

A Study on the Relationship Between Stroke Order Accuracy and Character Form Accuracy in Chinese Character Writing by Thai Learners

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Abstract: In this study, written tests are conducted to investigate the dynamic process of Chinese character writing among 76 Thai learners of different proficiency levels. It focuses on examining the relationship between stroke order accuracy and character form accuracy. The findings indicate a significant positive correlation between stroke order accuracy and character form accuracy among Thai learners. That is to say, the higher the stroke order accuracy, the higher the character form accuracy. It should be noted that the relationship between stroke order accuracy and character form accuracy changes with learners' proficiency in Chinese characters. The two are significantly correlated for beginners but insignificant for advanced learners. It is suggested that Thai Chinese teachers should continue to provide targeted instruction on Chinese character "hand-writing" and emphasize the importance of stroke order. It is also necessary for Thai learners to practice the writing of Chinese characters and develop a strong awareness of stroke order and character form.

Keywords: Stroke Order; Chinese Character Writing; Chinese Character Instruction; Thailand

1. Introduction

1.1 Research Background

Stroke order refers to the sequence and direction of the strokes used to write each Chinese character, while character form is defined as the two-dimensional form that constitutes square Chinese characters [1]. Both elements play a crucial role in localized Chinese character teaching. However, the Chinese character instruction in Thailand has

been significantly neglected [2], and character writing has long been identified as a difficulty in teaching.

Thai language lacks morphological variations, which means no change in gender, number, or case [3]. This is clearly different to the experience of learners from Western countries, where English words show significant inflectional variations. In Thai language, the position of a word in a sentence determines its function as a verb, noun, adjective, or adverb, which is a unique aspect of the language.

Although Chinese shows no morphological changes, there are clear differences in the writing system between Chinese and Thai characters. The characteristics of Chinese strokes are mainly "horizontal and vertical", whereas Thai writing features curves and rounded lines. This discrepancy often causes errors in writing among the Thai learners of Chinese characters. Therefore, it is essential to conduct localized research on Chinese character writing in Thailand.

Moreover, our teaching observations indicate that some Thai learners do not follow the correct stroke order when writing Chinese characters. Instead, they still try to produce the correct character upon completing the final stroke. This raises a number of questions: Is it necessary to require Thai learners to follow stroke order rules when writing Chinese characters? What is the relationship between stroke order accuracy and character form accuracy in their writing? To answer these questions, a further investigation should be conducted to explore the relationship between stroke order accuracy and character form accuracy for the Thai learners writing Chinese characters.

1.2 Research on Stroke Order Rules and

Chinese Character Writing

The stroke order discussed in this paper means the sequence in which each stroke is executed when writing characters. According to the Sequential Organization Hypothesis, stroke order information is stored in the brain in a kinetic form, which is conducive to the writing and recognition of Chinese characters [4]. As further indicated in the research of Sun et al. [5], following the correct stroke order allows learners to better develop high-quality orthographic representations.

However, what is the role of stroke order rules in Chinese character writing? There are different findings in this area. As argued by Yi [6], users typically focus on the final product of the writing, which means there is no strict need for perfect stroke order. Kitterman [7] found out that the accuracy of stroke order among American learners of Chinese had no significant effect on their overall writing accuracy, and that there was a strong negative correlation between stroke order accuracy and writing time. However, most scholars hold the view that mastering the correct stroke order is beneficial for Chinese character writing [2, 8-12]. Zhang highlighted the importance of stroke order in the teaching of Chinese as a foreign language [13]. In the view of Wan [14], stroke order is conducive to rationally segmenting the writing space, and error rate can rise due to a disorganized writing process. As indicated by Zhou [10], correct stroke order allows characters to be written both quickly and accurately, whereas incorrect stroke order may result in misspelled characters.

1.3 Research on the Relationship Between Stroke Order Accuracy and Character Form Accuracy

In a study that attracted widespread attention in the international Chinese language teaching community, Law et al. [15] investigated the instant copying of Chinese characters by 72 first-grade students to evaluate the importance of stroke order instruction and its impact on writing education. It was found out that learners' accuracy in writing Chinese characters was far lower when stroke order was considered, with even the familiar character "母" showing an average accuracy of only 20.6%. It means that there may be no strong relationship

between stroke order and character accuracy, with stroke order rules even exerting a negative effect on character accuracy. Then, Zhu [16] studied the effects of stroke sequence animation instruction on the writing performance of 100 students enrolled into a beginner Chinese course at a university in the United States, finding a significant negative impact on the outcomes of their character writing. By analyzing the stroke order of 280 Chinese characters written by 14 international students, Sheng discovered that while the error rate for stroke order was 64%, the accuracy of the completed characters reached 95% [11]. It was concluded that the correctness of the completed characters is not significantly affected by the standardization of stroke order. However, the statistical methods used in this study were not rigorous, as it relied solely on means for significance determination.

Some studies have revealed that stroke order accuracy is correlated with character form accuracy. For instance, Xiao investigated 19 Western learners of Chinese [17], observing through custom-designed tests and teaching practices that the students with good stroke order mastery (accuracy above 65%) made very few errors in character writing, while those with poor mastery (accuracy below 60%) made many mistakes. By exploring the impact of stroke count and stroke order on character composition among native Chinese speakers, Luo et al. found out that the error rate in writing characters adhering to stroke order was significantly lower than that of those that did not comply, particularly in characters with four and five strokes [18]. However, there were limited experimental materials, with the focus only on those characters with three, four, and five strokes. By assessing the character writing of eight Italian learners at a beginner level through dictation, Chen & Feng concluded that higher stroke order accuracy is correlated with higher character accuracy [19].

1.4 Research Questions

In summary, the findings are as follows: (1) There may be differences in the relationship between stroke order accuracy and character form accuracy among the learners at different levels; (2) The learners' proficiency in Chinese may affect the relationship

between stroke order accuracy and character form accuracy, an area that has attracted little attention in the existing research; (3) There is insufficient research on the nationalized studies of Chinese character writing, with relatively few studies focusing on Thailand.

Therefore, this paper explores the relationship between stroke order accuracy and character form accuracy in the writing of Chinese characters among Thai learners at different proficiency levels. Specifically, three questions will be answered: (1) Do the stroke order accuracy and character form accuracy of Thai learners change with their level of Chinese proficiency? (2) Is there any correlation between stroke order accuracy and character form accuracy among Thai learners? (3) Does the relationship between stroke order accuracy and character form accuracy vary among Thai learners at different proficiency levels?

2. Research Design

2.1 Sample Description

The experiment involved 76 Thai learners of Chinese, of whom 31 were males and 45 were females, with their ages ranging from 18 to 31 years. According to their results in the HSK examinations, 38 participants passed HSK levels 1 to 3 as the beginner group, and 38 participants passed HSK levels 5 to 6 as the advanced group. All the participants had normal vision but no writing disabilities. To prevent any influence on the experiment's results, the purpose of this study was not disclosed to the participants during the experimental process.

2.2 Experimental Tools

In total, 1,200 Chinese characters were randomly arranged from the handwritten character lists of the "Chinese Proficiency Grading Standards for International Chinese Language Education" [20] by levels. From each of the elementary, intermediate, and advanced handwritten character lists, 10 characters were randomly selected. This resulted in a total of 30 characters, with stroke counts ranging from 3 to 11. During a written test, the participants first wrote the stroke order of the characters and then the complete characters.

Although the knowledge of Chinese character forms can be assessed through the dictation of words or phrases [21], this method may provide insufficient context, potentially leading to the writing of homophones (e.g., "遇见" and "预见"). Therefore, a delayed copying method was used in this experiment, with the 30 characters randomly scrambled and presented using Microsoft PowerPoint. Each character was displayed for two seconds. The participants were required to immediately write down the character they had seen, along with its stroke order, in the corresponding space on the test sheet after the character disappeared (e.g., 遇见. 一 十 才 才 来 来 来). The next character was presented after all the participants completed writing. Before the formal experiment, three practice trials were conducted to ensure that each participant understood the experimental procedure.

2.3 Scoring Methodology

The stroke order accuracy is defined as the ratio of the number of correct stroke orders to the total number of strokes for the Chinese characters. Incorrect stroke orders were scored as follows. There are no points awarded if the stroke order is completely incorrect or not attempted. Each instance of incorrect stroke order is counted once. The actual number of errors is recorded if multiple stroke order errors occur during the writing process. The character form accuracy refers to the ratio of the number of correct strokes in the final product to the total number of strokes in that character.

The levels of Chinese character proficiency were assessed through the testing method developed by Xu & Jiang [22]. This assessment involves two components: a character recognition test and a character writing test, with the aim to evaluate the participants' ability to recognize and write Chinese characters, respectively. Subsequently, both groups of participants took the tests, with their total scores converted to a scale of 100 points. Table 1 lists the basic information about the participants.

Table 1. Basic Information of Participants in the Experiment

Group	Number of Participants	Chinese Proficiency Level	Character Proficiency Level	Average Score in Character

				Test (points)
Beginner Group	38	HSK Level 1-3	Beginner Level	95.211
Advanced Group	38	HSK Level 5-6	Advanced Level	98.142

The results of the paired sample T-test indicate a clear difference in character test scores between the two groups of participants ($t(37) = -2.557, p < 0.05$), which means the proficiency levels of the participants are effectively differentiated in the character test.

3. Research Results

3.1 Differences in Stroke Order and Character Form Accuracy between Two Groups of Thai Learners

A statistical analysis was conducted on the stroke order accuracy and character form accuracy of Chinese character writing among Thai students at different proficiency levels. The average results are shown in Table 2 below.

Table 2. Average Stroke Order Accuracy and Character Form Accuracy of the Two Groups (Standard Deviation in Parentheses)

Proficiency Level	Stroke Order Accuracy	Character Form Accuracy
Beginner Level	97.08%(3.98)	96.45%(3.25)
Advanced Level	98.38%(1.80)	98.80%(2.20)

A paired sample t-test was performed on the stroke order accuracy and character form accuracy of the two groups. According to the results, the difference in stroke order accuracy is marginally significant ($t(37) = -1.705, p < 0.10$), and advanced learners show a higher stroke order accuracy than beginner learners. In comparison, the difference in character form accuracy was highly significant ($t(37) = -3.931, p < 0.01$), indicating a significantly higher character form accuracy of advanced learners compared to their beginner counterparts.

3.2 The Correlation between Stroke Order Accuracy and Character Form Accuracy Among Thai Learners

To reveal the relationship among the stroke order accuracy, character form accuracy, and Chinese character test scores of Thai learners, a Pearson correlation analysis was conducted on the data, as shown in Table 3.

Table 3. Simple Correlations between Stroke Order Accuracy, Character Form Accuracy,

and Chinese Character Test Scores

		Stroke Order Accuracy	Character Form Accuracy
Character Form Accuracy	Correlation Coefficient	.281	—
	Significance (Two-tailed)	.088†	—
	Sample Size	38	—
Chinese Character Test Scores	Correlation Coefficient	.484**	-.144
	Significance (Two-tailed)	.002	.387
	Sample Size	38	38

Note: ** $p < .01$; † $.05 < p < .10$ indicates marginal significance.

The results demonstrate the positive correlation between stroke order accuracy and character form accuracy among Thai learners of Chinese characters, with a marginally significant correlation coefficient $p = 0.088$, suggesting the correlation between higher stroke order accuracy and higher character form accuracy.

Moreover, as shown in Table 3, stroke order accuracy also shows a significant positive correlation with Chinese character test scores ($p = 0.002$). This means the correlation among the three variables: stroke order accuracy, character form accuracy, and Chinese character test scores. To further explore the relationship between stroke order accuracy and character form accuracy with control on the influence of test scores, a partial correlation analysis was conducted by treating Chinese character test scores as a control variable (see Table 4).

Table 4. Partial Correlation between Stroke Order Accuracy and Character Form Accuracy

		Stroke Order Accuracy
Character Form Accuracy	Correlation Coefficient	.405*
	Significance (Two-tailed)	.013
	Degrees of Freedom	35

Note: * $p < .05$

As indicated by the results, there remains a significant positive correlation between stroke order accuracy and character form accuracy when Chinese character test scores are controlled ($p = 0.013$).

3.3 Correlation between Stroke Order Accuracy and Character Form Accuracy Among Thai Learners of Different Proficiency Levels

In this section, the correlation between stroke

order accuracy, character form accuracy, and Chinese character test scores for two groups of participants is examined, as listed in Table 5.

Table 5. Simple Correlation between Stroke Order Accuracy, Character Form Accuracy, and Chinese Character Test Scores for Two Groups of Participants

		Character Proficiency Level			
		Beginner Level		Advanced Level	
		Stroke Order Accuracy	Character Form Accuracy	Stroke Order Accuracy	Character Form Accuracy
Character Form Accuracy	Correlation Coefficient	.441**	—	.195	—
	Significance (Two-tailed)	.006	—	.241	—
	Sample Size	38	—	38	—
Chinese Character Test Scores	Correlation Coefficient	.557**	-.057	-.130	.037
	Significance (Two-tailed)	.000	.733	.436	.827
	Sample Size	38	38	38	38

Note:**p < .01

The results indicate the differences in correlation between stroke order accuracy and character form accuracy across different proficiency levels among Thai learners. Specifically, for beginner-level learners, there is a highly significant correlation between stroke order accuracy and character form accuracy ($p > 0.05$).

Furthermore, highly significant correlations are shown by both stroke order accuracy and character form accuracy for beginner-level learners with Chinese character test scores ($ps < 0.01$), as shown in Table 5. This suggests the correlation between all three variables. With control on the the influence of Chinese character test scores, a partial correlation analysis was conducted to explore the relationship between stroke order accuracy and character form accuracy for beginner-level learners. Table 6 shows the results.

According to Table 6, there remains a highly significant positive correlation between stroke order accuracy and character form accuracy among beginner-level learners when the influence of Chinese character test scores is controlled ($p < 0.01$).

Table 6. Partial Correlation between Stroke Order Accuracy and Character Form Accuracy for Beginner-level Learners

		Stroke Order Accuracy
Character Form Accuracy	Correlation Coefficient	.571**
	Significance (Two-tailed)	.000

	Sample Size	35
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Note: **p < .01

4. Discussion and Teaching Recommendations

The relationship between the accuracy of stroke order and character form in Chinese writing among Thai learners is investigated in this study to obtain the following results: (1) Advanced learners exhibit significantly higher stroke order and character form accuracy compared to beginner learners; (2) There is a positive correlation between stroke order accuracy and character form accuracy among Thai learners; (3) Stroke order accuracy shows a significant positive correlation with character form accuracy among beginner learners rather than advanced learners. These findings suggest that the proficiency level of Thai learners affects both their stroke order and character form accuracy, with distinct relationships observed between these two variables across different proficiency levels.

4.1 Influence of Proficiency Level on Stroke Order and Character Form Accuracy

As revealed by this study, the proficiency level of Thai learners affects their stroke order and character form accuracy in Chinese writing. Specifically, advanced learners show significantly higher accuracy in both stroke order and character form than their beginner counterparts.

However, this finding differs from the results obtained by An & Shan [23], as well as those obtained by An & Zou [24]. In their research, video recordings were used to explore the relationship between stroke order and character form among international students outside the Chinese character sphere. It was discovered that the participants were able to produce correctly formed characters although errors were made in stroke order, and that the frequency of stroke order errors showed no decrease with the improvement in Chinese language proficiency. It was concluded that stroke order issues do not directly reflect a student's proficiency in Chinese. However, these studies were based on real cases and no quantitative data was used, with a failure in systematically investigating the influence of students' Chinese proficiency.

In contrast, this study is consistent with the findings of Li and Feng et al. [25,26]. Li explored the dynamic process of Chinese

character writing among Thai students [25], revealing that the students at different learning stages varied in the level of stroke order accuracy, and that the mastery of stroke order increased as proficiency was improved. By examining the relationship between character recognition, comprehension, and correct writing among second language learners of Chinese, Feng et al. found out that the number of correctly written characters rose as language proficiency was improved [26]. In this study, stroke order and character form accuracy were lower as beginner Thai learners had not yet mastered the stroke order rules or developed an awareness of character form. As proficiency is improved, learners gradually developed a sense of orthographic awareness. Meanwhile, stroke order and character form knowledge are reliably stored in their mental lexicon. This mitigates the influence of their native language on Chinese character writing, thus causing a significant improvement in stroke order and character form accuracy.

4.2 The Significant Correlation between Stroke Order Accuracy and Character Form Accuracy

This study demonstrates a significant positive correlation between the stroke order accuracy and character form accuracy in the Chinese writing of Thai learners. In other words, as Thai learners' stroke order accuracy increases while writing Chinese characters, their character form accuracy is also improved.

By examining the issue from the perspectives of energy expenditure in writing dynamics and the informational content in memory learning, Shimomura explored the scientific basis of Chinese character stroke order [27]. According to the results, standard stroke order usually conforms to the principle of energy minimization, promoting memory retention, particularly for the characters with more strokes. As argued by the researcher, the rules governing stroke order represent the optimal sequence for stroke combination, derived from human experiences in learning and writing Chinese characters. From the perspective of cognitive characteristics related to stroke order rules, this reaffirms the close relationship between stroke order accuracy and character form accuracy.

4.3 The Relationship between Stroke Order and Character Form Accuracy Varies with

Proficiency Level

As indicated by this study, the relationship between stroke order accuracy and character form accuracy changes with the learners' proficiency level. A significant positive correlation was observed between stroke order accuracy and character form accuracy among beginners, instead of advanced learners.

The results obtained for beginner-level learners are consistent with those of Chen & Feng [19], who conducted longitudinal studies of stroke order writing and dictation to examine the development and patterns of stroke order among beginner Italian learners of Chinese. It was discovered that higher stroke order accuracy corresponds with higher character form accuracy. The Thai beginner learners in this study are at a similar developmental stage, as they have not yet fully understood the rules of stroke order or developed awareness of character forms. Combined with the "negative transfer" effect from their Thai orthography, beginner learners must ensure correct character writing by engaging in deep cognitive processing of the basic features of each stroke, the sequence of strokes, and their combinatory relationships. This leads to the close relationship observed between stroke order accuracy and Chinese character writing.

In contrast, stroke order accuracy shows no correlation with character form accuracy among the advanced Thai learners in this study, which indicates that the accuracy of the final character produced is unaffected by the correctness of stroke order, regardless of the high proficiency of the learners. This may result from the fact that advanced students have developed long-term motor memory for character writing, achieving a degree of automatization in their skills. Furthermore, with the improvement of learners' proficiency, their awareness of stroke order and character form becomes increasingly stable within their mental lexicon. Thus, there are no errors in the overall character, even if individual strokes are executed incorrectly, which further explains the high rates of stroke order accuracy (98.38%) and character form accuracy (98.80%) observed among advanced Thai students.

4.4 Suggestions for Teaching Chinese Characters

In the process of teaching Chinese characters in Thailand, educators should adapt their writing

requirements to the different levels of learners. For beginners, it is essential to strictly follow the correct stroke order, which ensures that students develop good writing habits from the outset of their character learning journey. For advanced learners, writing requirements can be relaxed to some extent. It may be unnecessary to strictly follow stroke order if the overall integrity of the character is maintained. Regardless of proficiency level, all Chinese language learners need to gain a solid understanding of both stroke order and character structure by practicing repetitive stroke order. With stroke order integrated into their mental representation of characters, this improves the accuracy of their character writing.

For Thai Chinese language teachers, "hand-writing" should not abandon. Recently, some scholars have proposed a Chinese character teaching approach that emphasizes "e-writing as primary and hand-writing as secondary" [28,29], while others support teaching only "e-writing" without "hand-writing" [30]. Different from various phonetic scripts such as Thai, Chinese characters are logographic, combining phonetics and semantics with a two-dimensional characteristic. "Hand-writing Chinese characters" plays a significant role in the localized teaching of Chinese characters. Writing characters are beneficial for quickly establishing the awareness of character structure, supporting the long-term motor memory related to characters [31,32]. Therefore, Thai character instruction should pay attention to "hand-writing." In future research, it remains necessary to validate the potential for integrating e-writing and hand-writing, where students first overcome their apprehension toward character learning through digital methods and then learn and become accustomed to hand-writing [33].

5. Conclusion

In this study, the accuracy of stroke order and character structure in their writing is quantitatively compared through a cross-sectional research design involving 76 Thai Chinese language learners of different proficiency levels. The results show that the stroke order and character structure accuracy of advanced learners are significantly higher compared to beginners. Furthermore, there is a notable positive correlation between the accuracy of stroke order and character structure among Thai learners. That is to say, higher

stroke order accuracy leads to higher character structure accuracy. However, the relationship between stroke order accuracy and character structure accuracy varies by proficiency level. For beginners, there is a significant positive correlation, while for advanced learners, the two are not correlated. The results of this study provide scientific evidence for the teaching of stroke order in Chinese character writing, which can help improve the efficiency of learning for Thai students under the constraints of classroom time. This plays a positive role in advancing the research on localized Chinese character writing. There are some limitations facing this study. The impact of stroke count was not examined. Due to the differences in stroke count, the complexity of character structure varies, and there is a need to further explore the relationship between stroke order and character structure across the characters with different stroke counts. Additionally, the relationship between character proficiency and overall Chinese language proficiency was not explored. Since Chinese characters are just one aspect of language learning, it is necessary to further explore the relationship between the two in terms of localized Chinese language instruction.

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