structure
明	Component mirrored displacement	"月" was on the left while "日" was on the wright
好	Component mirrored displacement	"子" was on the left while "女" was on the wright

[1] In isolation, it seems that this error could also be classified as a "error of mistakenly added strokes ". But the author, after examining the overall picture of learner's errors, found that the learner did not add any strokes when he was writing "大", and that the grapheme of "大" was flatter, while the character for "木" in "尖" subject to error was relatively square, which was consistent with the grapheme of "木" written by him when "木" was a single character. Therefore, we classify this example of error as "component alternation or replacement".

The most typical errors that learners made when they chose to memorize Chinese characters were those influenced by the associated Chinese characters, predominated by stroke error (see Table 9 for examples). The interference of associated Chinese characters on new characters was mainly manifested in strokes (stroke shape, inter-stroke relation)

Table 9: Examples of typical errors of Characters-associative mnemonics

Associated Chinese characters	Chinese characters	Type of error	error description
八	见	Stroke shape error	The vertical curved hook was written as the right-falling stroke
木	采	Stroke missing	The dot in the middle was missing
儿	见	Inter-stroke relation error	The last two strokes were written as "儿"
月	舟	Inter-stroke relation error	The horizontal stroke met the vertical left-falling stroke and the horizontal turning&hook
刀	力	Wrongly written character due to similar forms	"力" was written as "刀"

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After examining the errors of learners using **Symbol mnemonics**, we did not find the expected symbolic errors of strokes, and the distribution of errors involved in Symbol mnemonics was almost the same as that in Stroke mnemonics. For some learners, specific symbols were "special strokes" of their own construction, and they were more familiar with these symbols than with strokes, so they will preferentially associate these symbols with Chinese characters in their memory. However, from the scientific point of view of Chinese characters, Stroke mnemonics is still superior to Symbol mnemonics, and we can find that the memory effect of Stroke mnemonics is significantly better than Symbol mnemonics in all stages of memorization through the comparison of dictation results. In addition, although we did not directly find symbolic errors of strokes, the ambiguity of symbols and inconsistency with strokes did lead to learners' inaccurate processing of details such as stroke position, number, and inter-stroke relations, which led to error. See Table 10 for an example of a specific error.

Table 10: Examples of typical errors in Symbol mnemonics

Chinese character	Specific description of Symbol mnemonics	Type of error	Error description
儿	"乚" was written as "L"	Stroke mirrored displacement	The left and right was subject to stroke mirrored displacement
笔	"Zhuzi head" was written as a flying bird in a stick figure	Stroke missing	Two horizontal strokes were missing in the "Zhuzi head"
毛	"T"+旁边的线"T" + the line next to it	Stroke missing	A left-falling stroke was missing in "毛"
耳	A box-shaped matter is cut into three parts	Mistakenly added strokes	An extra horizontal stroke was added in the middle
毛	Reverse "J" + three lines through it.	Inter-stroke relation error	The vertical curved intersected with the left-falling stroke
巾	Sideward E	Inter-stroke relation error	The long vertical stroke met the horizontal turning & hook
笔	Two K+ a flying saucer	Inter-stroke relation error	The vertical curved hook intersected with the left-falling stroke

Learners who used the **Stroke mnemonics** to memorize Chinese characters did not produce stroke shape errors, which indicates that the stroke shapes were well remembered and consolidated in the process of using the mnemonics to memorize Chinese characters. Learners produced fewer stroke errors when using Stroke mnemonics and Form-pronunciation-meaning associative mnemonics, which shows that the mnemonics method is effective in strengthening the foundation of Chinese character writing for beginners.

4. Teaching Suggestions

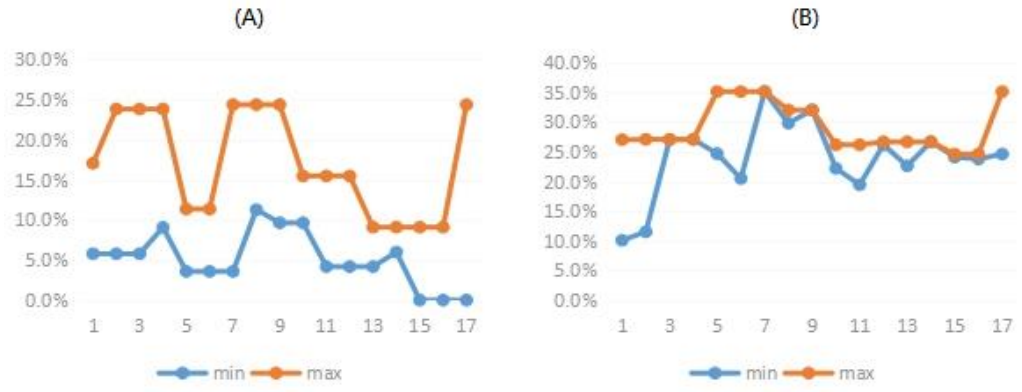

Figure 3: Moving min-max graph of (A)Components-associative mnemonics and (B)Stroke mnemonics

van Geert & van Dijk (2002) developed the technique of moving min-max graphs, which helps to visualize the extent of variation. In this paper, we look at the magnitude of individual differences in learners' use of a particular memory method by plotting moving min-max graphs with a time window of 3 time points. We will focus on the distance between the maximum and minimum lines, i.e. the bandwidth, which reflects the degree of discrete variation in the data, i.e. the degree of individual difference within learners who choose this method.

(1) **Guiding students to make reasonable use of the Components-associative mnemonics:** Components are the structural units of compound Chinese characters and also important functional units, so they should be fully utilized in teaching. However, learners were unable to get a fruitful result after using Components-associative mnemonics to memorize Chinese characters, and one of the major reasons is that the strokes within the components are wrong. Therefore, when using components to teach Chinese

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characters, in addition to emphasizing their function and structure at the component level, we should not neglect the teaching of the forms of the components themselves. It is important to emphasize not only the function, meaning, and structure at the component level to cultivate students' awareness and ability to assemble components, but also to focus on the teaching of the form of the component itself. In this way, learners are guided to pay attention to both the overall shape of the component and the details of the strokes inside the component, and ideally, to combine the Components-associative mnemonics with the Stroke mnemonics to reduce "consequential error. In doing so, the best memory effect can be achieved. By plotting a moving min-max graph of the Components-associative mnemonics (Figure 3) and observing its bandwidth, we found that, overall, individual differences in learners' ability to memorize Chinese characters using the Components-associative mnemonics are small, and thus we speculate that this method may be highly teachable.

(2) **Emphasize the effectiveness of the Stroke mnemonics:** Chinese teachers have always attached great importance to the teaching of strokes when they teaching Chinese characters, and the research of this paper also found that the teaching of strokes is important and effective, and the Stroke mnemonics is also the one with fewer errors and a higher accuracy rate. Therefore, the author believes that teachers should value the importance of strokes in learning Chinese characters to learners, especially those who are learning Chinese characters from scratch. On top of that, the teachers should cultivate students' awareness of accurate stroke recognition and stroke writing, and require them to be able to identify and write correct stroke shapes, inter-stroke relations, and stroke numbers. When learners are found to use symbols as "special strokes", the teacher should explain the systematic relationship between the strokes and the Chinese characters, and guide students to write strokes in a standard way. By plotting the moving min-max graph of the Stroke mnemonics (Figure 4) and observing its bandwidth, we found that the use of the Stroke mnemonics among learners vary greatly, and there may be some learners who realized the importance of strokes but could not stick to them. A learner once complained to the author that "Strokes are effective for memorizing Chinese characters, but the process of memorizing strokes is annoying." In the face of such a situation, teachers should channel students' negative feelings, urge them to stick to the use of the Stroke mnemonics to remember Chinese characters, and employ interesting ways (e.g., Chinese character copying competition) to encourage students to use the Stroke mnemonics more often and arouse students' attention to the strokes.

(3) **Emphasize the diversity of mnemonics:** Feng Liping (2013) suggestion on teaching Chinese characters is very scientific and coincides with the results of this study: "Different learning methods will produce different memorization effects, so students should be encouraged to make deeper processing based on the analysis of Chinese characters, rather than simply repeating and copying them. Teachers should take into account the characteristics of the Chinese characters themselves, learners' errors, learners' cognitive styles and preferences, and the characteristics of the stage at which learners memorize the characters to guide them to choose the most appropriate and efficient mnemonics, and to lead them to review and cycle through the characters in a timely manner. For different types of Chinese characters, teachers should guide learners to use a variety of mnemonics.

5. Conclusion

Through the analysis of the relationship between different mnemonics and memory effect, we have the following main conclusions: (1) the role and effect of mnemonics is relatively stable, and due to the nature of the memory curve and test, learners short-term memory and memory consolidation stages are better than the immediate memory and long-term memory stages; (2) in different stages of memory, Form-pronunciation-meaning-associative mnemonics, Stroke mnemonics, and Characters-associative mnemonics all have better memory effects because they are consistent with the characteristics of Chinese characters; (3) different mnemonics lead to different writing errors of Chinese characters, the Repetitive practice method mainly leads to stroke missing error, and the Characters-associative mnemonics mainly leads to the confusion between the memorized Chinese characters and the associated Chinese characters on the strokes; (4) although the Components-associative method has a poor memory effect overall, the main reason lies in the error of strokes within the wrong component, and the error rate appearing only at the level of component addition or missing, component misplacement, etc. is not high, so the component mnemonics is still effective in memorizing Chinese characters. Therefore, when teaching Chinese characters, teachers should guide students to make reasonable use of Components-associative mnemonics, pay attention to the effectiveness of the Stroke mnemonics, and value the diversity of mnemonics.

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