NANYANG TECHNOLOGICAL UNIVERSITY

SCHOOL OF HUMANITIES AND SOCIAL SCIENCES

A Look into Character Amnesia:

The Effects of Romanization on Character Knowledge in Chinese language

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A Final Year Project submitted to
the School of Humanities and Social Sciences,
Nanyang Technological University
in partial fulfillment of the requirements for the
Degree of Bachelor of Arts
in Linguistics & Multilingual Studies

2017

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Acknowledgments

This thesis would not have been possible without the help, support and guidance from several people…

To **Alice Chan**: For all your invaluable advice and suggestions on my project. Thank you for your guidance in firming up my project in the initial stages and providing me with the assurance that my project is doable. Your dedication in providing insights even when you're heavily pregnant is admirable. I thank you from the bottom of my heart!

To **Yvonne Lai**: I am thoroughly grateful for your generous guidance and support. The last few months of work could never have been done without your intellectual advises and encouragement. Words can never be enough to thank you for your kindness!

I am also extremely thankful to the lab's Project officer, **Galston Wong** for his help rendered in providing much-needed assistance with booking the labs and also, imparting his knowledge of the E-prime software and SPSS, which was crucial in collecting the required data.

Thank you to all **11 participants** for their patience and commitment to attend all three sessions. Data collection would not have been so smooth without their help.

This is in dedication to the many friends who provided me with love and encouragement…

To **Xinyi**: For being the one person that I can find solace with, even when you're a million miles away.

To **Joleen**: For your unwavering support for me. Thank you also, for helping me gather my participants.

To **Erin** (썼): Misery loves its company. Thank you for the four years of friendship and being there for the craziest part of my university life. School (and FYP) would not have been the same without you.

Thank you to all my friends who have stayed by me throughout the years

And for you, my B.

Last but not the least, I would like to thank my family for all their love and encouragement…

For all the support you've given me all these years,

Thank you.

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Abstract

Character amnesia is the experience of native speakers of logographic languages forgetting how to write their language. The advancement of technology and the use of pinyin input system have often been cited as reasons for the attrition of character knowledge. Using a within-participant design, eleven Malay participants was recruited to explore the relationship between the effects of using hanyu pinyin on the attrition of character knowledge (specifically in the aspects of character writing) in the Chinese language. There were a total of three sessions with a learning session (*pre-practice testing*), a practice condition session (*write, pinyin typing and word recognition*) and a final testing session (*post-practice testing*). Character knowledge attrition rate was measured through the decline of accuracy in the post-practice testing. Testing includes the *writing test, pinyin test, stroke test* and *word recognition test*. Overall results showed a direction in which writing practice leads to better performance as compared to words that are practiced through pinyin typing and recognizing of the character. In addition to that, words were performed better in stroke test as compared to the writing test, suggesting the occurrence of character amnesia. Future studies can look into ways to improve the issue of character amnesia.

(199 words)

Introduction

Have you ever visualised a character in your mind, yet find yourself unable to write it down? Many have experienced such an effect in the Chinese language, where an individual is able to visualize the word, but when attempting to write the character, it seemingly disappears from their mind and they forget how the character is supposed to be written. This is termed as character amnesia, a prevalent issue in South-East Asian languages that relies on a logographic writing system (Hilburger, 2016). In such a system, the basic graphemes are logograms and each character represents a word and has its own pronunciation which is undecipherable by its look. The introduction and use of Hanyu pinyin input methods with the advancement in technology has been cited as the underlying reason for this phenomenon due to the increased dependence on typing on technology instead of writing. This paper will attempt to explore the effect of usage of Hanyu pinyin on the writing of characters in the Chinese language.

Chinese language and its romanization – Hanyu Pinyin

As compared to the English language that has 26 letters, Chinese language has a complicated system of strokes and radicals. Chinese language is a logographic language which has an opaque orthography that is phonetically mute (Moser, 1991). That is, the pronunciation of the character is not apparent from the shape of the characters. Similarly, the sound of the character would not provide a clue of how the character looks like. This however has changed with the implementation of a new system of using Latin alphabets to write Chinese characters, widely termed as 汉语拼音 'Hanyu Pinyin'. For the purpose of this study, it will be referred to as *pinyin*. This system was introduced in the 1950s and quickly became the international standard for the spelling of Chinese adopted by the International Organization for Standardizaion (Fox, 2017). Pinyin allows for the description of character pronunciation and provides users of Chinese an informative way to read and recognize Chinese characters even if they are not skilled at recognizing the scripts. This system is known to have vastly increased literacy throughout China (Fox, 2017). For individuals who use Chinese, the system provides them with an efficient manner of inputting Chinese characters on devices such as mobile phones and computers. It is also one of the most popular methods of inputting Chinese characters in China and Singapore. Although it is not expected that the pinyin system will ever replace Chinese characters, there is a drop in the ability of individuals writing the Chinese characters. With the increasing number of people using pinyin and other phonetic

systems to write Chinese on electronic devices, some question if the ancient system of writing will die a natural death (Chew, 2015).

Prevalence of character amnesia and the lack of research

As described before, character amnesia is experienced by native speakers of Chinese and Japanese languages causing the tendency of them forgetting how to *write* their language. This phenomenon is suggested to be caused by the increasing reliance on input methods offered by modern technology (Hilburger, 2016). With decreasing necessity to physically write characters, it is not required for one to have full knowledge of the strokes that constitutes the character, which is the essential prerequisite to writing the Chinese characters, resulting in the loss of ability to write Chinese characters (Zimmermann, 2005).

There are some papers which discussed the issue of character amnesia (Marta, 2012; Nishimoto & Wei, 2015; Zimmermann, 2005). In China, Zimmermann (2005) received complaints from individuals that have forgotten how to write Chinese characters. This is cited with the reason that they use the computer all the time and don't remember how to write by hand anymore. There have also been news reports that schools in China have been told to run more calligraphy classes, citing that computer use and text messaging are ruining writing styles of children (BBC, 2011 as cited in Marta, 2012). This phenomenon can be further evidenced by a study by Nishimoto & Wei (2015) which tested 30 Chinese postgraduates' students on the writing of 54 frequently used Chinese characters. The words were chosen from a list of 100 frequently used Chinese characters that are often miswritten. It was found that participants only managed to remember 20% of the characters.

However, even with the increasing occurrence of character amnesia, there has been limited research on the topic – specifically in the writing of Chinese characters and effects of character input on technology. Most of the papers described the phenomenon and provided the theory that the use of pinyin input is the one of the reasons behind the knowledge attrition of writing of Chinese characters. However, there is no direct evidence to that theory. Therefore, the aim of this study is to explore the effects of the use of pinyin as an input system for Chinese language and to substantiate the possibility of that leading to the forgetting of writing Chinese characters. Specifically, would the use of pinyin input be detrimental to the memory of writing Chinese characters and consequently contribute to character amnesia in the Chinese language.

Effect of pinyin on learning the Chinese language

Most studies have been conducted with the focus on how pinyin can be detrimental to learning of the Chinese language. Guan, Liu, Chan, Ye, and Perfetti (2011) found that for second language learners, writing training has been observed to reinforce orthographic knowledge which is required for recognition of Chinese characters. Pinyin training, on the other hand, has been found to be helpful only in the area of phonological representation. That is, participants who were trained using pinyin had better phonemic awareness. Writing, on the other hand, enhanced the orthographic knowledge that is needed for word recognition. This finding is in line with Cao et al. (2010)'s neuroimaging study that suggests that only the act of writing refines visual-spatial information and neuromotor memories, which ultimately is useful in helping one recognise Chinese characters.

In these studies, writing training has been found to be beneficial for word recognition. However, pinyin training has found to be lacking in this element. To the best of the researcher's knowledge, no papers have looked at how the use of pinyin input may affect character knowledge, specifically character writing, in the long term. In other words, would the use of pinyin input lead to knowledge attrition of characters?

Technology and character learning

Past research has also investigated the relationship between technology and character learning. By testing primary school children in China, it was found that the use of the language input systems that are present in computers and phones is negatively correlated with the reading scores of children (Tan, Xu, Chang & Siok, 2012). This suggests that the use of pinyin typing has hindered their reading development. In a study to determine the effects of writing training and typing training, it was found that handwriting training has improved character recognition in older children (mean age of 4 year old) (Longcamp, Zerbato-Poudou, & Velay, 2005). This study observed English characters and has found substantial evidence to how writing practice is more beneficial to the recognition of characters. Similarly, a study that focused on the recall and recognition of English words found that participants' memorised words better with handwriting than keyboard typing in a free recall test (Mangen, Anda, Oxborough & Brønnick, 2015). Their findings suggest that by writing, there is a facilitation effect of a richer encoding of words to the long-term memory which is contributed by an enriched cognitive processing. This is due to the increased visual attention to the character when writing as compared to visual feedback from the screen.

In these studies, typing on technology devices has found to be detrimental in the recognition and memory of characters in both English and Chinese. Looking at character amnesia then, it leads to the question of whether the use of pinyin input system would lead to the attrition of character knowledge that was learned.

Current study

Much of the past research has concluded that the use of pinyin as an input system would have detrimental effects on the learning of Chinese language in the aspects of reading and memory of characters (Guan, Liu, Chan, Ye, & Perfetti, 2011; Tan, Xu, Chang & Siok, 2012; Mangen, Anda, Oxborough & Brønnick, 2015). There is, however, to the best of the researcher's knowledge, no research that has been done to investigate the effects of using pinyin on the attrition of character knowledge (specifically in the aspects of character writing). In addition, this research is designed to direct attention to the detrimental effect of the use of pinyin input system on one's ability to write Chinese characters accurately. Thus, this exploratory study aims to address the main research question:

1. Does the practice of pinyin input typing affect the recollection of writing in Chinese character?

At the same time, it aims to explore similar grounds on:

2. Which type of practice methods (writing/typing/word recognition) is the most effective in helping one to remember the characters?

By addressing these two questions, the effects of using pinyin input system on the long-term memory of writing Chinese characters can be further investigated. At the same time, the effect of the different practices (writing/pinyin input/word recognition) on recognising words and remembering the characters and ultimately writing them successfully can be explored as well. It is hypothesised that if one uses pinyin input system as a manner to produce Chinese characters, rather than the actual act of writing, they would find it more challenging to remember how to write the characters as supported by findings from Mangen, Anda, Oxborough & Brønnick (2015). Similarly, it is predicted that in the aspect of recognising characters, words that are practised using the pinyin input system would achieve a lower rate of recognition than those that are practised using the writing system.

In the attempt to study the effects of pinyin usage on the attrition of character knowledge, the methodology of this study requires participants with no Chinese background to learn Chinese characters. After learning the characters, they will be introduced to three practice conditions;

writing, pinyin typing and word recognition, before being tested a week later on their long-term memory for their writing, stroke, pinyin typing and recognition ability.

Methodology

Participants

Eleven undergraduates (9 females and 2 males; M_{age} = 22.27 years, SD = 2.61) from two Singapore universities (Nanyang Technological University and National University of Singapore) took part in this study. Participants were all bilingual in English and Malay. None of the participants had knowledge of Chinese characters. After a briefing on the procedure of the study, participants were required to sign the consent form and to fill in the code identifier questionnaire and the participant information questionnaire, regarding their language background. All participants were healthy individuals with normal eyesight and they were required to pass an audiometric screening for the frequencies 500Hz, 1000Hz, 2000Hz and 4000Hz at 25dB. Monetary compensation was given to participants at the end of the study.

Materials and Stimuli

Three groups of Chinese characters were selected to be implemented in a within-group design and were randomly assigned to the three experimental conditions in the study. Words with lesser strokes were specifically chosen to facilitate the learning process, taking into account that participants have no background in Chinese. The three groups had similar graphic complexity, total stroke counts and belonged to similar character structure categories (as appended in Appendix A). The symmetrical features of characters were taken into account as it was found that symmetrical structure and stroke number characters play an important role in visual recognition of Chinese characters (Chen & Huang, 1999).

Stimuli were all presented through a 13-inch computer using the E-prime software and the sounds were played through headphones.

Practice sheets were provided during the **learning sessions** (as appended in Appendix B).

There was four-part to the **testing** and they were either required to write on the test paper provided (as appended in Appendix C) or to input their answers on the computer by typing on the keyboard:

1. **Writing test:** the sound of the character was played and participants were to write the corresponding character in the test paper provided. This tests participants' knowledge of character writing.

2. **Pinyin test:** the character was presented on the screen and participants were to type in the corresponding pinyin, testing their character-pinyin knowledge.

3. **Stroke test:** the character was presented on the screen and participants were to write down the character stroke by stroke. This tests their knowledge of the sequence of strokes to the character.

4. **Recognition test:** a character was presented and an audio was played at the same time. Participants were to decide whether the character and audio correspond to each other. This tests on whether participants are able to recognise and match the character with the pronunciation.

Procedure

The study comprised of three phases: learning, practice and testing. Prior to the learning session, participants were given a character preview recognition test (as appended in Appendix D) to ensure that they do not have any knowledge of the Chinese characters that are involved in the study. Figure 1 below summarises the procedure of the study.
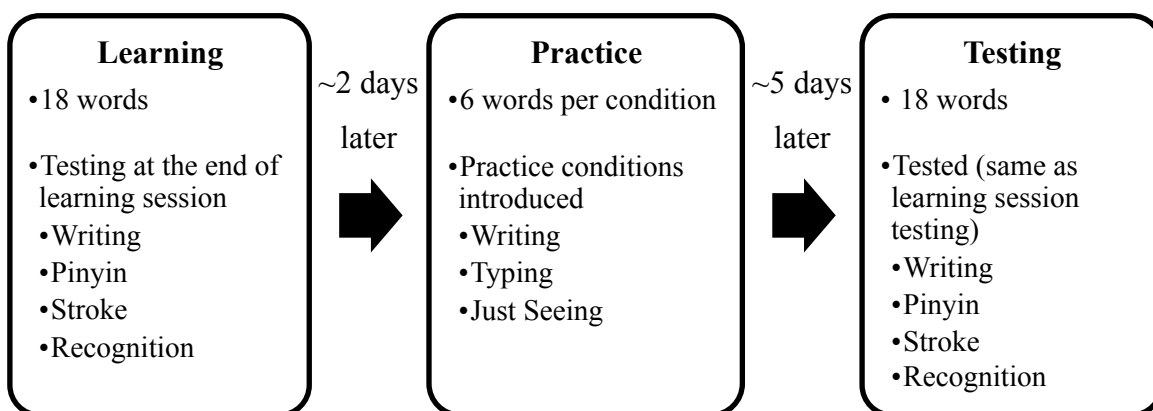

Learning	Practice	Testing
•18 words	•6 words per condition	• 18 words
•Testing at the end of learning session	•Practice conditions introduced	•Tested (same as learning session testing)
•Writing	•Writing	•Writing
•Pinyin	•Typing	•Pinyin
•Stroke	•Just Seeing	•Stroke
•Recognition		•Recognition

~2 days later ~5 days later

Figure 1. The process of study procedure.

Learning phase

In the learning phase, participants were exposed to a total of 18 characters, separated into four sessions with 4 to 5 words being learned per session. The whole learning phase lasted for an hour and an additional 15-20 minutes for participants who needed more time to revise characters that they got incorrect during the post-practice testing. Figure 2 illustrates the learning procedure.

Participants sat in a quiet room with a 13-inch monitor in front of them. They were exposed to the Chinese characters, the corresponding pronunciation and also the Pinyin of the Chinese characters. Each character was presented one at a time with participants moving on to the next character at their own pace. They were given a practice writing paper and instructed to

fill in the corresponding character that was shown on the screen. Each character was practised a total of 18 times. They were briefed on the four different tests that they will go through at the end of the learning phase and were told specifically to learn the writing of the characters.

In each session, a short mini quiz after the exposure of characters was included to reinforce their learning. The quiz includes the *writing test, pinyin test, stroke test* and *recognition test* (as previously mentioned in the materials and stimuli section). Participants were given additional time for revision of wrong characters. After two learning sessions, there was a mid-review quiz for the 9 words learned. The pre-practice test has the same test format as the quizzes.

Participants who did not score 100% in the pre-practice test were given an extra 15-20 minutes to revise the characters that they got incorrect and were later tested again till 100% accuracy. On average, 80% of the participants required the additional revision time.
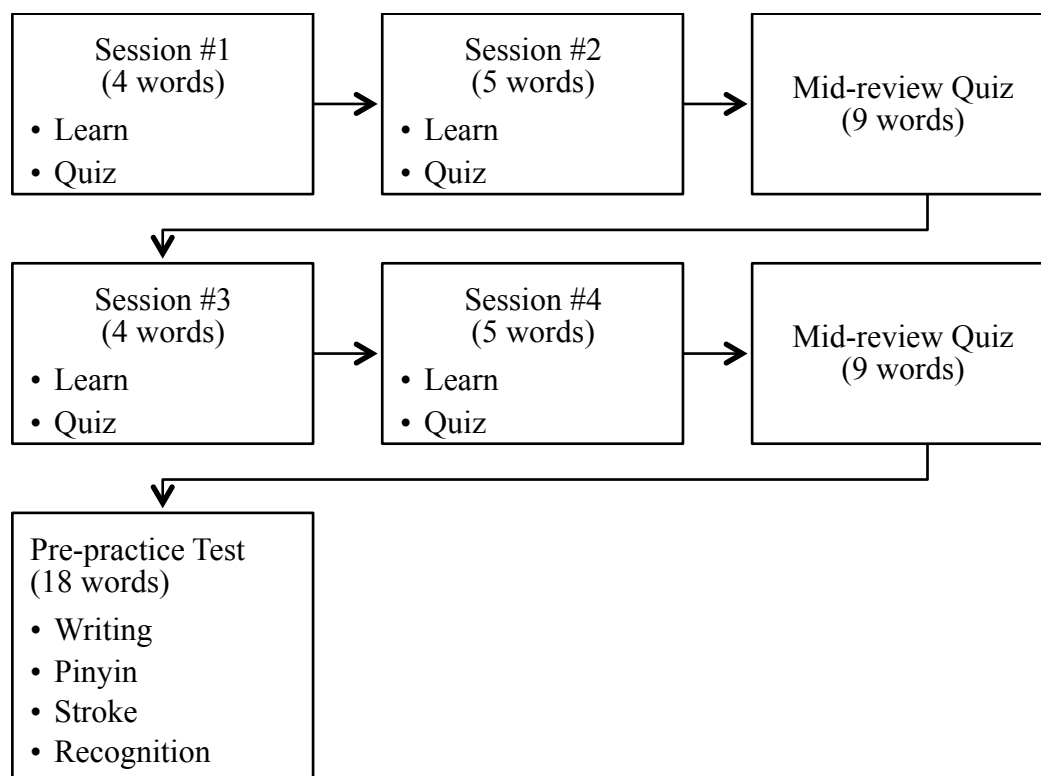

Figure 2. The procedure of the learning phase.

Practice phase

The practice session was conducted 2-5 days after the learning session ($M = 2.55$, $SD = 2.58$). The practice session lasted approximately an hour and the characters are presented to them at random on a computer screen. The three practice conditions were introduced – writing,

typing and word recognition. Within each condition, participants perceived the characters via two different modalities:

> *Writing:* Participants were to **write** the corresponding character when they *hear* the word; or when they *see* the pinyin characters.

> *Pinyin*: Participants were to **type** in on the computer the corresponding pinyin characters when they *see* the word; or when they *hear* the word

> *Word recognition*: Participants were to **decide** whether the character on the screen corresponds to what they *hear*; or to the pinyin characters *they see* on the screen.

Testing phase

The testing session was conducted 5-7 days later after the practice phase ($M = 5$, $SD = 1.84$). In the testing phase, a test of the same format as in the post-practice test of the learning phase was given to the participants. There were the same four sections to the post-practice test – a writing test, pinyin test, stroke test, and recognition test. The percentage of accuracy from the post-practice testing is then computed for each condition for data analysis.

Results

Checking for significance of difference in accuracy before & after practice conditions

Two paired-samples t-tests were conducted to compare the decline of accuracy in the post-practice testing after the practice conditions based on the practice conditions. This was to check if there was a significant difference in ability to recall the characters between the learning session test (of a 100% accuracy) and the post-practice testing.

Pre-practice testing

For the testing that follows the learning session (pre-practice testing), participants were expected to achieve a 100% accuracy. This was then compared with the performance in the testing during the final session (post-practice testing). A decline of accuracy was expected in the post-practice testing due to possible memory decay.

Accuracy based on practice conditions (comparing before & after the practice phase)

A paired-samples t-test was employed to compare the accuracy performance in the post-practice testing after different practice conditions, i.e. writing, pinyin typing, and word recognition. There was a significant difference in the performance for all the practice conditions in comparison with the pre-practice testing; in the writing condition ($M = 91\%$, $SD = 0.13$) ($t(43) = 4.25$, $p < .01$); pinyin typing condition ($M = 89\%$, $SD = 0.15$) ($t(43) = 4.62$, $p < .01$); and the word recognition condition ($M = 87\%$, $SD = 0.17$) ($t(43) = 4.86$, $p < .01$) (as

shown in Figure 3). This result indicates that there were a substantial drop in ability to recall the Chinese characters in every practice condition.
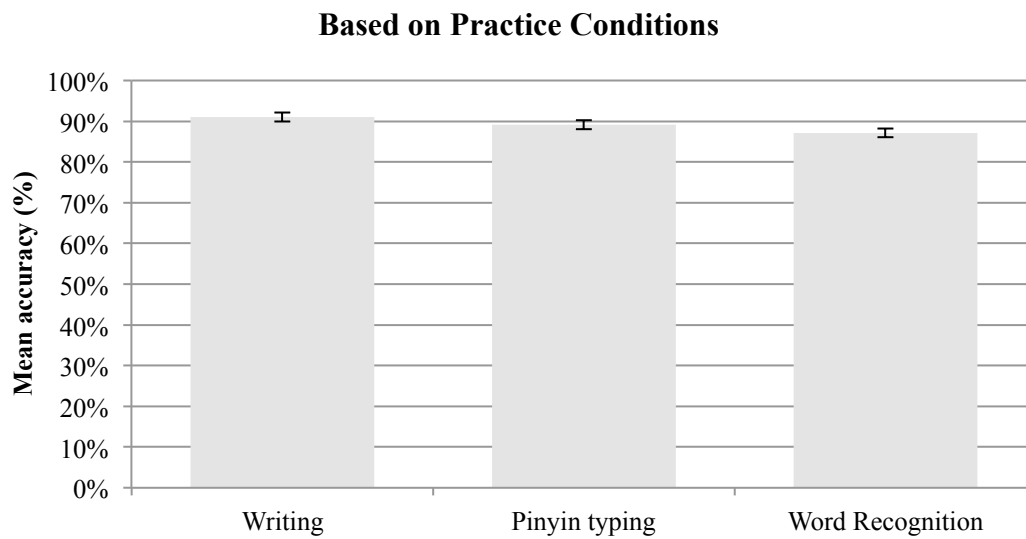
Based on Practice Conditions

Figure 3. Mean accuracy (proportion correct) in the post-practice testing based on the practice conditions.

Accuracy based on test types (comparing before & after practice conditions)

Similarly, paired-samples t-tests were conducted to compare the performance in the post-training phase based on the four types of tests, i.e. writing, pinyin, stroke and recognize. There was a significant difference in the accuracy for all the four tests (as shown in Figure 4) – writing test ($M = 79\%$, $SD = 0.18$) ($t(43) = 6.11$, $p < .01$); pinyin test ($M = 86\%$, $SD = 0.17$) ($t(43) = 4.38$, $p < .01$); stroke test ($M = 92\%$, $SD = 0.10$) ($t(43) = 3.97$, $p < .01$); and recognition test ($M = 97\%$, $SD = 0.04$) ($t(43) = 2.62$, $p < .05$). The results suggest that for all the tests, there is a substantial drop in ability to recall the characters.
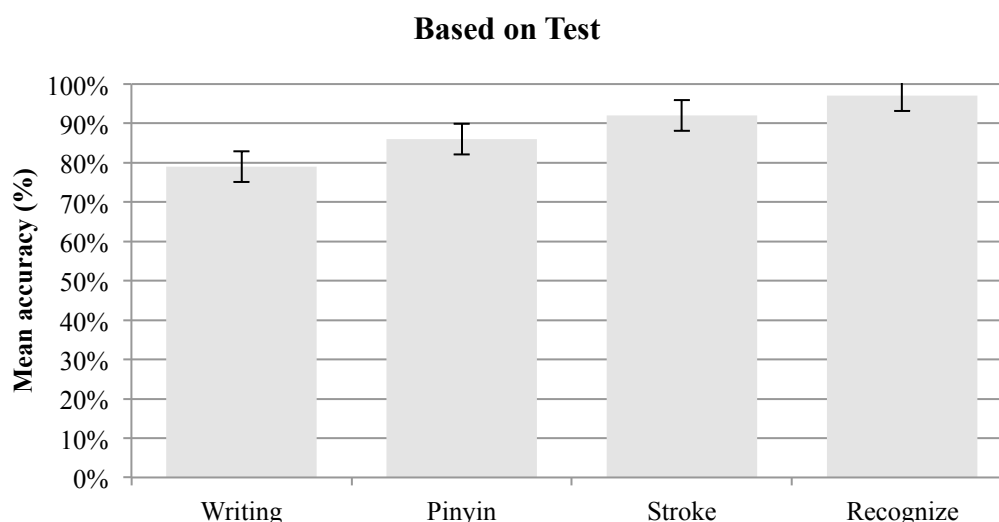
Based on Test

Figure 4. Mean accuracy (proportion correct) in the post-practice testing based on the test types.

As can be observed through the statistical analysis of the performance of the pre- and post-practice tests, there was a substantial drop in accuracy in the post-practice tests after the practice phase and thus, signifying that there was a noteworthy effect.

Effects of practice conditions in the post-practice testing tests

A 3 (practice conditions: writing vs. pinyin vs. word recognition) × 4 (test types: writing vs. pinyin vs. stroke vs. recognition) repeated measures ANOVA was conducted to compare the effect of practice conditions on the four different types of tests. Figure 5 presents the accuracy performance of the four types of tests across the three practice conditions.
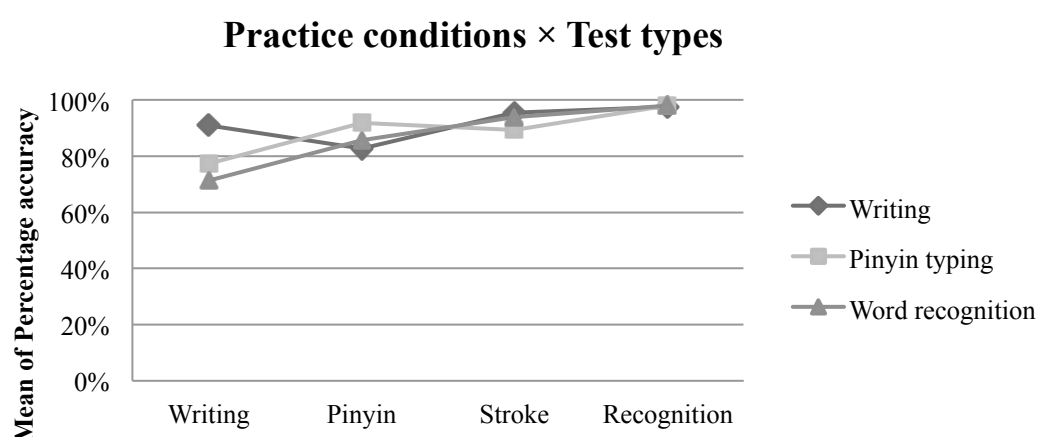
Practice conditions × Test types

Figure 5. Accuracy performance on the four types of tests (writing, pinyin, stroke, and recognition test) throughout the three practice conditions (writing, pinyin typing, and word recognition).

The main effect of practice conditions was not significant ($F(2,20) = 2.30$, $p = .125$). This suggests that across the conditions, they were not much significantly different from each other. By visually viewing the results (see Figure 3), however, there was a trend with writing practice had a better practice effect as compared to pinyin typing and followed by word recognition condition.

The main effect of test types was significant ($F(3,30) = 10.89$, $p < .01$). The results suggest that participants performed significantly different on the test of writing, pinyin, recognition, and stroke. Post hoc analysis showed that there was a significant difference between the writing test and recognition test ($t(32) = -5.46$, $p < .01$). This indicates that the accuracy rate for the writing test was significantly lower than that in the recognition test. This suggests that participants performed much better in the recognition test as compared to the writing test. There was also a significant difference between the pairs of the writing test and stroke test ($t(32) = -3.97$, $p < .01$). This indicates that when participants were looking at the character, they knew the exact stroke of the character and performed better at the test as compared to the writing test. Finally, the comparison for the performance between the stroke test and recognize test was also significant ($t(32) = -2.40$, $p < .05$). The finding indicates that participants performed better at the recognition test than the stroke test. There was, however, no significant difference in the accuracy between the writing test and pinyin test ($t(32) = -1.71$, $p = .096$) and also, between the pinyin test and stroke test ($t(32) = -1.94$, $p = .060$). The results showed that regardless of the way they practice the characters, participants performed significantly better in the recognise test in comparison with the stroke test, pinyin test and writing test. They also performed better in the stroke test as compared to in the writing test.

The interaction of the practice conditions and test types was significant ($F(6,60) = 3.24$, $p < .01$). Paired samples t-tests were used to make post hoc comparisons between test types to examine the interaction effect within practice conditions. In the writing practice condition, there was a significant difference between the pinyin test ($M = 82\%$, $SD = 0.16$) and the recognition test ($M = 97\%$, $SD = 0.04$) ($t(10) = -3.32$, $p < .01$). There was also a significant difference between the pinyin test and the stroke test ($M = 95\%$, $SD = 0.07$) ($t(10) = -3.02$, $p < .05$). This suggests that for the words that were practiced through writing, participants performed significantly poorer in the pinyin test as compared to the recognition test and the stroke test. In the pinyin condition, there was a significant difference between the writing test ($M = 77\%$, $SD = 0.21$) and the pinyin test ($M = 91\%$, $SD = 0.11$); ($t(10) = -2.37$, $p < .05$) as well as the writing test and the recognition test ($M = 97\%$, $SD = 0.05$); ($t(10) = -2.92$, $p < .05$).

This indicates that participants performed significantly poorer at the writing test as compared to pinyin test and recognition test when words were practiced through pinyin typing. In the word recognition condition, there was a significant difference between the writing test (M = 71%, SD = .15) and stroke test (M = 93%, SD = .08); ($t(10)$ = -4.03, p < .01). There was also a significant difference between writing test and recognition test (M = 97%, SD = .05); ($t(10)$ = -6.33, p < .01). This indicates that participants performed significantly poorer at the writing test as compared to stroke test and recognition test when words were practiced through the word recognition condition.

Discussion

The aim of this study was to examine whether the practice of pinyin typing would affect the recollection of characters in writing. By assessing the accuracy rate after the practice conditions, we can measure the character knowledge attrition of participants. The higher attrition rate suggests for that participant has forgotten more characters and by comparing between different practice conditions, we can deduce how each practice have an effect on learned characters. It is hypothesised that if one uses pinyin input system as compared to writing as a method to produce Chinese characters, they would find it much more difficult to remember how to write the characters. Another research question that this study wanted to explore was to find out which type of practice (writing/typing/word recognition) is the most effective in helping one to remember the characters.

Examining main effects of tests

The significant results observed for the main effects in tests reflect the difficulty level of the tests – participants performed the best at the recognise test, followed by the stroke test, pinyin test, and finally the writing test. This trend is in line with the notion that writing is a more difficult skill to master and requires more effort whereas recognising a character and sound is easier (Moser, 1991).

In addition to that, the results indicate that participants performed better at the stroke test in comparison with the writing test. This significant difference suggests that when looking at the character, participants can perform well in writing the stroke in the correct order. However, they fail in writing the character correctly when hearing the audio. This mimics the phenomenon of character amnesia in which one is able to recognize the character, but having the tendency to forget how to write it. Therefore, this provides evidence to a real case of character amnesia.

Examining main effect of practice conditions

There was no significant difference between the mean accuracy of writing practice, typing practice and word recognition practice condition. Nevertheless, from the graph (refer to Figure 3), we can observe a trend with writing practice, that is, a higher accuracy rate, which translates to a lower overall knowledge attrition. This is followed by typing practice and word recognition practice conditions. Even though there are no significant results indicating a substantial difference in accuracy rate, the trend in the results point us in the direction that the words that are practised through the writing condition have a higher accuracy rate in the writing test, whereas words that are practised through pinyin typing fall behind in both writing and stroke test. This supports the hypothesis that writing practice has a greater effect in helping one to maintain their character knowledge. In addition to that, pinyin typing was found to have a higher attrition rate.

Examining the interaction effects of practice with the tests

The findings from the study conducted by Guan, Liu, Chan, Ye, and Perfetti (2011) lends support to the findings in this study; writing strengthens orthographic knowledge and pinyin strengthens the phonological aspect of language (i.e. they would be better at the pronunciation of characters). The current study (refer to Figure 5) shows that for words that have gone through the writing practice, they had a higher accuracy rate in the writing test and had a lower accuracy rate for pinyin test. On the contrary, for words that had gone through the pinyin typing practice, they had a higher accuracy in the pinyin test but a lower accuracy rate for the writing test. This suggests that each practice method may be playing a specific, albeit separate role in maintaining learned words. That is, writing helps in retaining more of the character writing aspects whilst reducing the reliance on pinyin (and thus, leading to the decline in accuracy rates in the pinyin task). On the other hand, practice that was done through typing tends to put more focus on pinyin, and the character as a whole rather than the intricate strokes that make up the character. This can be further substantiated by the observation that in the stroke test, words that have gone through the writing practice had a higher accuracy rate as compared to the pinyin typing practice. This seems to suggest that writing practice has an element that allows one to remember the strokes that makes up the character and pinyin typing lacks in that element. This is in line with past research which suggests that the advantage of writing may come from a sensory-motor source. Writing has found to benefit one in gaining sensory-motor memory traces that supports character formation suggested to be benefited by the improved memory for characters (Cunningham &

Stanovich, 1990; Naka, 1998; Shadmehr & Holcomb, 1997). Therefore, when individuals increase the usage of pinyin as an input method, it may lead to them forgetting how to write the characters.

Lastly, when words were practised just by looking at the character and deciding if the audio corresponds to the character, participants performed poorly at writing test in comparison to stroke test and recognition test. As stated, the prerequisite to writing words includes the orthographic knowledge of character. Therefore, poor performance observed in the writing test suggests that words that are practiced through just looking does not help in the deep practice of the character.

Limitations and future research

This study was primarily interested in the use of pinyin input and its effect in character knowledge attrition. It is acknowledged that the methodology was a simplistic one, but it took a logical path of attempting to compare the performance before and after conditions. The use of participants that have no Chinese background to explore the attrition of Chinese character knowledge is a novel initiative but may come with limitations. Given that the brain neural networks are found in specialized brain regions that process logographs (Tan et al., 2001), the effect in these non-Chinese participants may not be generalizable to Chinese individuals who have a language experience and established brain neural networks in discerning Chinese characters. Future studies could replicate this study on Chinese individuals to substantiate the effects of the use of pinyin by using less frequently used words or an artificial language.

Participants did mention that the words were actually quite easy to remember and thus, the characters chosen for this study could have been too simple. However, that was in consideration of time limitations of the study session and the fact that participants had no knowledge of the Chinese language. Future studies could choose more complicated words that include more of the nonsymmetrical characters as they would be more challenging to learn (Chen & Huang, 1999).

Lastly, this study is limited by the small sample size of 11 participants. Nevertheless, the directionality does point us in the hypothesised direction. Thus, future studies, could enroll more participants to further substantiate the findings of this study.

<div align="center">

Conclusion

</div>

The advancement of technology has inevitably led to individuals typing more and writing less by hand. Even though they may be able to recognise the character and link them to the

corresponding phonemic representations, they are unable to write the characters. The current project substantiates the phenomenon of character amnesia and demonstrates that the use of pinyin typing may have a detrimental effect to the maintenance of Chinese language in the aspect of character writing. A practical implication of the study is to raise awareness of character amnesia and the reason behind the attrition in character knowledge, allowing Chinese or Japanese individuals to rectify this issue in their own ways. On the same note, future research can also work on the phenomenon of character amnesia to find ways to improve the situation.

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I

Appendix A:
Character Stimuli

Condition	Word	Strokes	Pinyin	Symmetrical
Writing	水	4	shui	No
Pinyin typing	月	4	yue	No
Word recognition	元	4	yuan	No
Writing	大	3	da	Yes
Pinyin typing	木	4	mu	Yes
Word recognition	天	4	tian	Yes
Writing	小	3	xiao	No
Pinyin typing	门	3	men	No
Word recognition	亡	3	wang	No
Writing	工	3	gong	Yes
Pinyin typing	日	4	ri	Yes
Word recognition	皿	5	min	Yes
Writing	开	4	kai	No
Pinyin typing	牛	4	niu	No
Word recognition	火	4	huo	Yes
Writing	仇	4	chou	No
Pinyin typing	仅	4	jin	No
Word recognition	汗	6	han	No

Appendix B:
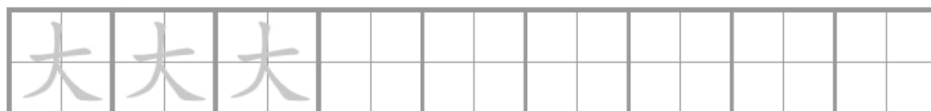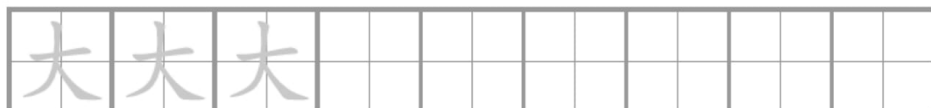**Worksheet for learning session**
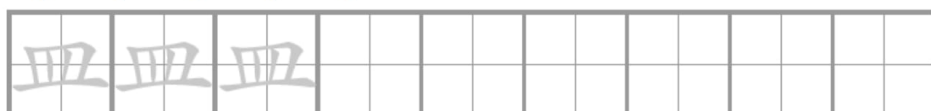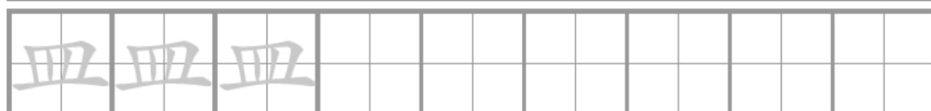
Participant No: _____

LEARNING SESSION 1

Please practice writing the characters and fil in all the boxes. There are three examples for you to trace.
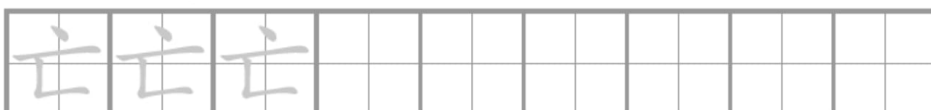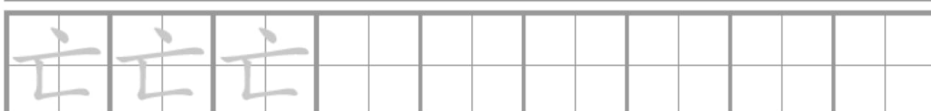
开 开 开 开   kai

元 元 元 元   yuan

木 木 木 木   mu

日 日 日 日   ri

TRIAL TEST SESSION 1

PART I
Listen to the audio and write down the corresponding character

1	
2	
3	
4	

PART II
Write the character based on strokes

For example:
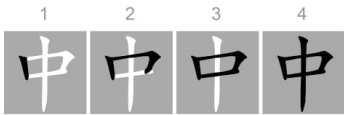
	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

Participant No: _____

LEARNING SESSION 2

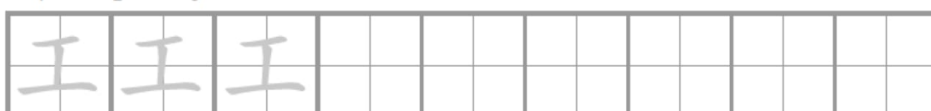Please practice writing the characters and fill in all the boxes. There are three examples for you to trace.

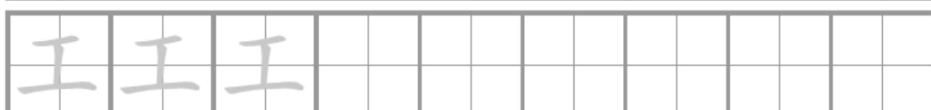大 大 大 da

皿 皿 皿 皿 皿 min

亡 亡 亡 wang

工 工 工 gong

(The word 汗 [han] is on the next page)

Participant No: _____

汗 汗 汗 汗 汗 汗   han
1　2　3　4　5　6

汗	汗	汗									

汗	汗	汗									

(Turn over next page for the trial test session)

VI

Participant No: _____

TRIAL TEST SESSION 2

PART I
Listen to the audio and write the character

1	
2	
3	
4	
5	

PART II
Write the character based on strokes

For example:
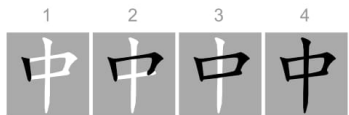
	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

LEARNING SESSION I TEST

PART I
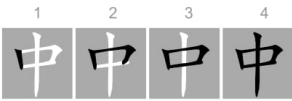Listen to the audio and write the corresponding character

1		4		7	
2		5		8	
3		6		9	

Part II
Write the character based on strokes

For example:

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

Participant No: _____

LEARNING SESSION 3

Please practice writing the characters and filling in all the boxes. There are three examples for you to trace.

月 月 月 月　　yue

牛 牛 牛 牛　　niu

水 水 水 水　　shui

仅 仅 仅 仅　　jin

(Turn over next page for the trial test session)

TRIAL TEST SESSION 3

PART I
Listen to the audio and write down the corresponding character

1	
2	
3	
4	

PART II
Write the character based on strokes

For example:
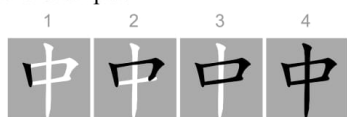
	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.
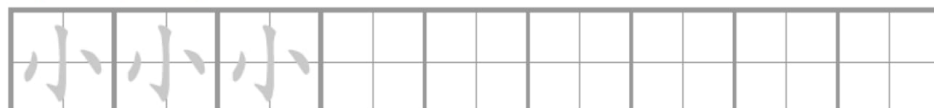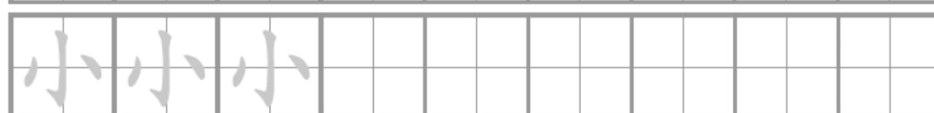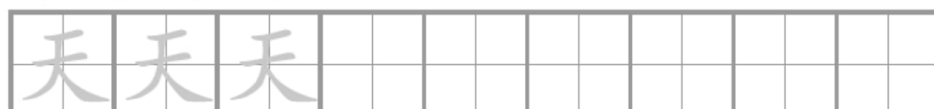
LEARNING SESSION 4
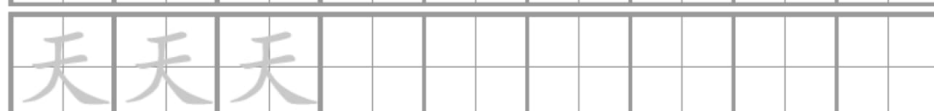
Please practice writing the characters and filling in all the boxes. There are three examples for you to trace.

小 小 小   xiao

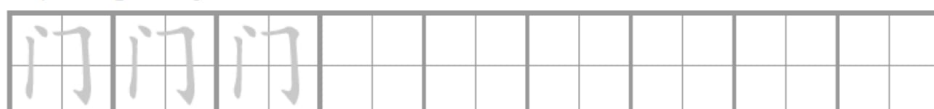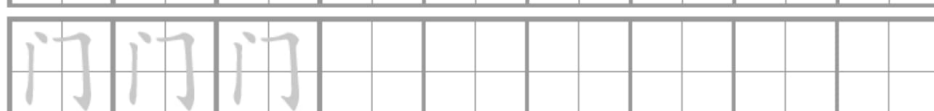小 小 小

小 小 小

天 天 天 天   tian

天 天 天

天 天 天

门 门 门   men

门 门 门

门 门 门

火 火 火 火   huo

火 火 火

火 火 火
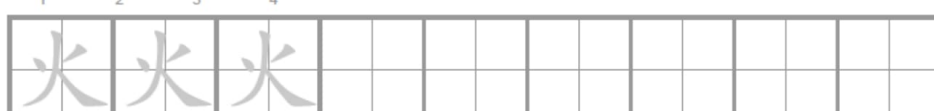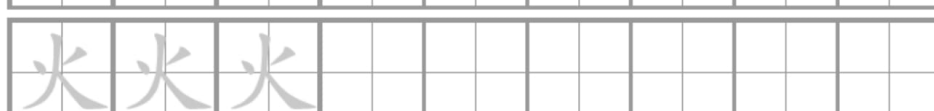
(The word 仇 [chou] is on the next page)

仇 仇 仇 仇   chou
1 2 3 4

仇 仇 仇

仇 仇 仇

(Turn over next page for the trial test session)

TRIAL TEST SESSION 4

PART I

Listen to the audio and write the character

1	
2	
3	
4	
5	

PART II

Write the character based on strokes

For example:
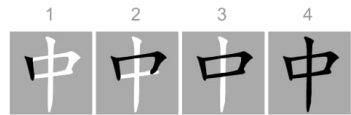
	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										

PART III

Type in the Romanized character on the computer

PART IV

You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

Participant No: _____

SESSION II TEST

PART I
Listen to the audio and write the corresponding character

1		4		7	
2		5		8	
3		6		9	

Part II
Write the character based on strokes

For example:

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

Appendix C:
Pre-practice (learning session) & Post-practice (final session) test

Participant No: _____

TEST FOR LEARNING

PART I
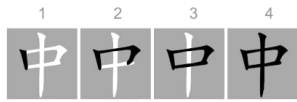
Listen to the audio and write the corresponding character

1		10	
2		11	
3		12	
4		13	
5		14	
6		15	
7		16	
8		17	
9		18	

Part II
Write the character based on strokes

For example:

1	中			
2	中			
3	中			
4	中			

	1	2	3	4	5	6	7	8	9	10
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										

PART III
Type in the Romanized character on the computer

PART IV
You will see a character on the screen and hear an audio play. Press 1 if the two corresponds. If not, press 0.

Appendix D:
Character preview recognition test

水	月	元
shui	yue	yuan
小	门	亡
xiao	men	wang
工	日	皿
gong	ri	min
大	木	天
da	mu	tian
开	牛	火
kai	niu	huo
仇	仅	汗
chou	jin	han