The time-course of lexical activation in Japanese two-character word recognition

An eye-tracking lexical decision study

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Morphological Processes

- How do the whole and its parts contribute to our recognition of a complex entity as a coherent meaningful unit?

- Japanese and Chinese logographic (morphographic) two-character words have a multiple layer of morphological complexity.

- How are two-character words (= most common word type) recognized?
Morphological Processes

Sub-lexical Model
(Radical-driven Decomposition)

Supra-lexical Model

Identification system

Word

Character

Radical

Feature

Identification system

Word

Character

Radical

Feature
Research Questions

1. What is the order of activating the constituents and the whole word representations?

2. What is the relative importance of the left and the right constituents in complex word processing?

3. What is the role of attention? (what do eye fixations reflect?)

→ We conducted lexical decision with eye-tracking experiments (see Kuperman et al., 2009 for Dutch lexical decision with eye-tracking)

→ We tested relevant lexical predictors in mixed-effects regression modeling (Baayen, Davidson, & Bates, 2008).
Lexical Decision with Eye-tracking

- **Participants**
  21 Japanese speakers in Canada

- **Materials**
  708 two-character words
  708 nonwords
  (non-existing combination of characters)

- **Procedure**
  472 words in one session * 3 sessions
  Fixation point manipulation
  (Left, Central, Right)
Lexical Predictors

**Whole Word**
Whole Word Frequency,
Google Doc Frequency (residualized)

**Character**
Left Kanji Frequency
Right Kanji Frequency

**Radical**
Left Kanji Radical Frequency
Right Kanji Radical Frequency

**Feature**
Whole Word Strokes
Left Kanji Strokes (residualized)
Right Kanji Strokes (residualized)
Response Time Analysis

**Feature**

- **Whole Word Strokes:** 97 ms

**Radical**

- **Left Kanji Radical Freq:** ns
- **Right Kanji Radical Freq:** ns

**Character**

- **Left Kanji Freq:** -56 ms
- **Right Kanji Freq:** -43 ms

**Whole Word**

- **Whole Word Freq:** -175 ms
- **Google Doc Freq:** -182 ms
Observed Eye Movements

- When readers were motivated to read from right to left, more fixations were needed (effect size = 0.1 subgazes)
- Eye movements were mostly character-based.
Sub-lexical Radical-based Model’s Prediction for 1st Subgaze Duration
### 1st Subgaze Duration Analysis

<table>
<thead>
<tr>
<th>Feature</th>
<th>Feature</th>
<th>Radical</th>
<th>Radical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Kanji Strokes</td>
<td>Right Kanji Strokes</td>
<td>Left Kanji Radical Freq</td>
<td>Right Kanji Radical Freq</td>
</tr>
<tr>
<td>126 ms</td>
<td>59 ms</td>
<td>32 ms</td>
<td>- 31 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Character</th>
<th>Character</th>
<th>Whole Word</th>
<th>Whole Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left Kanji Freq</td>
<td>Right Kanji Freq</td>
<td>Whole Word Freq</td>
<td>Google Doc Freq</td>
</tr>
<tr>
<td>- 135 ms</td>
<td>24 ms</td>
<td><em>ns</em></td>
<td>- 25 ms</td>
</tr>
</tbody>
</table>
2nd Subgaze Duration Analysis

<table>
<thead>
<tr>
<th>Feature</th>
<th>2nd Subgaze Duration (ms)</th>
<th>EyePosition</th>
<th>Left Kanji Strokes</th>
<th>Right Kanji Strokes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>108 ms</td>
<td>43 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radical</th>
<th>2nd Subgaze Duration (ms)</th>
<th>EyePosition</th>
<th>Left Kanji Radical Freq</th>
<th>Right Kanji Radical Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>ns</td>
<td>33 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Character</th>
<th>2nd Subgaze Duration (ms)</th>
<th>EyePosition</th>
<th>Left Kanji Freq</th>
<th>Right Kanji Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>35 ms</td>
<td>- 55 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Whole Word</th>
<th>2nd Subgaze Duration (ms)</th>
<th>EyePosition</th>
<th>Whole Word Freq</th>
<th>Google Doc Freq</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>- 83 ms</td>
<td>- 90 ms</td>
</tr>
</tbody>
</table>
Smaller Font, Different Nonwords, Left Fixation & Analysis of 1st Fixation Durations: Basic Results were replicated!

- Left Kanji Strokes: 127 ms
- Right Kanji Strokes: -56 ms
- Left Kanji Radical Freq: 32 ms
- Right Kanji Radical Freq: ns
- Left Kanji Freq: -119 ms
- Right Kanji Freq: 44 ms
- Whole Word Freq: ns
- Google Doc Freq: -46 ms
1st Subgaze Duration Analysis

- **Feature**
  - Left Kanji Strokes
  - Right Kanji Strokes

- **Radical**
  - Left Kanji Radical Freq
  - Right Kanji Radical Freq

- **Character**
  - Left Kanji Freq
  - Right Kanji Freq

- **Whole Word**
  - Whole Word Freq
  - Google Doc Freq

*ns*
Summary

1. What is the order of activating the constituents and the whole word representations?

   → Effects of the characters were facilitatory, large, and more robust than effects of the whole word and the radicals during the earliest time frame (radical effects were small and inhibitory)

2. What is the relative importance of the left and the right constituents in complex word processing?

   → It is not an either-or issue. They contribute at different points in time.

3. What is the role of attention?

   → Attention modulates lexical processes.
Our Proposal: Character-driven Processing Model

- Effects of the characters were facilitatory, large, and more robust than effects of the whole word and the radicals during the earliest time frame (radical effects were small and inhibitory).
- Given this, we propose a character-driven processing model with a level-skipping assumption.
- Character-driven processing pattern was found regardless of the font size and nonword types.