Effect of stroke-order learning and handwriting exercises on recognizing and writing Chinese characters by Chinese as a foreign language learners

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Abstract

This study used a computer-based teaching system to investigate the effectiveness of stroke-order learning and writing exercises in promoting the ability of Chinese-as-a-foreign-language (CFL) learners to recognize and write Chinese characters. This study included a 2 (stroke-order and non-stroke-order) × 2 (writing exercise and non-writing exercise) × 2 (test point) mixed factorial design involving a total of 91 participants. We compared the difference in their Chinese character learning, including Chinese character recognition and handwriting, based on the learning conditions. We found that CFL learners who practiced writing the characters had improved accuracy in their Chinese writing assignments and meaning assignments compared with students who did not practice writing, indicating that writing exercises helped students to memorize the orthography and output of Chinese characters. Writing exercises also helped improve memorization of the meaning of Chinese characters. However, the traditional emphasis on the correct stroke order, which has been considered helpful for learning Chinese characters, demonstrated no significant impact on the effectiveness of recognizing and writing Chinese characters.

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1. Introduction

In recent years, learning the Chinese language has gained popularity worldwide. However, the logographic system of Chinese characters is unique and complicated, and the forms of Chinese characters do not provide hints on pronunciation, resulting in difficulties learning the language. Among the listening, speaking, reading, and handwriting skills required to learn the Chinese language, handwriting is the most challenging skill (Allen, 2008). In a traditional sense, accurately learning a Chinese character (based on the specific strokes and stroke order when writing Chinese characters) is an important task when the Chinese language is included in elementary school education curricula in areas where Chinese is spoken, such as Taiwan, China, and Hong Kong. However, learning to write the character according to the specific stroke order of each character requires a significant amount of time and effort. Some previous studies suggested that handwriting or watching the stroke-order animation may improve the efficiency of learning Chinese characters. However, there is no evidence to show the effect of writing the character according to the specific stroke order on learning the character. In this study, we investigated the role of writing according to the correct stroke order on Chinese character recognition and handwriting.

2. Literature review

2.1. Characteristics of Chinese characters

Compared with English words, which are created with 26 letters, Chinese characters are more complicated because Chinese has thousands of characters. Chinese characters are created with many different strokes. Strokes, radicals and whole characters are the three levels of the form of Chinese characters. Radicals are composed of many different strokes and are constituent components of Chinese characters. Chinese characters can have only one radical (e.g., 女 means "female") and can be composed of more than one radicals (e.g., 母 means "mother") (Chen, et al., 2013). Chinese characters are logographic; the form connects the meaning and
pronunciation, and the connection between form and pronunciation is weak. Thus, the identification of form has become essential for the processing of meaning of the text (Tan, Spinks, Eden, Perfetti, & Siok, 2005). Chinese character recognition includes understanding the orthography (e.g., strokes, structure relationships between strokes, and radical rules and radical location) of Chinese characters (Chen, Chang, Chiu, Sung, & Chang, 2011; Hong, Wu, Chen, Chang, & Chang, 2016). To strengthen the memory of the form—meaning link is an important issue in Chinese character learning.

2.2. Handwriting in Chinese character learning

The complex structure of Chinese characters increases the difficulty of writing Chinese for learners who believe that learning Chinese writing is a waste of time (Allen, 2008). However, a strong association is found between the reading and writing of Chinese among native Chinese speakers (Chan, Ho, Tsang, Lee, & Chung, 2006; Tan et al., 2005) believed that handwriting skills promote literacy because: (1) they provide an awareness of the visual dimension of the stroke structure of Chinese characters, and (2) repeated writing forms long-term motor memory. During the learning process, learners naturally come to understand the structure of Chinese characters by repeated writing practice, which further improves the memory retention and consolidation of Chinese character structures in the long-term memory (Tan et al., 2005).

Numerous studies have shown that handwriting helps to strengthen the connection between form and the meaning of Chinese characters among CFL learners, which further promotes the memorization of Chinese characters and literacy (Cao et al., 2012; Guan, Liu, Chan, Ye, & Perfetti, 2011). A study by Guan, Liu, Chan, and Perfetti (2011) used native English speaker as the CFL subject to compare the reading only condition and reading plus handwriting condition of Chinese characters learning. The results showed that learners practicing handwriting performed better in lexical decision tasks and partial cue-based recognition tasks, suggesting that Chinese writing can improve the development of Chinese orthographic representations in CFL learners and enhance memorization of the meaning of Chinese characters. No significant connection was observed between knowing the form and knowing how to pronounce the character between the two groups. However, the handwriting condition did not teach learners the correct stroke order. Thus, these studies could not illustrate whether writing with a specific stroke order improved students’ orthographic knowledge or effective learning of Chinese characters.

2.3. Stroke-order in Chinese character learning

Chinese writing has specific rules, such as the sequence from left to right and from top to bottom. Each character has specific strokes, written appearance, and stroke order. To the L1 learning, stroke-order writing is important for memorizing the forms and the orthography of Chinese characters (Tsai, Kuo, Hordng, & Chen, 2012). Studies have shown that stroke number and stroke order are part of the psychological representation of Chinese characters (Parkinson, Dyson, & Khurana, 2010). During the process of learning Chinese characters, an additional introduction to and analysis of the strokes of each character strengthened the effectiveness of learning (Jin, 2006; Shimomura, 1980; Tan et al., 2005). A study by Jin (2006) compared traditional pen and paper-based teaching with three different computer multimedia presentations (e.g., displaying the combinations of radicals, displaying the stroke-order animation, and displaying the Chinese phonetics). The results showed that multimedia presentations improved the accuracy assessments of pronunciation, literacy, and form identification compared with the traditional pen and paper-based teaching. Among the computer multimedia presentations, the display of radical combinations provided the greatest teaching effect, followed by the stroke-order animation and Chinese phonetics (Jin, 2006), suggesting that stroke-order animations may provide a positive benefit when learning Chinese characters.

3. Research context and hypotheses

In this study, we examined the effect of writing according to the correct stroke order on Chinese character recognition and handwriting. According to the aforementioned literature, random handwriting (without following the specific stroke order to write) or simply watching the stroke-order animation can help in learning Chinese characters; however, it is unclear whether stroke-order learning can help in memorizing the form and improve literacy. Thus, it is unclear whether stroke-order learning and writing according to stroke-order improve the efficiency of learning Chinese characters. In addition, it is unclear whether watching stroke-order animations to learn the stroke order and following the correct stroke order to write Chinese characters provide a more effective learning strategy than simply watching the animation or random handwriting.

Hence, this study investigated the role of stroke-order learning for Chinese character recognition and Chinese writing exercises by assessing the effects of correct stroke-order writing on literacy and the output of Chinese characters. By comparing the differences and interactions between stroke-order learning and non-stroke-order learning, as well as between writing exercises and non-writing exercises, we further evaluated the impact of stroke order and writing on learning Chinese characters. As previous studies suggested that writing may help to strengthen the form—meaning link in memory retention, we also examined the immediate learning effect and the learning effect on character recognition after two weeks.

Based on the literature review, stroke-order learning and handwriting exercise may positively influence the form—meaning link, but not the form-sound link of characters. In addition, present studies emphasize the importance of writing Chinese characters in an accurate stroke order. We assumed that stroke-order learning and handwriting exercises positively influence Chinese character recognition and handwriting. Writing with correct stroke-order can improve CFL learners’ accuracy in recognition and handwriting tasks. Moreover, handwriting based on the correct stroke order may improve the memory retention of Chinese characters.

The study hypotheses are as follows:

H1. In the recognition task, stroke-order learning, handwriting exercises had main effect on the meaning task, while stroke-order learning and handwriting exercises positively influence the form—meaning link of characters.

H2. There was no effect of stroke-order learning and handwriting exercises on the pronunciation task.

H3. In the handwriting task, stroke-order learning and handwriting exercise had main effect. Stroke-order learning and handwriting exercise positively influenced the handwriting learning.

H4. In the meaning task, stroke-order learning × handwriting exercises had interaction; the stroke-order group with handwriting exercise may perform better in the meaning task.

H5. In the handwriting task, stroke-order learning × handwriting exercise had interaction; stroke-order group with handwriting
exercise may perform better in the handwriting task.

**H6.** In the meaning task, stroke-order learning × handwriting exercise × test point had interaction. We expected that both stroke order learning and handwriting exercises will have an influence on the performance of meaning task and this phenomenon will be observed in delayed posttest only.

### 4. Method

#### 4.1. Experimental design

This study was of a $2 \times 2 \times 2$ mixed factorial design. The independent variables between two groups of tested subjects were the implementation of stroke order or lack thereof, whereas the independent variables within the tested subjects were the application of a writing exercise or lack thereof and the test points (i.e., immediately post-test and with a delay post-test). All participants were divided into two groups (i.e., stroke-order and non-stroke-order). Both groups received the learning context manipulation of Chinese character writing exercises and non-writing exercises and were tested at two time points: immediately or at two weeks after learning.

The dependent variables of this study were the accuracy in the Chinese character recognition task (i.e., meaning task and pronunciation task) and accuracy in the Chinese character writing task.

#### 4.2. Participants

The research participants ($n = 91$, 48 males and 43 females) were students of the Chinese study program from National Taiwan Normal University, Taiwan (ages ranging from 16 to 20 years). All the participants were native Portuguese or Spanish speakers who spoke English as a second language and had not reached the A1 level of the Common European Framework of Reference (CEFR) for the Chinese language. All the participants were randomly assigned into two groups: stroke-order group ($n = 45$) and non-stroke-order group ($n = 46$). No significant differences were found in the age, gender and pretest scores (recognition task and handwriting task) of the two groups.

#### 4.3. Materials

##### 4.3.1. Chinese character teaching system

This study used computer software as the manipulation tools for teaching. The software interface provided examples for teaching Chinese characters and the corresponding information, such as their stroke-order animation, pronunciation, Chinese phonetics (pinyin), and English translation. **Fig. 1** is an example of the teaching interface for the stroke-order and non-stroke-order groups. The target Chinese character is shown at the top left corner, and the English translation of the target Chinese character is shown at the top right corner. The bottom left corner shows the Chinese phonetics with the automatic pronunciation of the target Chinese character (three times). The learning interface for the stroke-order learning group is displayed as a stroke-order animation at the bottom right corner. The stroke-order animation is repeatedly displayed in the presence of the Chinese character. No stroke-order animation is displayed in the learning interface for the non-stroke-order group. This software also provided an area for handwriting assessment input by mouse or by touch panel. We used it to record the process of the participants’ writing (see **Fig. 2**).

##### 4.3.2. Experimental Chinese characters

Eighteen Chinese characters were selected for this study based on multiple types of spatial structure among Chinese characters. The three most common types of spatial structures among Chinese characters that affect learning include radicals (e.g., 日, 女), horizontal line bisection (e.g., 里, 真), and vertical line bisection (e.g., 九, 冰). The number of strokes in Chinese characters varies from 1 to 24, and the majority of the characters have between 6 and 13 strokes (Taylor and Taylor, 1995). Because of the difficulties for beginning learners in memorizing the meaning, pronunciation, and writing of characters, we selected Chinese characters with 5–7 strokes for the assessment based on a previous study for beginners (Tsai et al., 2012).

These characters were randomly put into two groups. The first group of characters was presented in the writing exercise condition, and the second group was presented in the non-writing exercise condition (see **Table 1**). No significant difference in word frequency was found in the two groups of target Chinese characters, and there was an average stroke number of 6.1 per character.

#### 4.4. Procedure

The research procedure of this study is shown in **Fig. 3**. First, the participants were required to undergo a pretest. Then, they were assigned into two groups (i.e., stroke order and non-stroke order). Both groups received the learning context manipulation of Chinese character writing exercises and non-writing exercises.

All the participants received computer training on the displayed Chinese characters and learned a total of 18 target Chinese characters. The display time of each character was 1 min. The computer teaching included the target Chinese character, pronunciation, pinyin, and English translation of the target Chinese character. The pronunciation was automatically played three times during the display of the Chinese character.

The stroke-order group watched the repeated stroke-order animation and displayed Chinese characters and wrote the characters three times on the worksheet according to the stroke-order in the writing exercise condition. They wrote the English translation and pinyin of the character in the non-writing exercise condition.

The non-stroke-order group watched the displayed Chinese characters and wrote the characters three times on the worksheet in the writing exercise condition, and they wrote the English translation and pinyin of the character in the non-writing exercise condition. There were two presentation orders of two conditions (writing exercise > non-writing exercise and non-writing exercise > writing exercise).

All the participants immediately received a post test to assess their learning and memorization of Chinese character recognition and handwriting. The delayed test was performed two weeks after the post test to assess the memory retention of Chinese character recognition.

#### 4.5. Assessment tasks

The assessment content in the pretest, immediate post test, and delayed post test were identical. The correct answers in the pretest were excluded from the score of the latter tests.

##### 4.5.1. Recognition task

The recognition tasks included 24 multiple-choice questions, 12 for the character meaning and 12 for pinyin (one character per question, one score per question). The task included 12 Chinese characters displayed in this study, with 6 characters from the writing exercise condition and another 6 characters from the non-writing exercise condition. Each question on the target Chinese character contained four English translation (or pinyin) choice options. The participants were required to select the English translation (or pinyin) that matched each character.
4.5.2. Handwriting task

A total of 12 Chinese characters displayed in this study were selected, with 6 characters from the writing exercise condition and another 6 characters from the non-writing exercise condition. The participants were required to use a mouse to write the target character. The left side of the monitor showed a 9-patch block, and the right side showed the phonetics and English translation of the target Chinese character. The participants were required to write the Chinese character displayed in the 9-patch block that matched the information on the right side. The computer system recorded the written track of the character, including the stroke order and strokes for subsequent data analysis (Fig. 2). The Chinese character writing assignments contained two scoring criteria: (1) form-stroke correct criteria (i.e., the overall accuracy of the shapes of the character, stroke order, and brushwork) and (2) form correct criteria (written accuracy of the shapes of Chinese characters). The form correct criteria were used to assess the learning effects based on memory and the production of Chinese form, whereas the form-stroke correct criteria were used to assess the manipulation of stroke-order learning.
5. Results

To test the H1, H2, H4 and H6, we examine the effect of stroke order, handwriting exercises and test point on recognition task, a three-way mixed design ANOVA was carried out on the recognition task assessment. In addition, to test the H3 and H5, a two-way ANOVA was carried out on the handwriting task assessment. When the difference reached significance, pairwise comparisons with LSD and paired sample t-test were performed to identify the pattern of differences. The significance level was set at α = 0.05. Tables 2–4 show the mean accuracy and standard deviations of the recognition tasks and handwriting task in the different tested groups.

5.1. Effect of the stroke-order learning, handwriting exercises and test point on Chinese character recognition

5.1.1. Accuracy of the meaning task

Consistent with H1, the results showed significant main effects of handwriting exercises $F(1, 80) = 4.54, p < .05, \eta^2_p = 0.54$, and test point $F(1, 80) = 6.64, p < .05, \eta^2_p = 0.77$, however, no main effects of stroke-order learning was found. Contrary to H4 and H6, no interactions were found in the meaning task. The accuracy of the meaning task in the writing exercises condition ($M = 0.66, SD = 0.29$) was significantly improved compared with the non-writing exercises condition ($M = 0.61, SD = 0.31$). In addition, the accuracy in the immediate post test ($M = 0.69, SD = 0.34$) was higher than the accuracy in the delayed posttest ($M = 0.59, SD = 0.34$).

5.1.2. Accuracy of the pronunciation task

For accuracy in the pronunciation task, only the main effect of test point reached significance, $F(1, 73) = 7.895, p < .01, \eta^2_p = 0.098$. The accuracy in the immediate post test ($M = 0.59, SD = 0.35$) was higher than the accuracy in the delayed post test ($M = 0.47, SD = 0.40$). Consistent with H2, No other significant effect was found.

Table 1

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Target Chinese character</th>
<th>Stroke number</th>
<th>Structure</th>
<th>Average stroke number</th>
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<td>Writing exercise</td>
<td>菓</td>
<td>6</td>
<td>Top to bottom</td>
<td>6.1 strokes</td>
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<td></td>
<td>仗</td>
<td>5</td>
<td>Horizontal line bisection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>恶</td>
<td>7</td>
<td>Top to bottom</td>
<td></td>
</tr>
<tr>
<td></td>
<td>曲</td>
<td>6</td>
<td>Radical</td>
<td></td>
</tr>
<tr>
<td></td>
<td>明</td>
<td>5</td>
<td>Horizontal line bisection</td>
<td></td>
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<td></td>
<td>辛</td>
<td>7</td>
<td>Radical</td>
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<td></td>
<td>谷</td>
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<td>Radical</td>
<td></td>
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<tr>
<td></td>
<td>伪</td>
<td>6</td>
<td>Horizontal line bisection</td>
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<tr>
<td></td>
<td>学</td>
<td>6</td>
<td>Vertical line bisection</td>
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<td></td>
<td>触</td>
<td>6</td>
<td>Radical</td>
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<td>捨</td>
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<td>Vertical line bisection</td>
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<td>贤</td>
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<td>Radical</td>
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<td>Vertical line bisection</td>
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<td></td>
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<td>7</td>
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<td>Horizontal line bisection</td>
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<tr>
<td></td>
<td>学</td>
<td>6</td>
<td>Vertical line bisection</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Procedure.
5.2. Effects of writing exercises and stroke-order learning on the accuracy of handwriting task

5.2.1. Form-stroke correct criteria for the accuracy of handwriting task

Consistent with H3 and H5, the results showed that there was no interaction between the accuracy of the handwriting task based on form-stroke correct assessments of learners in two groups and two conditions, $F(1,87) = 7.223, p < .01, \eta^2_p = 0.08$. A significant main effect was observed between the stroke-order learning group and the non-stroke-order learning group, $F(1,87) = 5.60, p < .05, \eta^2_p = 0.06$, with the written accuracy of the stroke-order learning group ($M = 0.33, SD = 0.31$) significantly improved compared with that of the non-stroke-order learning group ($M = 0.18, SD = 0.2$). Moreover, a significant difference was observed between the two exercise conditions, $F(1,87) = 10.991, p < .01, \eta^2_p = 0.112$, with the handwriting task accuracy of the writing exercise condition ($M = 0.31, SD = 0.35$) significantly improved compared with that of the non-writing exercise condition ($M = 0.24, SD = 0.27$). ANOVA was performed to determine the simple main effects. In the stroke-order learning group, the characters that had been practiced with handwriting ($M = 0.42, SD = 0.38$) had significantly higher accuracy in the writing task under the correct stroke form assessments compared with the characters that had not been practiced ($M = 0.28, SD = 0.30$); in the non-stroke-order learning group, no significant difference was observed in the accuracy of handwriting under the stroke form assessments between the characters in the writing exercise condition ($M = 0.21, SD = 0.28$) and the non-writing exercise condition ($M = 0.20, SD = 0.23$). However, in the writing exercise condition, those who learned the stroke order ($M = 0.42, SD = 0.38$) showed improved accuracy in the stroke form assessments of the handwriting task compared with learners who did not learn stroke order ($M = 0.21, SD = 0.28$); in the non-writing exercise condition, no significant difference was observed in the stroke form accuracy of handwriting task between stroke-order learning group ($M = 0.28, SD = 0.30$) and non-stroke-order learning group ($M = 0.20, SD = 0.23$).

5.2.2. Form correct criteria for the accuracy of handwriting task

For the accuracy of form correct criteria assessments, the result was inconsistent with the H3 and H5, only the main effect of writing exercise reached significance, only the main effect of writing exercise reached significance, $F(1,87) = 8.643, p < .01, \eta^2_p = 0.09$, with the writing exercise conditions ($M = 0.53, SD = 0.38$) exhibiting improved handwritten accuracy in the assessments based on the form correct criteria compared with the non-writing exercise conditions ($M = 0.46, SD = 0.34$). No interaction in the form correct criteria assessments were observed between the two learning groups and two writing exercise conditions, and no main effect were observed in the stroke-order learning groups.

6. Discussion

6.1. Effect of stroke-order on learning Chinese

This study showed that stroke-order animation learning had no significant effect on learning the meaning of Chinese characters. In the meaning tasks, students who received stroke-order learning did not display a significant improvement in memory compared with students who did not receive stroke-order learning. The use of animations alone to teach the stroke-order of Chinese characters was not sufficient to improve the recognition of Chinese characters or effectiveness in learning their literal meaning. These findings did not support a previous study by Jin (2006) that suggested that displaying the stroke-order animation has a positive impact on character learning.
In the pronunciation learning, no significant differences were observed in the pronunciation accuracy assessment between the stroke-order learning groups. This result was consistent with previous findings by Guan et al. (2011) and confirmed that the stroke order and orthography were weakly associated with the pronunciation of Chinese characters, which may explain why learning stroke order rules and watching the stroke-order animation were ineffective in establishing a connection between form and pronunciation.

In the handwriting task, no significant differences were observed in written accuracy between the two stroke-order learning groups based on the form correct assessment criteria (put the form of Chinese characters), suggesting that these learning strategies did not have an impact on memory and output of form. However, when applying the form-stroke correct criteria, an improvement was observed in the writing accuracy assessments in the group with stroke-order learning compared with the non-stroke-order learning group, indicating that the stroke-order animation can help CFL learners memorize Chinese stroke orders.

In summary, stroke-order learning had no impact on the recognition and output of the form of Chinese characters; however, it did help learners memorize the stroke order.

6.2. Effect of handwriting exercises on learning Chinese characters

This study showed that conditions with and without handwriting practice had a significant effect on the learning and memorization of the meaning of Chinese characters. The characters that received handwriting practice showed a higher accuracy in the assessments of meaning compared with the characters that did not, suggesting that handwriting practice improved the connection between the form and meaning of the character as well as the memory retention of the meaning of Chinese characters. Studies by Tan et al. (2005) and Guan et al. (2011) demonstrated that practicing writing allowed learners to memorize the orthography of Chinese via motor and learning memory, which assisted in the transfer and storage of such information to long-term memory. Moreover, writing practice could also promote the connection between form and the meaning of a Chinese character. The results of this study confirmed that writing practice significantly improved the memory of the meaning of Chinese characters.

Regarding pronunciation, no significant differences were observed in the accuracy of pronunciation task between two writing conditions in both the immediate posttest and delayed tests. Our findings were consistent with previous studies (Guan et al., 2011) and confirmed that Chinese writing practice did not help establish a connection between the forms and their pronunciation.

Regarding the effectiveness of learning Chinese handwriting, the accuracy of writing condition was significantly improved compared with non-writing condition according to both the form-stroke correct and form correct criteria. This result indicates that practicing handwriting is the key to correctly memorizing the form, strokes, stroke rules, and font output. By practicing writing the Chinese character, learners could determine the most precise method of writing the character. Obviously, Chinese writing practice helped the learners understand and memorize the stroke structure of Chinese characters, indicating the importance of Chinese writing for understanding the structure of Chinese characters.

6.3. Impact of stroke-order learning, handwriting exercises and test point on learning effectiveness

This study showed no interaction impact on recognition learning effectiveness between the learning groups, writing exercise conditions, and test points. Writing with correct stroke order did not improve the accuracy of character recognition of CFL learners. Additionally, the results showed that writing practice improved the form—meaning link in memory, and the impact on character recognition had no difference over time. The results indicate that handwriting in the traditional sense does not have an impact on learning Chinese characters, but writing the characters in general does. The results also support the assumptions that handwriting practice could indeed assist in memorizing the literal meaning of Chinese characters.

Regarding the writing task, interaction was observed in the accuracy assessments of the writing task between the two stroke-order learning groups and writing conditions. In the stroke-order learning group, characters that had been practiced in writing were written better than characters had not been practiced; however, in the non-stroke-order learning group, no significant differences were observed between the conditions with and without writing practice. These results indicate that stroke-order learning and writing exercises improved the writing accuracy of CFL learners, especially for form, stroke order, and brushwork. Moreover, the teaching of precise stroke order and writing exercises played an important role in writing according to the stroke order.

7. Conclusion

This study evaluated the impacts of two learning strategies (i.e., stroke-order learning and writing exercises) on the effectiveness of learning Chinese characters among CFL learners. Our results showed that (1) writing exercises helped learners understand the meaning of Chinese characters and was particularly helpful in memorizing the meaning of Chinese characters. This study confirmed the results of previous studies that writing helps strengthen the connection between forms and their meaning (Cao et al., 2012; Guan, Liu, Chan, Ye, & Perfetti, 2011), indicating that the process of handwriting provided another channel to encode the connection between forms and the literal meaning of Chinese characters and to retain such information in long-term memory. (2) Specific stroke order rules as a guide for learners practicing writing were not necessary for the font output of CFL learners. As long as learners practiced Chinese writing, they could correctly generate the form of Chinese characters regardless of whether they followed a specific stroke-order rule. In addition, learning the stroke order did not improve the pronunciation or understanding of Chinese characters’ meaning. (3) Stroke-order learning allowed learners to memorize the correct stroke order. Therefore, stroke-order learning together with stroke-order writing practice of Chinese characters could improve stroke-order memorization.

Previous studies on methods of teaching Chinese characters rarely focused on the evaluation of stroke-order learning. No study has reported the impact of a specific stroke-order on word recognition or the impact of practicing Chinese writing with stroke-order on learning Chinese. This study showed that handwriting was important for CFL learners in learning Chinese characters. Writing improved the memory retention of the meaning of Chinese characters in CFL learners and improved the ability to write in Chinese. Traditional teaching of Chinese writing has focused on stroke order; however, learning a specific stroke order did not improve the recognition of the meaning of Chinese characters or the writing accuracy of CFL learners. Thus, it may not be necessary to require learners to follow a stroke order in all characters; rather, having learners practice handwriting could be applied to achieve more efficient learning.

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