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Reading in one’s first language

- Long research tradition in Psychology
- Research using eye-tracking, e.g.
  - Lexical ambiguity resolution (e.g., Binder, 2003, Duffy Morris & Rayner)
  - Morphological processing (e.g., Andrews Millar & Rayner, 2004)
  - Discourse processing (e.g. Cook & Myers, 2004)
Looking into reading proficiency

Reading in a second/foreign language

• Research in SLA and Language Testing (e.g., Bernhardt, 2010; Grabe, 2009; Kado, 2005; Khalifa & Weir, 2009)

• Research using eye-tracking, e.g.

  In SLA & bilingualism:
  – Task complexity (e.g., Révész, Sachs & Hama, 2014)
  – Lexical access (e.g., Van Assche et al., 2009, 2011)
  – Syntactic ambiguity resolution (e.g., Dussias & Sagarra, 2007)

  In testing L2 reading:
  – CAE multiple-choice items (Bax & Weir, 2012)
  – practice IELTS sentence completion & matching tasks (Bax, 2013)
  – PTE Academic banked-gap fill items (McCray, Alderson & Brunfaut, 2012; McCray, 2013)
  – APTIS test (Brunfaut & McCray, 2015)
Evidence that eye-tracking provides insights into L2 reading processing


Evidence of relationship with L2 reading product?
Looking into reading proficiency

Aim
Initial statistical modelling L2 reading proficiency with various eye-tracking measures
- Exploring how people read in L2
- Exploring how to analyse eye-tracking data to gain further insights into L2 reading

Needed
- L2 readers
- A measure of their L2 reading ability *(dependent variable)*
- Eye-tracking measures, which are thought to relate to the skill of the reader *(independent variables)*
50 ESL speakers

- **Asian-L1:**
  51% Chinese, 4% Korean, 4% Thai, 4% Arabic, 2% Nepali, 2% Hindi

- **European/South American/African-L1:**
  12% Spanish, 4% Italian, 4% Portuguese, 2% Dutch, 2% German, 2% Slovene, 2% Greek, 2% Hungarian, 2% Russian

- 20% male, 80% female
- 17-49 years old (M=26.4, SD=7.57)
- 2-25 years studied English (M=11.4, SD=4.95)
- .5-13 years lived in English-speaking country (M=1.72, SD=2.28)
- 21% foundation year students, 4% UG students, 65% PG students, 12% employed
Looking into reading proficiency

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Methodology

L2 reading test

DIALANG reading test (http://dialangweb.lancaster.ac.uk/)

- 44 items
- Item types:
  - Multiple choice (39)
    - 37 four-option, 1 three-option, 1 five-option
    - traditional MC-question, MC text completion, MC gap-fill
  - Matching headings (4)
  - Fill-in-the-blank (1)
Methodology

L2 reading test

DIALANG reading test (http://dialangweb.lancaster.ac.uk/)

- Types of reading:
  - Reading for main idea (14)
  - Reading for detail (8)
  - Inferencing (22)

- CEFR A1-C2
Looking into reading proficiency

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Methodology

Tool

Tobii TX300 eyetracker
Eye-tracking data collected on L2 texts

Nine L2 texts:

• 3 Cambridge ESOL computer-based suite
  – One text from each of these:
    • Cambridge English: Preliminary (PET) – B1
      Text: 261 words
    • Cambridge English: First (FCE) – B2
      Text: 655 words
    • Cambridge English: Advanced (CAE) – C1
      Text: 816 words
  – + 1 four-option MC item per text
  – Types of reading:
    • inferencing - main idea (3)
Eye-tracking data collected on L2 texts

• 6 DIALANG reading items
  – Two from each of these:
    • Basic level
      Text: 34 & 48 words
    • Intermediate level
      Text: 79 & 54 words
    • Advanced level
      Text: 70 & 41 words
  – + 1 three- or four-option MC item per text
  – Types of reading:
    • Identifying main idea (3)
    • Inferencing (3)
Eye-tracking measures, following the L1 literature:

a) Fixation number & duration

b) Saccade number & length

c) Regression number & length
Methodology

L2 reading tasks

- Text
- Item
### Methodology

#### Fixation-related measures

<table>
<thead>
<tr>
<th>Measure name</th>
<th>Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.fix</td>
<td>The total number of fixations</td>
<td>More proficient readers will have fewer fixations, reflecting the fact that they need fewer fixations to process the text.</td>
</tr>
<tr>
<td>Sum.fix.dur</td>
<td>The sum of fixation times on a text</td>
<td>More proficient readers will have a shorter sum fixation duration, reflecting their increased overall processing speed.</td>
</tr>
<tr>
<td>Med.fix.dur</td>
<td>Median log fixation duration</td>
<td>More proficient readers will have shorter median fixation duration, reflecting the speed with which they can process the textual information from a fixation.</td>
</tr>
</tbody>
</table>
**Methodology**

### Saccade-related measures

<table>
<thead>
<tr>
<th>Measure name</th>
<th>Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.sac</td>
<td>Number of saccades</td>
<td>More proficient readers will have a lower number of saccades due to their longer saccade length and decreased need for re-reading.</td>
</tr>
<tr>
<td>Med.sac.length</td>
<td>Median log length of a saccade</td>
<td>More proficient readers will have a longer median saccade length due to their ability to take in more text in a single fixation.</td>
</tr>
<tr>
<td>SD.sac.length</td>
<td>SD of log length of saccade</td>
<td>More proficient readers will have a more regular reading pattern and thus a lower SD of log saccade length.</td>
</tr>
</tbody>
</table>
## Methodology

### Regressions-related measures

<table>
<thead>
<tr>
<th>Measure name</th>
<th>Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.reg</td>
<td>Number of regressions</td>
<td>More proficient readers will have a lower number of regressions, because they don’t (or less often) need to re-read parts of the text.</td>
</tr>
<tr>
<td>Med.reg.length</td>
<td>Median log length of a regression</td>
<td>Potentially, more proficient readers make regressions for different reasons (e.g. slight overshooting rather than re-reading entire bits of text).</td>
</tr>
<tr>
<td>SD.reg.length</td>
<td>SD log length of a regression</td>
<td>More proficient readers will have a more regular reading pattern and thus a lower SD of log regression length.</td>
</tr>
</tbody>
</table>
## Methodology

### Combined measures

<table>
<thead>
<tr>
<th>Measure name</th>
<th>Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Info.measure</td>
<td>Median log forward saccade length divided by log of following fixation duration</td>
<td>More proficient readers will have a higher info measure as they can take in more characters in a lower time period (i.e. faster processing).</td>
</tr>
</tbody>
</table>
Methodology

L2 reading tasks

- Text
- Item
Methodology

Areas of Interest (AoI)

The concert given by the Nash Ensemble on 5 October as part of the South Bank’s Haydn Festival will be dedicated to the memory of Christopher van Kampen. On 13 October, with the viola player Paul Silverthorne and the London Sinfonietta under Martin Brabbins, he was due to give the world premier of the viola concerto ‘Misere in memoriam Oleg Kagan’. This concert will now also be dedicated to his memory.

Which of the people mentioned has recently died and is to be remembered in a concert?

- Christopher van Kampen
- Martin Brabbins
- Oleg Kagan

“Text” Area of interest

“MC stem” Area of interest

“MC options” Area of interest
# Methodology

## AoI-related measures

<table>
<thead>
<tr>
<th>Measure name</th>
<th>Description</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Text.to.stem</td>
<td>Number of switches between the ‘Text’ AoI and the ‘MC stem’ AoI</td>
<td>More proficient readers will have a lower number of switches between the ‘Text’ and the ‘Stem’ as their more accurate initial processing of the text does not require them to switch (as much) in order to correctly respond.</td>
</tr>
<tr>
<td>Text.to.option</td>
<td>Number of switches between the ‘Text’ AoI and the ‘MC options’ AoI</td>
<td>More proficient readers will have a lower number of switches between the ‘Text’ and the ‘Options’ as their more accurate initial processing of the text does not require them to switch (as much) in order to correctly respond.</td>
</tr>
</tbody>
</table>
1. Pearson’s correlations between L2 reading ability and each individual eye-tracking measure.

2. Backwards stepwise multiple linear regression to investigate the joint predictive power of the variables.
# Initial Findings

Eye-tracking measures related to the **text**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD or -1sd , +1sd)</th>
<th>Correlation with L2 reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw.scores</td>
<td>31.86 (6.74)</td>
<td>NA</td>
</tr>
<tr>
<td>N.fix</td>
<td>2005 (408)</td>
<td>-0.00 (p=0.98)</td>
</tr>
<tr>
<td>Sum.fix.dur</td>
<td>482 (125) Seconds</td>
<td>0.09 (p=0.52)</td>
</tr>
<tr>
<td>Med.fix.dur</td>
<td>219 (119, 242) Milliseconds</td>
<td>-0.17 (p=0.23)</td>
</tr>
<tr>
<td>N.Sac</td>
<td>1281 (303)</td>
<td>0.01 (p=0.94)</td>
</tr>
<tr>
<td>Med.sac.length</td>
<td>72.10 (61, 85) Pixels</td>
<td>0.30 (p=0.04)</td>
</tr>
<tr>
<td>SD.sac.length</td>
<td>0.46 (0.07) log (Pixels)</td>
<td>-0.32 (p=0.02)</td>
</tr>
<tr>
<td>N.reg</td>
<td>380.42 (160)</td>
<td>0.17 (p=0.23)</td>
</tr>
<tr>
<td>Med.reg.length</td>
<td>-52 (42, 64) Pixels</td>
<td>0.06 (p=0.70)</td>
</tr>
<tr>
<td>SD.reg.length</td>
<td>0.75 (0.10) log (Pixels)</td>
<td>-0.41 (p=0.00)</td>
</tr>
<tr>
<td>Info.measure</td>
<td>0.79 (0.04)</td>
<td>0.35 (p=0.01)</td>
</tr>
</tbody>
</table>

*p<.05
# Initial Findings

Eye-tracking measures related to the items

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD or -1sd, +1sd)</th>
<th>Correlation with L2 reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>N.fix</td>
<td>985 (280)</td>
<td>-0.04 (p=0.80)</td>
</tr>
<tr>
<td>Sum.fix.dur</td>
<td>209 (67) Seconds</td>
<td>-0.06 (p=0.68)</td>
</tr>
<tr>
<td>Med.fix.dur</td>
<td>192 (174, 213) Milliseconds</td>
<td>-0.04 (p=0.76)</td>
</tr>
<tr>
<td>N.Sac</td>
<td>496 (148)</td>
<td>-0.06 (p=0.69)</td>
</tr>
<tr>
<td>Med.sac.length</td>
<td>111 (93, 132) Pixels</td>
<td>0.28 (p=0.06)</td>
</tr>
<tr>
<td>SD.sac.length</td>
<td>0.58 (0.09) log (Pixels)</td>
<td>-0.29 (p=0.04)</td>
</tr>
<tr>
<td>N.Reg</td>
<td>239(87)</td>
<td>0.01 (p=0.97)</td>
</tr>
<tr>
<td>Med.reg.length</td>
<td>82 (68 -102) Pixels</td>
<td>0.12 (p=0.42)</td>
</tr>
<tr>
<td>SD.reg.length</td>
<td>0.76 (0.08) log (Pixels)</td>
<td>-0.34 (p=0.02)</td>
</tr>
<tr>
<td>Info.measure</td>
<td>0.88 (0.04)</td>
<td>0.29 (p=0.04)</td>
</tr>
<tr>
<td>Text.to.stem</td>
<td>11 (5.5)</td>
<td>0.36 (p=0.01)</td>
</tr>
<tr>
<td>Text.to.option</td>
<td>37 (17)</td>
<td>-0.06 (p=0.67)</td>
</tr>
</tbody>
</table>

*p<.05
Analyses

1. Pearson’s correlations between L2 reading ability and each individual eye-tracking measure.

2. Backwards stepwise multiple linear regression to investigate the joint predictive power of the variables.
## Findings

Eye-tracking measures related to the **text**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate (Standardised)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum.fix.dur</td>
<td>0.43</td>
<td>0.007**</td>
</tr>
<tr>
<td>SD.sac.length</td>
<td>-0.55</td>
<td>0.000***</td>
</tr>
<tr>
<td>info.measure</td>
<td>0.72</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

*Adjusted R-Squared = 0.35  
P-value = 0.00****
## Findings

Eye-tracking measures related to the **items**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate (Standardised)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD.sac.length</td>
<td>-0.44</td>
<td>0.01*</td>
</tr>
<tr>
<td>info.measure</td>
<td>0.32</td>
<td>0.00***</td>
</tr>
<tr>
<td>Text.to.stem</td>
<td>0.40</td>
<td>0.00**</td>
</tr>
</tbody>
</table>

*Adjusted R-Squared = 0.34*  
*P-value = 0.00***
Conclusions

L2 reading

• When modelled separately a number of eye-tracking variables correlate with L2 reading

• Three-variable model explaining 35% of the L2 reading variance:
  — Fixation-related measure:
    — sum of fixation duration
  — Saccade-related measure:
    — SD length saccades
  — Combined measure (saccade & fixation):
    — Info measure
• The **consistency of the length of saccades** seems to be a good predictor of L2 reading ability

• The **combination of sequential saccade lengths and fixation durations** seems to be a good predictor of L2 reading ability

• The fact that the results were similar across two different stimuli (text vs items) is promising and further research to confirm the findings is desirable

• The finding that, when other variables are accounted for, the switching between text and item stem is a significant explanatory factor is also new
Conclusions

Methodological innovations

1. Inclusion of interactions between measures in the modelling process
2. The extraction and analysis of more complex eye-tracking metrics than are commonly seen in the investigation of reading

But note that this is an exploratory study, not a confirmatory one --> further research needed!
Thank you for listening, and watching!

Tineke Brunfaut

Lancaster linguistics eyetracking lab:
http://wp.lancs.ac.uk/ltrg/eye-tracking-lab/