Top-down Effects On Reading In Aphasia: An Eye-tracking Study

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Disclosure Statement

Dr. Kim and Dr. Bolger have no relevant financial or nonfinancial relationships within the products or services described, reviewed, evaluated or compared in this presentation.
Background

• Many individuals with *aphasia* also present with acquired reading impairments (*alexia*)

• SLPs have successfully used text-based reading treatments to improve reading fluency and comprehension (Beeson & Insalaco, 1998; Cherney, 2004; 2010; Kim et al., 2010)

• Mechanism?
  • Added semantic/syntactic contextual information from text provides top-down facilitation (Beeson & Insalaco, 1998)

• Oral reading is typically used to investigate reading processes in individuals with aphasia
Is this a true representation of his reading abilities?

Fluency
- Concomitant motor speech impairments
- Oral reading may not accurately reflect how he is processing text

Comprehension
- PWA have known impairments in attention, working memory
- ‘Off-line’ measures of comprehension may underestimate abilities
Eye-Tracking

• A potentially useful tool for examining reading in people with aphasia (PWA)
• Moment-to-moment processing can be examined *without* requiring an oral response

*Fixation Duration* = time spent looking at a word

*Regressions* = backward movements to re-read text

Reflect comprehension processes

*The uncle steps his green scoter near grandmother's house.*
Eye-movements are affected by top-down and bottom-up variables

**Top-Down (higher order comprehension processes)**
- Rayner et al. (2006)
  - ‘global text passage difficulty’
  - inconsistencies in text
- Frazier & Rayner (1982)
  - garden path sentences

**Bottom-Up (lexical variables)**
- Inhoff & Rayner (1986); Johnson & Rayner, (2007)
  - word frequency
- Behrmann et al. (2001)
  - word frequency, imageability, word length

more difficult words/texts = longer fixation durations more regressions
Eye-movements are affected by reading proficiency

  - Less proficient readers
  - Developmental Dyslexia
  - Acquired Alexia

Less reading proficiency = longer fixation durations, more regressions
Purpose of this study

1. Is eye-tracking feasible to examine text-reading processes in people with aphasia (PWA)?

2. Do high predictability sentence contexts facilitate word reading (i.e. shorter fixation durations, fewer fixations, fewer regressions) relative to low predictability contexts for PWA and controls?
   a) What factors contribute to the size of the context effect?
Method: Participants

<table>
<thead>
<tr>
<th></th>
<th>PWA (N = 11)</th>
<th>Controls (N = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>6M / 5F</td>
<td>5M / 5F</td>
</tr>
<tr>
<td>Age</td>
<td>56.7 (22-83)</td>
<td>56.9 (40-73)</td>
</tr>
<tr>
<td>Education*</td>
<td>11.5 (8-14)</td>
<td>15.2 (12-18)</td>
</tr>
<tr>
<td>WAB Aphasia Quotient (out of 100)</td>
<td>65.4 (21.3 – 94.7)</td>
<td>4 non-fluent, 8 fluent</td>
</tr>
</tbody>
</table>

- Inclusion criteria:
  - pass hearing and vision screenings
  - intact gross cognitive skills (Raven’s CPM score > 5\textsuperscript{th} %ile for age/education)
Method: Procedure

• Behavioral Reading Assessments
  • Single word reading (Arizona Battery for Reading & Spelling; ABRS Beeson et al., n.d.)
  • Text Reading (Gray Oral Reading Test-4; GORT-4, Wiederholt & Bryant, 2001)
  • Reading Comprehension – patients only (Reading Comprehension Battery for Aphasia-2; RCBA-2, LaPointe & Horner, 1998)

• Eye-Tracking Assessment
  • 120 sentences (80 experimental, 40 fillers)
  • Y/N comprehension questions after 20% of sentences
  • EyeLink 1000 Desk-mounted eye-tracker with chin mount & button box
Eye-Tracking Stimuli

- 80 experimental sentences containing a target noun
  - targets: 20 HF and 20 LF nouns (matched for length, # of phonemes, # of syllables, # of orthographic neighbors, age of acquisition, imageability)
  - each target noun placed in pairs of high/low predictability sentences (context)
    - Pairs of sentences matched for length and syntactic complexity
    - Target words never in sentence-initial or final positions

- Predictability judgments verified by 38 undergraduate linguistics students completing cloze-task
  - Target words provided 74% (high) and 4% (low) of time, in line with literature on sentence predictability (Balota et al., 1985)
80 experimental sentences

<table>
<thead>
<tr>
<th>Context (Predict-ability)</th>
<th>Frequency of Target Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>20 High picture</td>
</tr>
<tr>
<td>Low</td>
<td>20 Low cheek</td>
</tr>
<tr>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

Mean K-F frequency (instances / million words)

- picture: 215
- cheek: 10
<table>
<thead>
<tr>
<th>Context (Predict-ability)</th>
<th>Frequency of Target Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>The artist painted a <strong>picture</strong> of the dog.</td>
</tr>
<tr>
<td>Low</td>
<td>The man admired the <strong>picture</strong> at the store.</td>
</tr>
</tbody>
</table>

**Reduced/No Frequency Effect**

**Frequency Effect**
Eye-Tracking Measures

• Word Level (Target Nouns)
  • total fixation duration (sum of all fixations on word, including regressions)
  • number of fixations

• Sentence Level
  • total number of fixations
  • total number of regressions

• Analyzed using repeated measures ANOVA*
  • between subjects factor: group
  • within subjects factor: context, frequency of target word
Results: Behavioural Reading Assessments

Single word reading (ABRS)

Text reading (GORT-4)

<table>
<thead>
<tr>
<th></th>
<th># of passages read</th>
<th>Rate words/min</th>
<th>Errors per 100 wds</th>
<th>Comprehension % correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWA (N = 10*)</td>
<td>4.8</td>
<td>42.7 (23.7)</td>
<td>20.4 (21.5)</td>
<td>70.3 (12.3)</td>
</tr>
<tr>
<td>Ctrls (N = 10)</td>
<td>10</td>
<td>175.5 (27.9)</td>
<td>0.8 (0.4)</td>
<td>82.2 (9.6)</td>
</tr>
</tbody>
</table>

PWA < controls; $p < .001$ rate; $p < .01$ errors; $p < .05$ comprehension

Reading comprehension (RCBA-2)
• average = 82/100 (56-96)

PWA < controls; $p < .001$
7 phonological alexia
4 mixed alexia
Results: Eye-Tracking Assessments

- PWA differed from controls on all four measures
  - longer total fixation durations on target words
  - more fixations on target words
  - more fixations on overall sentence
  - more regressions on overall sentence

<table>
<thead>
<tr>
<th></th>
<th>Total Fixation Duration – Targets (msec)</th>
<th># Fixations – Targets</th>
<th># Fixations – Overall Sentence</th>
<th># Regressions – Overall Sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWA</td>
<td>800</td>
<td>3.0</td>
<td>20.1</td>
<td>3.9</td>
</tr>
<tr>
<td>Controls</td>
<td>347</td>
<td>1.4</td>
<td>10.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

all differences significant at $p < .001$
C6: ~1900 msec

The children walked down to the street for the festival.

P10: ~15000 msec

The children walked down to the street for the festival.
Results

- Significant effect of group ($p < .0001$), context ($p < .001$), context x group interaction on all measures

![Graphs showing data for sentence total fixation duration, target total fixation duration, sentence total # regressions, and target total # fixations for Alexia and Controls under high and low context conditions.](image)

- $p < .001$
- $p < .05$
- $p < .01$
Context x Frequency Interaction Effect

- Expected context x frequency interaction effect observed only on *Target Total Fixation Duration* measure for control group

\[ p < .05 \]
Context Effect

- What factors were predictive of the context effect?
- Multiple regression analysis
  - dependent variable = difference in target total fixation duration between high and low context conditions
  - significant models
    - off-line comprehension measures as predictors

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<tr>
<th></th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patients (R² = .60, p &lt; .05)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GORT-4 comprehension</td>
<td>15.07</td>
<td>4.43</td>
<td>3.41**</td>
</tr>
<tr>
<td><strong>Controls (R² = .72, p &lt; .05)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GORT-4 comprehension</td>
<td>-6.72</td>
<td>1.61</td>
<td>-1.02**</td>
</tr>
<tr>
<td>Eye-tracking comprehension</td>
<td>5.25</td>
<td>1.71</td>
<td>.75*</td>
</tr>
</tbody>
</table>

* p < .05, ** p < .01
Discussion

1. Eye-tracking is a feasible measure of reading processes in PWA
   - Eye-movements could be used to gauge comprehension without having to subject PWA to off-line comprehension measures

2. High predictability sentence contexts facilitated word reading relative to low contexts
   - PWA made significantly more fixations, regressions and longer total fixation durations than controls
   - This pattern of eye-movements reflects the greater difficulties PWA have encoding and understanding text – corroborated by poorer performance on other off-line reading measures
Discussion

- Top-down (context) manipulation impacted eye-movements more than bottom-up (frequency) manipulation
  - Low context was more detrimental to reading comprehension of PWA
  - Frequency x context interaction effect was only observed on target total fixation duration measure for controls only
    - This measure may be more sensitive to this manipulation than others
    - For PWA, context had more impact on eye-movements, over-riding word-level variables such as frequency

- Off-line reading comprehension measures were predictive of size of context effect for both patients and controls
  - Eye-movements (on-line comprehension measure) corroborates with traditional off-line comprehension measures
Clinical Implications and Next Steps…

- PWA can benefit from context
  - This is evident at a basic level in their eye-movements while reading
  - Text-based reading treatments capitalize on this – training oral word reading in context
  - Clinicians can go a step further and provide even more context/background about a text to-be-read
    - activate semantic networks and provides semantic facilitation to ‘prime’ the reading process

- Next steps:
  - manipulations of semantic, syntactic context, length of text to further develop models of aphasic reading comprehension
  - could be used to examine mechanisms of facilitations before and after treatment
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References


Questions?

Thank You!

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ANCOVA results

- including covariate weakens main effect of context (due to shared variance between covariate and between groups factor)
- context x education interaction significant only for target total fixation duration measure $F(1,255) = 4.28, p < .05$
- context x group interaction effects significant for 3/4 measures
  - target total fixation duration $F(1,255) = 19.12, p < .001$
  - target total # of fixations $F(1,255) = 5.62, p < .02$
  - sentence total # of fixations $F(1,255) = 7.41, p < .01$
- covariate (education) remains constant for each repeated measure of within groups factor, therefore ANOVA results are reported (after Thomson et al., 2009)