Outline

• Neural systems for reading alphabetic languages and Chinese
  • Educational neuroscience
    – An interactive computer game for helping children to master the metalinguistic knowledge of Chinese orthography.
      • Radical position and its function
      • Association between a phonetic radical and its phonological variation
    – To trace the lexicality effect on N400
      • Skilled readers
      • Typical developing children with different reading levels
      • Children with reading difficulties
      • Before the after the remediation (preliminary data)

Neural Signature for Dyslexia: Disruption of Posterior Reading Systems

An fMRI study of normal and impaired reading

The ventral mosaic in normal 9-year-old readers ... and in impaired readers

The VWFA activation correlates tightly with reading scores (replicating Shaywitz, Pugh et al.)

Dehaene et al., 2011

Neural Systems for Reading

Sally Shaywitz, Overcoming Dyslexia, 2003
When & how does the sensitivity of brain to print emerge?

- 32 nonreading kindergarten children
- Behavioral + fMRI + ERP

Reading-Related N170 response

- 150ms–200ms after onsets
- have been well defined in both ERP & MEG studies.
- generated from fusiform gyrus
  - lateralized to the left hemisphere fusiform gyrus (the visual word form area; Cohen et al., 2000)
- orthographic word-form detection

When & how does the sensitivity of brain to print emerge?

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Literate game

The task: Catch the letter that matches the sound you hear!

- Competitor’s results
- Player’s results
- Mouse pointer
- Correctly chosen letters
- Falling letters

Programming: Tuomo Hokkanen
Educational Neuroscience
Brain sensitivity to print emerges when children learn letter–speech sound correspondences
Brem et al., 2010

Training effect on N170

Occipito-temporal waveforms.
Maurer U et al. Brain 2007;130:3200-3210

Specialization for print in P1 and N1 segments (t-maps).
Maurer U et al. Brain 2007;130:3200-3210

Source localization.
Maurer U et al. Brain 2007;130:3200-3210

Chinese orthography
時 煌 舒
Chinese orthography

- Metalinguistic knowledge of Chinese orthography
  - Legal combination of strokes (to form a radical)
  - Radical position (Hsiao et al., 2009; Su et al., 2012)
  - Radical function
    - Consistency/regularity of phonetic radical (Lee et al., 2004; 2005; 2007; 2009)
    - Semantic transparency of semantic radical (Cheng et al., in preparation)
  - Radical combinability (orthographic neighborhood size) (Hsu et al., 2009; 2011)

Neural evidences for phonetic consistency

- Phonology
- Orthography

Consistency effect

Lee et al., 2009; 2012

Phonetic combinability/neighborhood modulates the consistency effect

- High combinability
- Low combinability

Phonetic combinability: the number of phonograms that sharing the same phonetic radical.

The statistical learning perspective for radical awareness

- By learning a set of characters that sharing the same orthographic structure (radical), children would gradually establish various types of functional representations.

Collective Teaching Method

- [Diagrams and illustrations]
Distributed Teaching Method

緩 琉 瑞 流 稡
獰 搖 湖 遥 瑗
來 琉 煙 碼 碌

Collective Teaching Method

• 尹 yao2: 搖、瑤、遙、謠、徭、徭
• 胡 hu2: 珊、瑚、湖、鬍、瑚、瑚
• 遞 liu2: 流、琉、硫
  shu1: 疏、梳
  yu4: 鐸

A computer assisted interactive game for learning Chinese

• Design principle
  – Repetitive and collective exposure to a set of phonograms that share a specific phonetic radical

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• Objectives: implicit learning of
  – Radicals and their most likely positions
  – To acquire the radical-sound association
  – Homophone disambiguation

Computer-Assisted Character Learning (CACL) program (Huang, Zhou, Tzeng, Lee & Liu, 2012)

Hit the Carrot if the character contains the target radical...

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Computer-Assisted Character Learning (CACL) program (Huang, Zhou, Tzeng, Lee & Liu, 2012)

Hit the Carrot if the character contains the target radical...
Hit the Carrot if the character contains the target radical...

Do not Hit the carrot (it is a orthographic similar distractor)

Do not Hit the carrot, ...

Feedback information

Hit

False alarm

Miss

Provide two-character words for homophone disambiguation

Extra credits from making compound words from the target character

Hit

False alarm

Miss
The Hall of Fame

Improvemen on naming speed

Control group
Experimental group

Exp_RAN reading time
Pre-test
Post-test

Con_RAN reading time
Pre-test
Post-test

Experimental group showed a significant improvement on rapid naming time of characters, across all grades.

Lexicality effect

- The lexicality effect refers to how readers react to real word, pseudoword, and nonword.
- This effect reflects whether readers acquire the orthographic rules in a writing system.

Lexicality effects on N400 in skilled and developing readers

Skilled
children

10-11 yrs


N400

Participants

- Colleague students, N=17
- Normal developing children (3rd to 6th grades), subdivided into three reading levels
  - High
  - Medium
  - Low
    - Chinese character recognition task (CCRT) score

- Dyslexic children and their age-matched control (Poster No:3-43)
Skilled readers

Mean amplitude of N400

N400: pseudo > real = non, across all sites

Low reading ability

Mean amplitude of N400

N400: non > pseudo > real, @ frontal to central sites

Medium reading ability

Mean amplitude of N400

N400: non > pseudo > real, @ frontal to central sites

High reading ability

Mean amplitude of N400

non > pseudo > real @ frontal
Adult-like pattern @ Pz: pseudo > real = non

Lexicality effect at frontal site

Lexicality @ Fz

Low ability Medium ability High ability adults

Lexicality effect at Pz

Lexicality @ Pz

Low ability Medium ability High ability adults

N400: pseudo > real = non, across all sites
The training effect

- 10 dyslexic children (2nd to 6th grade)
- Behavioral and ERP measures for pre- and post-tests

Two groups of players (play less versus play more)

<table>
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<tr>
<th>Play</th>
<th>Grade</th>
<th>Grade score of CCRT</th>
<th>Time(mins)</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>more</td>
<td>5th</td>
<td>2.5</td>
<td>1281</td>
<td>115685</td>
</tr>
<tr>
<td></td>
<td>6th</td>
<td>2.9</td>
<td>1796</td>
<td>139805</td>
</tr>
<tr>
<td></td>
<td>8th</td>
<td>3.8</td>
<td>3485</td>
<td>190440</td>
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<td>5th</td>
<td>1.2</td>
<td>45</td>
<td>29720</td>
</tr>
<tr>
<td></td>
<td>6th</td>
<td>3.2</td>
<td>56</td>
<td>34490</td>
</tr>
<tr>
<td></td>
<td>3rd</td>
<td>1.1</td>
<td>10</td>
<td>1610</td>
</tr>
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Improvement on Chinese character recognition (CCRT)

Training effect on N400

Conclusions

- We presented a game for strengthening children’s orthographic knowledge.
  - The behavioral data show its effectiveness in improving children’s naming speed (naming fluency) and Chinese character recognition score.
Conclusion

- By using lexicality effect on N400 as an index
  - Normal developing children treat all types of stimuli as potential lexical items to look for meanings.
  - The frontocentral N400 showed an inverted function to the degree of wordlikeness.
- Non-character pseudocharacter real character

Larger N400 Smaller N400

- As children learn more characters, they would gradually show an adult-like lexicality effect (pseudo>non=real) at centro-parietal sites.
- The lexicality effect on N400 may serve as a neural marker to index the development of orthographic processing for children in learning to read.

Future direction

- Collaborations among cognitive neuroscience, machine learning, and education
  - Evidence-based CAI program
  - Effectiveness evaluation on behavioral and neural levels
- Possible applications for early intervention in clinical and educational settings.

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National Chengchi University

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Brain and Language Laboratory

~Thank you~