Why does writing help reading in Chinese learning: Evidence from an fMRI study

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Visual forms of Chinese

Complex spatial relationships
- left-right, 吐/tu4/
- up-down, 杏/xing4/
- inside-out, 困/kun4/
Mapping systems of Chinese

(Tan, et al., 2005)
Predictors of reading achievements

• Visual-orthographic skills have a greater unique contribution than phonological skills in Chinese reading acquisition (Huang & Hanley, 1995; Siok & Fletcher, 2001; Ho & Bryant, 1999; McBride-Chang, 2005; Ho & Chan, 2007).

• Reading depends on writing (Tan, 2005).
Neural correlates for Chinese and English

(Cao, 2009, 2010; Bolger, Perfetti, 2005; Tan, Laird, 2005; Kuo, 2001; Chee, 1999; Booth, Lu, 2006)
Regions identified using meta-analysis as greater for Chinese as compared to alphabetic languages in Tan et al., 2005.

<table>
<thead>
<tr>
<th>Anatomical Region</th>
<th>H</th>
<th>BA</th>
<th>x</th>
<th>y</th>
<th>z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inferior Occipital Gyrus</td>
<td>L</td>
<td>18</td>
<td>-32</td>
<td>-84</td>
<td>-5</td>
</tr>
<tr>
<td>Middle Frontal Gyrus</td>
<td>L</td>
<td>9</td>
<td>-46</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>Premotor Cortex</td>
<td>L</td>
<td>6</td>
<td>-44</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Cingulate Gyrus</td>
<td>Cingulate</td>
<td>32</td>
<td>-2</td>
<td>19</td>
<td>45</td>
</tr>
<tr>
<td>Inferior Occipital Gyrus</td>
<td>R</td>
<td>18</td>
<td>36</td>
<td>-84</td>
<td>-19</td>
</tr>
<tr>
<td>Fusiform Gyrus</td>
<td>L</td>
<td>19</td>
<td>-34</td>
<td>-52</td>
<td>-6</td>
</tr>
<tr>
<td>Inferior Parietal Lobe</td>
<td>L</td>
<td>40</td>
<td>-36</td>
<td>-46</td>
<td>50</td>
</tr>
<tr>
<td>Fusiform Gyrus</td>
<td>R</td>
<td>37</td>
<td>34</td>
<td>-61</td>
<td>-25</td>
</tr>
<tr>
<td>Precentral Gyrus</td>
<td>L</td>
<td>6</td>
<td>-46</td>
<td>0</td>
<td>48</td>
</tr>
</tbody>
</table>
How about second language learning?

• Use L1 network– assimilation?
• Use L2 network – accommodation?
• Both but depends on what L1 and L2 are?
Assimilation

(Tan, 2003)
Accommodation

English speakers viewing English

English speakers viewing Chinese

viewing Chinese-English

(Liu, 2007)
Assimilation and accommodation

(Nelson, 2009)
Assimilation and accommodation

• Chinese L1 learning English – Assimilation
• English L1 learning Chinese -- Accommodation
Study 2010 Spring

• The goal of this study was to find a training method that helps accommodation at both the visual form level and the mapping level in English speakers learning Chinese.
Methods

• Within-subject design
  Character writing – orthography
  Pinyin writing – phonology
• 17 undergraduate students from CMU or Pitt
  English monolingual speakers
  taking Chinese level 1 class
  no exposure to Chinese before taking the class
## Training Procedures

<table>
<thead>
<tr>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-test training</td>
<td>training</td>
<td>training</td>
<td>training</td>
<td>training</td>
</tr>
<tr>
<td>test</td>
<td>test</td>
<td>test</td>
<td>test</td>
<td>Test Post-test</td>
</tr>
</tbody>
</table>
Training Procedures

剖 anatomy 15sec
pou 800ms
剖 800ms
剖 800ms
Tests

- lexical decision -- Orthography
- character-sound matching -- Phonology
- character-meaning matching -- Semantics
Post test before fMRI

<table>
<thead>
<tr>
<th></th>
<th>Character Writing</th>
<th>Pinyin Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meaning</strong></td>
<td>0.96</td>
<td>0.95</td>
</tr>
<tr>
<td><strong>Pronunciation</strong></td>
<td>0.92</td>
<td>0.96</td>
</tr>
</tbody>
</table>
fMRI tasks

- Passive viewing
- Lexical decision
- Implicit writing
Results

Accommodation—Passive Viewing

Chinese>English

English>Chinese
Results

Behavioral—Lexical Decision

<table>
<thead>
<tr>
<th></th>
<th>Writing</th>
<th>Pinyin</th>
<th>Novel</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acc</strong></td>
<td>0.91 (0.09)</td>
<td>0.80 (0.08)</td>
<td>0.66 (0.14)</td>
<td>0.97 (0.04)</td>
</tr>
<tr>
<td><strong>RT</strong></td>
<td>755 (72)</td>
<td>759 (82)</td>
<td>781 (96)</td>
<td>563 (69)</td>
</tr>
</tbody>
</table>

The graph shows the accuracy and reaction time (RT) for different conditions: writing, pinyin, novel, and baseline. The asterisks indicate significant differences.
Writing effects -- LD

Writing > Pinyin

Bilateral SPL
Writing effects -- LD

Writing > Pinyin

Right pre-motor, motor cortex
Pinyin effect -- LD

Pinyin > Writing

Right IFG
Writing effects -- LD
Writing > pinyin = novel
Learning effects -- LD

Writing = Pinyin > Novel

Bilateral occipital cortex
Learning effects -- LD

Writing > Pinyin > Novel
Learning effects -- LD

Writing = pinyin > novel
Summary

• Character writing enhances visual-spatial representation of characters
• Character writing add additional motor-related representation to the network
• Character writing enhances semantic representation
• Pinyin writing enhances phonological representation
Lexical integration/selection

Visual Orthographic Analysis

Writing related hand movement

MFG

SPL

MOG

FG

M
Implicit writing task

Writing $>$ pinyin

Right fusiform gyrus
Implicit writing task

Writing > pinyin

Left S/MTG
Implicit writing task

Writing > pinyin

Left MFG
Summary

• Writing helps to establish high quality representation of orthography, which facilitates the mapping to semantics and phonology and the integration between them as well.
Conclusions

• Character writing training invoked greater activation in the Chinese network (bilateral SPL, motor cortex, right FG, left MFG), suggesting greater accommodation.
• Pinyin writing training is more helpful with phonological representation.
Thanks!

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