Patterns of silent reading in aphasia: Insights from the analysis of eye movements.

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This talk

• Present parts of my PhD project on reading in aphasia

CITY UNIVERSITY
LONDON

• Supervised by:

Jane Marshall  Madeline Cruice  Robin Thompson

• Talk covers theory of eye tracking & showing data
Motivation for the project

• The ability to read is linked to quality of life (Lynch et al, 2013)
• Both assessment and therapy are often restricted to reading out loud and reading at the word level
• Silent reading is the usual pattern of reading – but not much known about silent reading in aphasia
• In the healthy population, eye tracking has become a successful method to study silent reading
• A good start to studying silent reading in aphasia would be to compare it to healthy reading using eye tracking
Eye tracking and the eye mind hypothesis

Cognitive processing correlates with eye movement behaviour (Just & Carpenter, 1980)
Eye movements during reading

The backpackers are staying in a hostel…

regression

saccades

fixations
There have been numerous studies about silent reading at the sentence level showing an influence of:

- Word frequency (Rayner et al, 2004; Calvo & Meseguer, 2002)
- Predictability/context (Rayner et al, 2004; Frisson et al, 2005)
- Word length (Rayner et al, 2011)
- Font (Rayner et al, 2006)
- Age of acquisition (Juhasz & Rayner, 2006)
Why eye tracking is useful for studying aphasia

- The analysis not tied to articulation
- There is no additional behavioural task
- Eye movements reflect automatic/natural reading
- We can study the time course rather than endpoint - underlying cognitive processes
There is a growing number of reading studies in aphasia using eye tracking

- Reading difficulties shown by longer fixation durations & more regressions (Kim & Bolger, 2012; Knilans & DeDe, 2015)

- Reading is influenced by predictability/context (Kim & Bolger, 2012)

- We don’t know what the similarities and differences are to healthy reading
Goal of this study

Exploring the potential of using eye-tracking to investigate mild difficulties in silent reading by people with aphasia (PWA) compared to neurologically healthy individuals (NHI).
Aims of this study

1. Can eye movements differentiate PWA and NHI?
Longer fixation durations for PWA, more fixations and regressions

2. Is there a link between comprehension accuracy and eye movement data?
Better accuracy → shorter eye movements

3. Are PWA/NHI influenced by linguistic factors such as word frequency and predictability?
Expectation to find larger effects for PWA than NHI
Methods-participants

<table>
<thead>
<tr>
<th>Group</th>
<th>20 neurologically healthy individuals (NHI)</th>
<th>17 people with aphasia (PWA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (SD) range</td>
<td>53.60 (14.54)</td>
<td>58.76 (14.96)</td>
</tr>
<tr>
<td></td>
<td>22-76</td>
<td>22-80</td>
</tr>
<tr>
<td>Education</td>
<td>4.7</td>
<td>3.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3= A levels/Apprenticeship</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4= Diploma/College Degree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5= Bachelor’s Degree)</td>
</tr>
<tr>
<td>Aetiology</td>
<td>na</td>
<td>all single left hemisphere</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 6 months post onset</td>
</tr>
<tr>
<td>(Other) neurological impairment</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Visual impairment</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Developmental dyslexia</td>
<td>no</td>
<td>no</td>
</tr>
</tbody>
</table>
## Methods-PWA language profile

| Aphasia severity = AQ (WAB) | 82.33 (SD= 8.43), range = 64.1–93.0  
|                           | (4 moderate, 13 mild) |
| Overall semantics composite score | 0.95 (SD=0.03), range = 0.88–0.99 |
| Reading confidence after stroke score | 58/120 (sum of 12 questions with scale 1-10) |
| Reading pleasure after stroke score | 4.53/10 (1 question with scale 1-10) |
## Methods - materials

<table>
<thead>
<tr>
<th>Condition</th>
<th>Frequency*</th>
<th>Predictability**</th>
<th>Example sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HF P</td>
<td>high frequency</td>
<td>predictable</td>
<td>Anna was able to get a reduced ticket for the show because she is a <em>student</em> working there.</td>
</tr>
<tr>
<td>HF U</td>
<td></td>
<td>unpredictable</td>
<td>Claire loves flowers and wants to be a <em>student</em> learning how to make nice bouquets.</td>
</tr>
<tr>
<td>LF P</td>
<td>low frequency</td>
<td>predictable</td>
<td>Claire loves flowers and wants to be a <em>florist</em> learning how to make nice bouquets.</td>
</tr>
<tr>
<td>LF U</td>
<td></td>
<td>unpredictable</td>
<td>Anna was able to get a reduced ticket for the show because she is a <em>florist</em> working there.</td>
</tr>
</tbody>
</table>

* Frequencies obtained from the WebCelex [http://celex.mpi.nl/](http://celex.mpi.nl/), HF and LF differ in both Celex and the SUBTLEX database

** Predictability ratings from online norming studies with healthy participants

Methods - procedure

Apparatus: EyeLink 1000 (SR Research) video-based eye tracker
Procedure: Reading each target sentence silently & answering yes/no question
Methods - measurements

- Global measurements:
  - accuracy
  - average fixation duration
  - sentence reading time
  - number of fixations
  - number of regressions

- Eye movement measurements on target word:

  Ryan loves old castles and is interested in their geology and tales.
1. Can eye movements differentiate PWA and NHI?
Results – Overall reading characteristics comparing NHI with PWA

Fixations (blue dots) in the reading of a NHI (top) and PWA (bottom)
Results – Overall reading characteristics comparing NHI with PWA

Anna was able to get a reduced ticket for the show because she is a student working there.

Anna was able to get a reduced ticket for the show because she is a student working there.
# Results – Overall reading characteristics comparing NHI with PWA

<table>
<thead>
<tr>
<th>Measure</th>
<th>NHI</th>
<th>PWA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean (SD)</td>
<td>median (IQR)</td>
</tr>
<tr>
<td>Accuracy in %</td>
<td>95.64% (0.06)</td>
<td>100% (0.93-1)</td>
</tr>
<tr>
<td>Average fixation duration (ms)</td>
<td>224.34 (24.12)</td>
<td>n.a.</td>
</tr>
<tr>
<td>Average sentence reading time (ms)</td>
<td>3875.10 (999.47)</td>
<td>3678.05 (2981.94-4872.90)</td>
</tr>
<tr>
<td>Mean nr. of fixations (per sentence)</td>
<td>15.13 (3.40)</td>
<td>15.34 (11.97-18.21)</td>
</tr>
<tr>
<td>Mean nr. of regressions (per sentence)</td>
<td>3.16 (1.49)</td>
<td>2.82 (2.0-4.40)</td>
</tr>
</tbody>
</table>

****p≤0.0001;

T refers to T-test; Z refers to the Mann-Whitney U test; r refers to Pearson’s r effect sizes
2. Is there a link between comprehension accuracy and eye movement data?
Results – accuracy and eye movements

significant relationship between accuracy & total durations, $r_s = -0.63$, $p < 0.0001$ (Spearman’s correlation)
3. Are PWA/NHI influenced by linguistic factors such as word frequency and predictability?
Results - Word frequency and predictability

Total durations both groups
Summary and discussion

1. Eye movements can differentiate PWA and NHI
   • Aphasia compromises reading efficiency
   • There were strong differences in all measurements even though accuracy only shows mild reading impairments

2. There was a correlation between accuracy and eye movements
   • Indicates that there is a relation between on- and offline measures

3. Reading is influenced by word frequency & predictability, but PWA showed a larger context effect and more interaction
   • Supports interactive-compensatory processing (e.g. Stanovitch, 1986)
Conclusion and future directions

- Analysis of eye movements can contribute to understanding reading behaviour in aphasia.

- An interesting aim for future work would be to focus on case studies to find out about some reading behaviour in more detail.

- Planning reading treatment according to a detailed eye movements analysis.
Thank you
Acknowledgments

All participants in this study

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