Writing to read: the case of Chinese

Qi Zhang
School of Applied Languages and Intercultural Studies, Dublin City University
qi.zhang@dcu.ie

Ronan G. Reilly
Department of Computer Science
Maynooth University
ronan.reilly@nuim.ie

Abstract

This paper describes two experiments that explore the potential role of Chinese character writing on their visual recognition. Taken together, the results suggest that drawing Chinese characters privileges them in memory in a way that facilitates their subsequent visual recognition. This is true even when the congruency of the recognition response and other potential confounds are controlled for.

1 Introduction

With China's rapid economic rise, the Chinese language is becoming more of a practical and attractive subject for university students across the world. There has, consequently, been an increase in the popularity of learning Chinese as a foreign language (henceforth, CFL). According to a report in the Financial Times (Pignal, 2011), only one in 300 elementary schools include Chinese in their curriculum, while one in every 30 was teaching Chinese language by 2008 in the US. In the UK, the number of CFL learners in higher education institutions increased by 125% between 1996 and 2007 (Hu, 2010).

Despite the growing demand to learn Chinese, there have been general concerns regarding the difficulties of studying the language. Since the Chinese writing system is logographic in nature, it is significantly different from any European languages that use Roman-derived alphabets. For this reason, one of the main challenges for CFL learners is to learn Chinese characters (Shen, 2004: 168; Wang et al., 2003; Everson, 1998: 196).

2 A brief introduction to Chinese orthography

Before we look into the relationship between writing and reading, it is necessary to provide a brief overview of Chinese orthography. There are three tiers in the orthographic structure of a Chinese character: stroke, radical, and character (Shen and Ke, 2007). Usually, several strokes function as building blocks to construct a radical, and one or more radicals are used to form a character.

There are generally two kinds of Chinese characters: integral and compound (Shen and Ke, 2007; Wang et al., 2003). The former are composed using one radical only, while the latter consist of two or more radicals. For example, 女 (nǚ) means female and 马 (mǎ) denotes the meaning of a horse. When these two integral characters serve as left and the right radicals, their combination becomes a compound character 妈 (mā) meaning mother. A compound character usually has a semantic radical (i.e., 女 meaning female in the character of 妈) that denotes the meaning of that character and a phonetic radical (马 pronounced as mǎ) that provides insights into the pronunciation of the compound character.

Although the Chinese writing system has a pictographic origin, it also has a Romanised form – pinyin – to represent its phonology (Shen and Ke, 2007; Bassetti, 2005; Wang et al., 2003). Each Chinese character can be transcribed into pinyin including onset, rime and tone (Wang et al., 2004). As shown in Table 1 below, 女is represented by pinyin nǚ. 'n' is the onset, 'ǚ' is the rime and the symbol above it indicates the tone of this character.

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	integral character /semantic radical	integral character /phonetic radical	compound character
	女	马	妈
Pinyin	nǚ	mǎ	mā
English	female	horse	mother

Table 1. An example of a Chinese compound character

The sharply contrasting differences between the phonology and orthography of Chinese present a challenge to adult CFL learners who have an alphabetic first language. Due to familiarity with alphabetic-like phonological representation of Chinese, they tend to develop an unbalanced acquisition of phonology and orthography. Typically, this involves a faster acquisition of phonology than orthography (Everson, 1998). Indeed, it is very common for CFL beginners to go through a mapping exercise in their mind between the logographic characters and alphabet-like phonology, as well as semantics, in reading. In other words, they attempt to associate form with sound and meaning when learning to read (Cao et al., 2013a; Xu et al., 2013; Shen, 2004).

Despite the complexity of orthographic representation in Chinese reading, CFL language classroom traditionally pays little attention to supporting adult learners facing difficulties arising with Chinese reading (Chang et al., 2014). There have been three different curricula used in CFL classrooms in general (Zhang and Lu, 2014; He and Jiao, 2010).

The 'unity type' encourages CFL beginning learners to develop all four language skills (i.e., listening, speaking, reading and writing) at the same time. In order to achieve the same proficiency in four skills, far more lecture hours have to be spent on learning to write. The second one is the 'delay' type, which simply delays learning to read and write. This curriculum disadvantages CFL ab initio learners in a way that they are unable to read or write Chinese after a certain period of studying. The 'lag' curriculum emphasises listening and speaking while some Chinese writing – but not everything that CFL beginners have acquired in oral/aural skills – is taught at the early stage. However, this may lead to a discrepancy between listening/speaking and reading/writing skills at a later stage. Therefore, the choice of curriculum depends on when it may be best to introduce reading and writing skills to adult CFL beginners.

The current study investigated whether orthographic knowledge acquired through writing significantly contributed to reading development in a group of Irish adult beginning CFL learners all of whom had an alphabetic-first language background.

3 Writing-on-reading in Chinese

As pointed out by Guan et al. (2011), the phonological representations of words are usually strengthened when learning to read an alphabetic writing system. This is based on the assumption that 'orthographic knowledge is intimately tied to the phonological constituent of a word' (Guan et al., 2011; see also Cao et al., 2013b). Since alphabetic writing is based on a number of orthographic units (i.e. letters) that can be mapped onto phonemes and recombined to form written words, reading proficiency depends on success in establishing the phonological connections to orthography (Cao et al., 2013b; Tan et al., 2005). In this case, alphabetic reading can be helped by learning orthographic representations, which in turn contribute to the development of writing skills. On the other hand, the contribution of writing to reading development may be moderate in English or any alphabetic languages compared to Chinese (Cao et al., 2013b; Guan et al., 2011).

Orthographic knowledge of Chinese does not correspond to systematic phonological representations, since the language uses a logographic writing system. There is little or no systematic grapheme-phoneme correspondence in Chinese script (Xu et al., 2013). Specifically, the basic Chinese writing units (i.e., strokes) are not mapped to phonemes (Guan et al., 2011). Although a phonetic radical of a compound character can be connected to the phonological awareness of this character in Chinese, the connection is much less intimate than in alphabetic languages (Cao et al. 2013b). As can be seen in the example of the character '妈', the connection of the phonetic radical '马' (mǎ) is associated with the phonological representation of '妈' (mā) at the syllabic level rather than the phoneme level. The same can be applied to '吗' (ma, being used at the end of a sentence functioned as a question mark), '骂' (mà, meaning to scold), but not to a number of other characters such as '驾' (jià, meaning to drive a horse), '驴' (lǘ, meaning donkeys). Therefore, the grapheme-phoneme correspondences are not reliable in Chinese (Shu, et al. 2003).

In addition, Chinese consists of a large number of homophones, which allows a syllable to correspond to many different characters with various meanings. Therefore, phonological information is unlikely to be as reliable as the orthographic form of a character in reading comprehension (Cao et al. 2013a; Tan et al. 2005).

For this reason, in comparison to alphabetic representations, orthographic rather than phonological awareness might be a more effective factor in Chinese reading achievement. Consequently, writing characters could be a more critical component of learning to read. In a study of Chinese children's reading, Tan et al. (2005) found that the writing performance of beginning readers is strongly associated with their reading skills. In other words, for native speakers who are exposed to Chinese in daily life and so have developed phonology-to-semantics link before formal schooling, their development in writing serves as a more significant contributing factor to their reading fluency than phonological awareness. Another study of Chinese children (Li et al., 2002) found that a significant contributing factor in reading proficiency was morphological awareness. At the character level, a single character usually represents a single morpheme and a character usually needs to combine with another one to form a word. Therefore, it is essential for Chinese learners to be able to recognise a character and activate the morphological knowledge from the visual input in order to go from comprehension of a word, to a phrase, and then to sentences and texts. For this reason, writing a character, rather than pronouncing it, is more likely to play an effective role in developing learners' morphological knowledge and consequently in learning to read Chinese (Packard et al., 2006). Apart from research on native Chinese speakers, Guan et al. (2011) conducted a study of adult CFL learners and found that handwriting characters, instead of pinyin-typing or reading-only conditions, produced greater accuracy in subsequent lexical decision and semantic tasks.

In addition, Chinese writing is different from alphabetic writing since the Chinese characters 'are packed into a square configuration, possessing a high, nonlinear visual complexity' (Tan et al., 2005). Guan et al. (2011) pointed out that Chinese orthography 'involves the coupling of writing related visual and motor systems'. This coupling may help establish the spatial configuration of strokes and radicals, which along with a temporal sequence of motor movements associated with stroke composition, completely defines the shape of the character (Cao et al., 2013b; Guan et al., 2011). Therefore, significant spatial analysis is intrinsic and highly organised motor activity is involved in writing a Chinese character (Tan et al., 2005).

Cao et al. (2013b) state that writing Chinese characters might facilitate the development of a visual-spatial memory, which also has a motor memory trace. Since motor memories can last for a very long period of time (Shadmehr and Holcomb, 1997), this writing-related motor information can be additional assistance for the activation of visual information in the process of Chinese character recognition. In other words, handwriting may pair the movement patterns, usually stroke sequencing through well-practiced writing (Parkinson et al., 2010), with the language stimuli, namely characters. This pairing-up can help establish long-lasting motor memories of Chinese characters which are exploited in the orthographic recognition process. This language-specific proposal is based on the concept of 'embodied cognition'. That is to say, a person must 'internally "run" or "simulate" the corresponding production process' when understanding a physical stimulus (Bi et al., 2009). In the case of writing-on-reading in Chinese, learners might automatically activate the corresponding motor programs for writing characters, which in turn in reading them.

The study by Tan et al. (2005) gives supporting evidence that motor programming contributes to the formation of long-term motor memory of characters amongst Chinese children. Most relevant to the current study, Cao et al. (2013b) has shown that character-writing training plays a crucial role in learning the visual-spatial aspects of characters among adult CFL learners. That is to say, handwriting can establish more precise visual-orthographic representations and therefore contribute to orthographic recognition in adult CFL beginners (Cao et al., 2013b; Guan et al., 2011).

The positive effect of writing on reading appears to be supported by results from native Chinese speakers and CFL adult learners. Nevertheless, the results from studies showing this effect have tended to be inconsistent. For example, Cao et al. (2013a) demonstrated that both handwriting and visual chunking can produce orthographic enhancement among adult CFL learners. While training on writing is effective for early visual attention, visual chunking, the decomposition of a character into orthographic 'chunks' such as radicals, can also be useful for recognition. The findings from Bi et al. (2009) challenged the writing-on-reading hypothesis in Chinese. A brain-damaged Chinese patient, who was impaired in accessing orthographic representations and had poor orthographic awareness and little graphic/stroke motor programs knowledge, was able to match characters to meaning-related pictures and reading them aloud. Writing, therefore, although important, may not be an essential factor in Chinese reading. Chang et al. (2014) suggested that handwriting was only mildly effective in reading by adopting certain types of teaching methods in a real classroom. The experiment on a group of Chinese children (Tan et al., 2005) also suggests a complex role played by phonological information in Chinese children's reading performance. Instead of no effect, there is a minor contribution of phonological awareness to Chinese reading ability.

Moreover, concerns have been raised about the usefulness of handwriting characters in an era of increasing reliance on electronic communication (Zhang and Lu, 2014; Allen, 2008). It might be an inefficient use of learners' time to practice handwriting as it is common to type the pinyin of a character and subsequently select the intended character from a list of computer-generated possibilities. Furthermore, with regard to theories of embodied cognition, typing can also be considered as a process of associating a pointing movement on keyboards to form a character, though this 'visuomotor association involved in typewriting should […] have little contribution to its visual recognition' (Longcamp et al., 2008: 803). Tan et al. (2013) examined Chinese children's reading development by comparing the reading performance of frequent users of pinyin-typing on e-devices with those spending more time on handwriting. Interestingly, they discovered that children's reading scores were negatively correlated with the use of the pinyin input method, while the reading performance was significantly positively correlated with handwriting. As a result, their study suggests that heavy utilisation of the pinyin input method and e-tools may interfere with the learning of visual-spatial properties of characters, at least among Chinese children.

4 Present study

The current study investigated the performance of a group of CFL beginners to examine the effectiveness of training in character writing on subsequent character recognition. Apart from character handwriting, participants' training also incorporated a pinyin writing task. The point of this task was to act as a control; both pinyin and character drawing involve motor movements, both are effortful in rather similar ways. So if there were an effect due character drawing as opposed to pinyin transcription, it should be related to the inherent features of character writing.

5 Experiment 1: Method

5.1 Participants

Eighteen CFL learners, students from the first author's university, took part in this experiment. They were all speakers of English as a first language and none had received any instruction in Chinese. Heritage learners were excluded from the experiment.

5.2 Materials and Procedure

The training session consisted in learning 30 integral characters. Their frequency of occurrence in a modern Chinese corpus comprising over 193 million words ranged from 29,968 to 3,083,707 with an average of 645,355 (Jun Da, 2004). The stroke count for the characters ranged from 1 through 7 with a median of 4.

During the experiment, participants were seated in front of a desktop computer. The PsychoPy presentation software system (Pierce, 2007) was used to display the materials and to record participant responses. Following an initial presentation of a prompt character ("+"), there was a 5-second exposure of both a character's form and its sound (a female native speaker spoke the character). The screen then displayed either a large C, instructing the participant to draw the displayed character, or a large P, instructing them to write the pinyin representation of the sound. Fifty percent of the time, the training response was to write pinyin and 50% of the time the participant had to draw the character. Choice of response mode and sequencing of the characters was random and the usual counterbalancing measures were taken. Each participant was required to make three passes through the training set of characters.

After training, participants were asked to do a recognition test. In this task, participants were presented with a single character and had to decide whether or not they had encountered it during training. The 30 training characters were randomly combined with 30 distractors matched on frequency and stroke complexity. The participant pressed a key to indicate whether or not they had seen the character during training. See Figure 1 for a schematic representation of the procedure in Experiment 1.

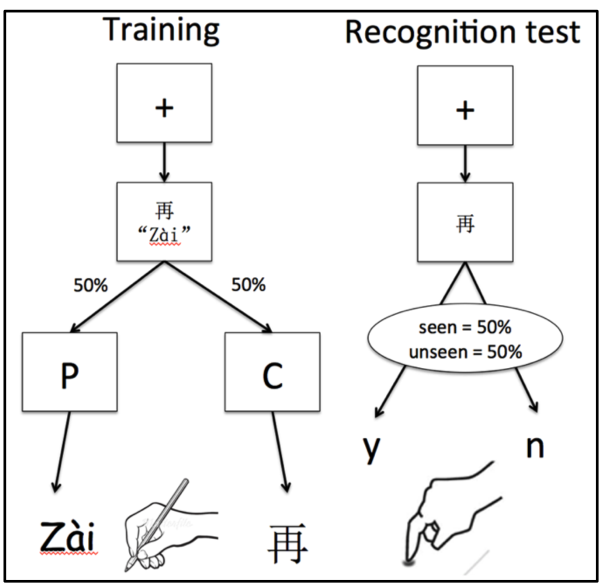

Figure 1: Schematic representation of training and testing modes in Experiment 1.

6 Experiment 1: Results and Discussion

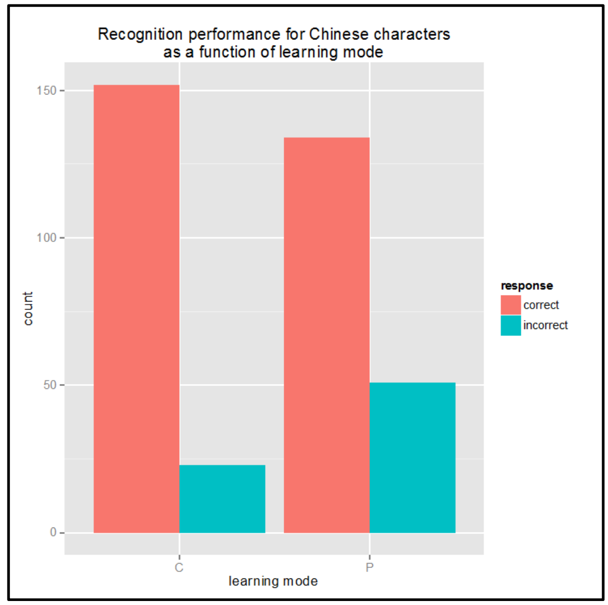

Figure 2: Correct recognition of Chinese characters as a function of learning mode: character drawing vs. pinyin transcription.

Participants responded correctly to the recognition task 81% of the time. Recognition data was analysed using a linear mixed model logistic regression (Jaeger, 2008). The dependent measure was the correctness of the recognition decision, the fixed factor was mode of training, and the random factors were participant and character. The probability of correctly responding was significantly affected by the mode of learning of the character (see Figure 2). If participants had been trained to draw it as opposed to transcribe its pinyin, there was a significant improvement in correct recognition ($|z|=3.21$; $p < 0.001$).

Now, it is possible that this character-drawing advantage may have been due simply to the character training mode causing participants to pay more attention overall to the character's orthography. It could be that the drawing task involved a greater depth of processing (Craik and Tulving, 1977) or a more elaborate encoding (Bransford et al., 1979). Moreover, the response task in Experiment 1 could be considered congruent to the character drawing training mode, since both training and testing focused on the orthography of the character. This congruency could have potentially biased the results to favour character drawing as a learning mode. Experiment

2 was designed to control for this and other potential confounds.

7 Experiment 2: Method

7.1 Participants

An additional 22 participants were recruited from a pool of CFL students who had completed seven weeks (approximately 45 hours) of previous instruction in Chinese in the first-year Chinese language course at both authors' universities. Heritage learners and learners whose native language was other than English were excluded from the experiment. The 22 participants reported having no substantial experience learning Chinese prior to enrolling in their current language programme. They were all taught from a similar curriculum employing the same textbook and instruction. Listening and speaking skills were developed simultaneously with reading and writing skills. Copying characters was regularly assigned as homework. Writing characters or pinyin from memory was also required for dictation quizzes. Before taking part in this experiment, the participants had prior knowledge of pinyin, general rules of stroke order, and knowledge of approximately 200 characters. Consequently, the effect of prior exposure to certain characters used in the current experiment was controlled for statistically in the data analyses.

7.2 Materials and Procedure

The training phase of the second experiment was identical to that of Experiment 1. Thirty-two integral characters were used in the training session. Among these characters, half were novel and half had been taught to the participants in class. The stroke count for the characters ranged from 1 through 7, with a median of 4. Based on the participants' existing knowledge of Chinese characters, none of the characters presented had more than one possible pronunciation. In addition, no two characters were selected which had the same possible pronunciation.

During the testing phase of Experiment 2, the stimuli were presented to the participants either as a character or as a sound. Participants had to decide whether a stimulus shown on a screen or played to them as audio was one of those taught to them in the training session. They were asked to make a decision quickly and accurately by pressing one of the keys on the keyboard to indicate their decision. The structure of the presentation of the materials was designed such that for half of the test items, the mode of presentation was congruent with the mode in which the item had been learned. By manipulating the congruency of training and testing modes it was hoped to control for any biases that might have affected the interpretation of the results from Experiment 1.

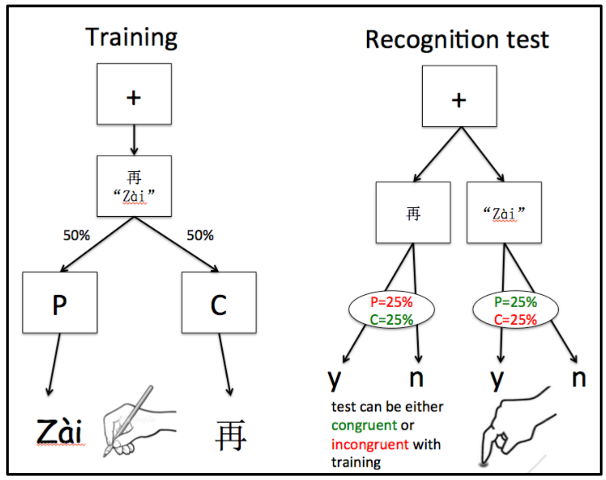

Figure 3: Schematic representation of training and testing in Experiment 2. Note that the training phase was identical to that of Experiment 1.

Recognition data was again analysed using linear mixed model logistic regression (Jaeger, 2008). The dependent measure was the correctness of the recognition decision, the fixed factors were mode of training (character drawing vs. pinyin transcription), congruency of recognition, and whether the participant had learned the character in class. A congruent recognition item involved the presentation of the character during training and the soliciting of a response during testing in the same modality (e.g., character drawing in training followed by character recognition as the test). The number of strokes comprising each character was entered into the model as a covariate to determine if the stroke count had an effect on correct responding.

Table 2 presents the results of the regression analysis. Note that the fixed factors (learn, train, and test) are coded as contrasts that test the difference in probability of responding for the two levels of each factor. The direction of the contrast is indicated by the labels: y-n, p-c, and ic-c. These represent, respectively, "yes - no", "pinyin - character", and "incongruent - congruent".

	estimate	**SE**	**z**	**pr(>|z|)**
intercept	-2.260	0.165	-13.69	< 0.001
strokes	-0.004	0.060	-0.063	0.950
learn:y-n	-0.882	0.255	-3.460	**< 0.001**
train:p-c	-0.277	0.246	-1.125	0.261
test:ic-c	0.533	0.273	1.954	**0.051**
learn x train	-0.562	0.496	-1.134	0.257
learn x test	0.162	0.507	0.320	0.749
train x test	-1.539	0.493	-3.125	**0.002**
learn x train x test	1.755	0.992	1.770	0.078

Table 2: Estimates from the logistic LMM predicting correct responses on the basis of stroke count, learning mode, testing congruency, prior learning in class, and the interactions between the last three terms.

The overall correct recognition rate was just over 85%. The results presented in Table 2 indicate that stroke count and training mode had no significant effect on correct responding. However, having already encountered a character in class had, as one would hope, a significant effect on recognition (|z| =3.46; p<0.001). The overall effect of congruency marginally improved recognition (|z|= 1.954; p = 0.05). There was, however, a significant interaction between congruency and training mode (|z|=6.7; p< 0.001). This interaction is graphed in Figure 2 and suggests that congruency plays a greater role in improving performance when participants had to draw the character during training rather than transcribe its pinyin form. In fact, planned comparisons reveal that the source of the significant training-by-testing interaction is the difference between congruent and incongruent conditions in the character drawing condition (|z| = 3.822; p< 0.001). This can also be seen in the relative differences in the congruency effect between training modes in Figure 4. Another effect of note is the marginally significant three-way interaction between prior learning, training mode, and testing mode (|z|=1.77; p=0.08). The source of this effect is that the training-by-testing interaction just discussed is eliminated for those items to which participants had some prior exposure in class. Effectively, the participants respond significantly more accurately to the learned characters, giving rise to a ceiling effect in performance.

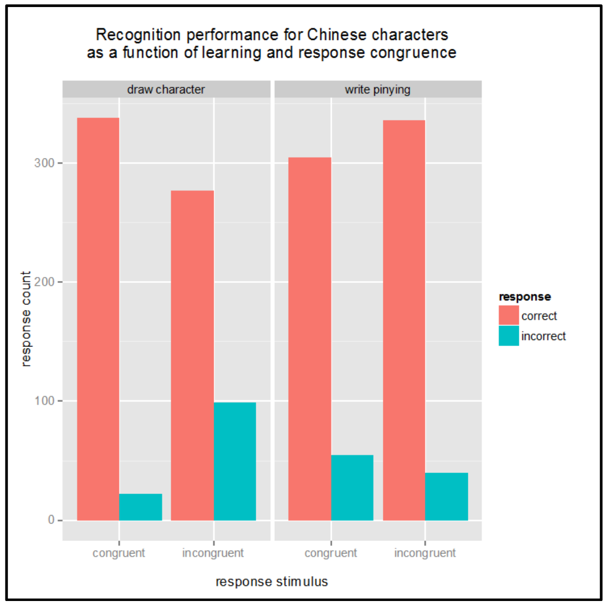

Figure 4: Correct recognition Chinese characters as a function of congruency of learning and testing modes.

8 General discussion

While the overall effect of congruency is close to significance, with congruent training and responding providing a recognition advantage, congruency alone cannot account for the significant advantage that training in character writing has for character recognition. The congruency-by-training interaction in Experiment 2 suggests that even when one controls for different response modes, learning to write the character rather than its pinyin has an overall stronger positive effect on visual recognition. Moreover, aural recognition appears to be less sensitive to congruency than visual recognition. If anything, we see a trend towards an inverted congruency effect in the case of pinyin training and aural recognition.

The basis for this interaction is not entirely clear. However, within a neuronal embodiment account (e.g., Pulvermueller, 2013), we could argue that it is due to differences in the neural encoding of the two modes of training. In the case of the character training mode, the participant goes straight from the visual representation to a motor encoding of the character. There is, therefore, potential for reciprocal connections to be reinforced between motor and visual representations, allowing visual representations to evoke motor ones, and vice versa (e.g., Garagnani et al., 2008). However, in the case of the pinyin encoding, there is an intermediate step involved – the sound has to be converted to the abstract pinyin code, which in turn is mapped to a motor programme involved in writing the pinyin. This affords the establishment of reciprocal connections between pinyin and its motor encoding, but NOT between the perceived sound and these motor encodings. This lack of direct support from the motor level in the case of the aural test may disadvantage recognition of the spoken character. A schematic representation of this account is given in Figure 5.

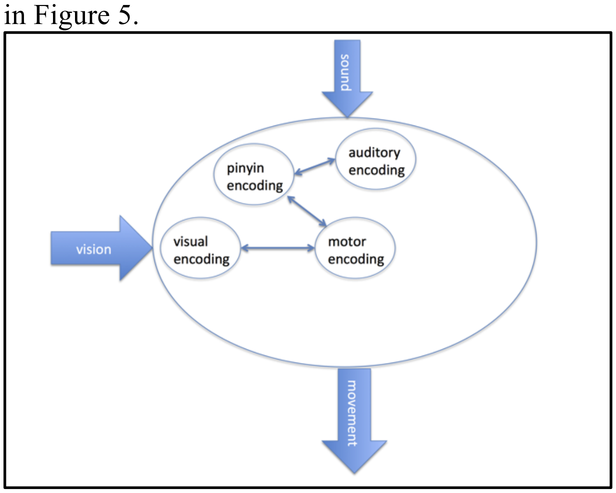

Figure 5: Schematic representation of the putative neural encoding processes underlying the two training modes in both experiments.

Returning to the initial motivation for carrying out this series of experiments, which was to understand what impact character drawing has on recognition in Chinese, the results of the two experiments described here support the hypothesis that character drawing is helpful in the visual recognition of Chinese characters. It is argued here that the reason for this is that the motor programs entrained during the learning phase of the experiments act to enhance recognition memory. This form of memory support, however, is not available for the pinyin learning phase (see Figure 5). Generalising this finding beyond the experimental paradigm to the broader topic of reading, we can argue that readers who draw characters as opposed to pinyin build a memory reserve for characters that can be used to augment their subsequent retrieval and recognition. On the other hand, readers who rely more extensively on pinyin input will not have this memory support to draw upon.

9 Conclusion

The result of the current study contributes to the debate regarding the optimum curriculum design for the CFL classroom. For example, it suggests that 'delay' or 'lag' curricula, which strongly focus on listening and speaking in the early stages of learning may not be optimal for CFL learners in helping them develop their knowledge of the relationship between character and sound. However, to definitively address this issue there would need to be a "lag" condition incorporated into the training regime.

Although the study may be interpreted as showing support for curricula that prioritise writing over other language skills, the results actually show that learning both the character and its pinyin simultaneously does not negatively affect character recognition. Therefore, some sort of combination of sound and character training, as exemplified in the training paradigm used here (see Figure 5), may turn out to be best.

The current study has several limitations that would need to be addressed in future research. For example, the corpus of Chinese characters we used consisted only of integral characters and was focused on their short-term recall rather than the acquisition of their meaning or long-term retention in context. Nonetheless, we hope our study will motivate future research to further investigate the effect of character writing on reading comprehension in Chinese language amongst CFL learners.

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