Making and Correcting Errors during Sentence Comprehension: Eye Movements in the Analysis of Structurally Ambiguous Sentences

PART 1

Reading through the Decades: Influential Papers in Psycholinguistics – Seminar

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Frazier & Rayner (1982)

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About Frazier & Rayner (1982) – Introduction and Background
Question

- **How** does human language **processing** lead to comprehension?
How do humans understand sentences?
Question

- How do humans deal with ambiguities?
How do humans recover from mistakes?
How did Frazier & Rayner (1982) seek to answer?
Possible Answer

- Garden-Path Theory of Sentence Comprehension
A Garden-Path Sentence

The horse raced past the barn fell
Garden-Path Theory

- Initial, single analysis/interpretation

- then, more than one possibility
Why ‘garden-path’?

- “to lead someone down the garden-path”

- to mislead, deceive...
How do humans understand sentences?
G-P Theory: analyses on a one-by-one basis

- **Garden-Path:** Main Feature

- **1st attempt**
- **2nd attempt**

- **Serial processing**

- **2nd attempt**
Garden-Path: One Contrasting View

- Parallel Processing Hp.: multiple, simultaneous analyses (Fodor et al., 1974)

- Parallel processing

- Concurrent, competing attempts
Garden-Path: Processing Difficulty [1]

- Depending on \textit{in-/compatibility} between (initial) interpretation and disambiguating material:
Garden-Path: Processing Difficulty [2]

- Depending on in-/compatibility between (initial) interpretation and disambiguating material:

Harder
Which one is harder/easier?

a) Since Jay always jogs a mile **this** seems like a short distance to him

b) Since Jay always jogs a mile **seems** like a short distance to him

Easier

Harder
How do humans deal with ambiguities?
Global vs. Local Ambiguities

Which one is globally/locally ambiguous?

a) Someone shot the servant of the actress who was on the balcony

- **Globally ambiguous**

b) Wherever Alice walks her sheep dog will follow

- **Locally ambiguous**
Late Closure: attachment of incoming lexical material into the last analysed item

1st Choice = Late Closure

2nd Choice

Since Jay always jogs a mile seems like a short distance to him
Minimal Attachment: attachment of incoming lexical material using the fewest phrasal nodes.

The city council argued the mayor’s position was incorrect.
How do humans recover from mistakes?
1. **Forward Reanalysis Hp.**: back to the very beginning of the sentence

Since Jay always jogs a mile seems like a short distance to him

- **Re-reading**
Since Jay always jogs a mile seems like a short distance to him

2. Backward Reanalysis Hp.: backward from the point of breakdown
3. Selective Reanalysis Hp.: focus only on the misleading portion
- How do humans understand sentences?

- How do humans deal with ambiguities?

- How do humans recover from mistakes?

- How to test this?
The Experiment – Method
Subjects

- # 16 Undergrads (Within-Sbj.)
# 16 Closure sentences; 4 versions:

- Late vs. Early
- Long vs. Short

**LC-Long:** Since Jay always jogs a mile and a half this seems like a short distance to him.

**EC-Long:** Since Jay always jogs a mile and a half seems like a short distance to him.

**LC-Short:** Since Jay always jogs a mile this seems like a short distance to him.

**EC-Short:** Since Jay always jogs a mile seems like a short distance to him.
# 16 Attachment sentences; 4 versions:
- Minimal vs. Non-Minimal
- Long vs. Short

**MA-Long:** I wonder if Tom heard the latest gossip about the new neighbours.

**NM-Long:** Tom heard the latest gossip about the new neighbours wasn’t true.

**MA-Short:** I wonder if Tom heard the gossip.

**NM-Short:** Tom heard the gossip wasn’t true.
Eye-tracking experiment:
- Self-paced reading of whole sentences
- Periodical comprehension questions
- 2-hr sessions per subj. (too much?)
The Experiment
– Results and Discussion
Data Analysis
**Data Analysis [1]**

- **Measured** variables (Dep. Var.):
  1. Total **Reading Time per Letter**

```plaintext
S_i_n_c_e__J_a_y__a_l_w_a_y_s__j_o_g_s__
...
```
Data Analysis [2]

- **Measured** variables (Dep. Var.):
  2. Reading Time per Letter for **Different Regions**

- **Manipulated** variables (Indep. Var.):
  - ambiguous region;
  - prior to the ambiguous region;
  - disambiguating region.

Since Jay always jogs a mile seems like a short distance to him
Measured variables (Dep. Var.):
1. Total Reading Time per Letter
2. Reading Time per Letter for Different Regions

Other Manipulated variables (Indep. Var.):
- First pass (red arrows);
- Second pass (blue arrows).

Since Jay always jogs a mile seems like a short distance to him
Measured variables (Dep. Var.):
3. Average Fixation Durations

Manipulated variables (Indep. Var.):
- Last 3 fix. prior to disambig. reg. (d-1, d-2, d-3);
- First 3 fix. in disambig. reg. (d, d+1, d+2).

Since Jay always jogs a mile seems like a short distance to him.
Data Analysis [6]

- **Measured** variables (Dep. Var.):
  4. Pattern of Eye-movements (regression frequency)

- **Manipulated** variables (Indep. Var.):
  - Region initiated from;
  - Region ended to.

Since Jay always jogs a mile seems like a short distance to him
**Plus!** Other **Manipulated** variables (Indep. Var.):

- **Sentence**
  - **Type**
    - **Closure**
      - **Late**
      - **Early**
  - **Attachment**
    - **Minimal**
    - **Non-Minimal**
  - **Length**
    - **Long**
    - **Short**
Predictions
Predictions

- G-P Th. + related proc. strat. (LC, MA) **apply**:
  - **Evidence**: RTs for **EC** and **NM** > RTs for **LC** and **MA**

- EC and NM are **harder** to process:
  - **Evidence**: Longer RTs in or around disambig. reg.

- Ambiguity is **detected** if:
  - **Evidence**: Longer RTs in ambig. reg.

- **Selective Reanalysis** Hp. applies:
  - **Evidence**: direct regr. from disamb. to ambig. reg.
Results:
Closure Sentences
Results: Closure Sentences [1]

- 2 (EC vs. LC) × 2 (Long vs. Short) ANOVA on Total Reading Time per Letter

<table>
<thead>
<tr>
<th></th>
<th>Early closure</th>
<th>Late closure</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long</strong></td>
<td>68 (176)</td>
<td>50 (240)</td>
<td>59</td>
</tr>
<tr>
<td><strong>Short</strong></td>
<td>57 (211)</td>
<td>55 (218)</td>
<td>56</td>
</tr>
<tr>
<td><strong>( \bar{X} )</strong></td>
<td>62.5</td>
<td>52.5</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values in parentheses represent the estimated reading rate in words per minute based on an average word length of 5 characters.
Results: Closure Sentences [2]

- $2 \text{ (Closure Type)} \times 2 \text{ (Length)} \times 3 \text{ (Region)} \times 2 \text{ (Pass)}$ ANOVA on Reading Time per Letter for Regions

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Region of the sentence</th>
<th>Before ambiguity</th>
<th>Ambiguity</th>
<th>Disambiguation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early closure</td>
<td>long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td></td>
<td>44</td>
<td>40</td>
<td>54</td>
</tr>
<tr>
<td>2nd pass</td>
<td></td>
<td>21</td>
<td>32</td>
<td>48</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>65</td>
<td>72</td>
<td>102</td>
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<tr>
<td>Early closure</td>
<td>short</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td></td>
<td>43</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>2nd pass</td>
<td></td>
<td>18</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>61</td>
<td>74</td>
<td>82</td>
</tr>
<tr>
<td>Late closure</td>
<td>long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td></td>
<td>43</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>2nd pass</td>
<td></td>
<td>12</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>55</td>
<td>50</td>
<td>63</td>
</tr>
<tr>
<td>Late closure</td>
<td>short</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td></td>
<td>40</td>
<td>42</td>
<td>47</td>
</tr>
<tr>
<td>2nd pass</td>
<td></td>
<td>16</td>
<td>27</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>56</td>
<td>69</td>
<td>69</td>
</tr>
</tbody>
</table>
### Results: Closure Sentences [3]

- $2 \times (\text{Closure}) \times 2 \times (\text{Length}) \times 6 \times (\text{Serial Order Fix.})$ ANOVA on Average Fixation Durations

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**Average Fixation Duration on the Three Fixations Prior to Reaching the Disambiguating Region (d) and the First Three Fixations in the Sentence Following the Initial Encounter with the Disambiguating Word**

<table>
<thead>
<tr>
<th>Serial order of fixation</th>
<th>1 (d−3)</th>
<th>2 (d−2)</th>
<th>3 (d−1)</th>
<th>4 (d)</th>
<th>5 (d+1)</th>
<th>6 (d+2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sentence type</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Early closure—long</td>
<td>252</td>
<td>259</td>
<td>236</td>
<td>301</td>
<td>285</td>
<td>313</td>
</tr>
<tr>
<td>Early closure—short</td>
<td>245</td>
<td>227</td>
<td>245</td>
<td>283</td>
<td>267</td>
<td>277</td>
</tr>
<tr>
<td>Late closure—long</td>
<td>248</td>
<td>239</td>
<td>243</td>
<td>260</td>
<td>247</td>
<td>242</td>
</tr>
<tr>
<td>Late closure—short</td>
<td>228</td>
<td>239</td>
<td>243</td>
<td>268</td>
<td>248</td>
<td>242</td>
</tr>
</tbody>
</table>

*Note.* These data were computed independent of the particular region of the sentence and consist only of the serial order that the fixations occurred in.
Results: Attachment Sentences
Results: Attachment Sentences [1]

- 2 (MA vs. NM) × 2 (Long vs. Short) ANOVA on Total Reading Time per Letter

### Reading Time per Letter (msec) for Each of the Four Attachment Sentence Versions

<table>
<thead>
<tr>
<th></th>
<th>Nonminimal attachment</th>
<th>Minimal attachment</th>
<th>( \bar{X} )</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Long</strong></td>
<td>61 (197)</td>
<td>45 (270)</td>
<td>53</td>
</tr>
<tr>
<td><strong>Short</strong></td>
<td>51 (235)</td>
<td>49 (246)</td>
<td>50</td>
</tr>
<tr>
<td>( \bar{X} )</td>
<td>56</td>
<td>47</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Values in parentheses represent the estimated reading rate in words per minute based on an average word length of 5 characters.
Results:
Attachment Sentences [2]

- 2 (Att. Type) × 2 (Length) × 2 (Region) × 2 (Pass) ANOVA on Reading Time per Letter for Regions

<table>
<thead>
<tr>
<th>Sentence type</th>
<th>Before ambiguity</th>
<th>Ambiguity</th>
<th>Disambiguation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonminimal attachment - lone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td>43</td>
<td>37</td>
<td>51</td>
</tr>
<tr>
<td>2nd pass</td>
<td>17</td>
<td>22</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>60</td>
<td>59</td>
<td>81</td>
</tr>
<tr>
<td>Nonminimal attachment - short</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td>43</td>
<td>36</td>
<td>47</td>
</tr>
<tr>
<td>2nd pass</td>
<td>10</td>
<td>15</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>51</td>
<td>70</td>
</tr>
<tr>
<td>Minimal attachment - long</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td>41</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>2nd pass</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>Minimal attachment - short</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st pass</td>
<td>42</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>2nd pass</td>
<td>8</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>48</td>
<td></td>
</tr>
</tbody>
</table>
Results:
Attachment Sentences [3]

- 2 (Length) × 6 (Serial Order Fix.) ANOVA on Average Fixation Durations

<table>
<thead>
<tr>
<th>Serial order of fixation</th>
<th>Sentence type</th>
<th>1 (d - 3)</th>
<th>2 (d - 2)</th>
<th>3 (d - 1)</th>
<th>4 (d)</th>
<th>5 (d + 1)</th>
<th>6 (d + 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonminimal attachment – long</td>
<td>248</td>
<td>259</td>
<td>258</td>
<td>291</td>
<td>284</td>
<td>301</td>
</tr>
<tr>
<td></td>
<td>Nonminimal attachment – short</td>
<td>247</td>
<td>235</td>
<td>226</td>
<td>292</td>
<td>280</td>
<td>267</td>
</tr>
</tbody>
</table>

Note. These data were computed independent of the particular region of the sentence and consist only of the serial order that the fixations occurred in.
Conclusions: Closure & Attachment Sentences
Conclusions: Closure & Attachment Sentences

- **Closure Sent.**: Longer RTs for *Disambig.* and *Ambig.* reg.

- **Attach. Sent.**: Longer RTs for *Ambig.* reg. on **second** pass

- **Both**: Longer average fixation durations for *Disambig.* reg. on **first** pass

  - Awareness of Ambiguity at that point.
Results: Pattern of Eye-movements
Results: Pattern of Eye-movements

- Cases of longer average fixations and regressions:

<table>
<thead>
<tr>
<th>Regression Initiated from</th>
<th>Before ambiguity</th>
<th>In ambiguity</th>
<th>In disambiguation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disambiguating region³</td>
<td>.03 (.01)</td>
<td>.33 (.36)</td>
<td>.12 (.11)</td>
<td>.52 (.51)</td>
</tr>
<tr>
<td>After disambiguating region</td>
<td>.01 (.02)</td>
<td>.06 (.05)</td>
<td>.04 (.05)</td>
<td>.15 (.15)</td>
</tr>
<tr>
<td>End of sentence</td>
<td>.18 (.17)</td>
<td>.10 (.12)</td>
<td>.02 (.02)</td>
<td>.33 (.34)</td>
</tr>
<tr>
<td>Total</td>
<td>.22 (.20)</td>
<td>.49 (.53)</td>
<td>.18 (.18)</td>
<td></td>
</tr>
</tbody>
</table>

Note. The values are proportions and are based on 222 regressions made by the subjects. The range of regressions was 5–29 per subject.

³ The values in parentheses are for the early closure and nonminimal attachment sentences.

⁴ In the minimal attachment sentences, the end of the sentence was considered to be the disambiguating region.

- Conclusions: no evidence for backward reanalysis.
Frazier & Rayner (1982) – Overall Findings
Overall Findings

- **G-P Th. + related proc. strat. (LC, MA) apply:**
  - **Evidence:** RTs for EC and NM > RTs for LC and MA
  - **Consequence:** immediate assignment of structure.

- **Selective Reanalysis Hp. applies:**
  - **Evidence:** direct regr. from disamb. to ambig. reg.
  - **Consequence:** only revision of incompatible parts having been previously assigned a (wrong) structure.
Reanalysis in Sentence Processing: Evidence against Current Constraint-Based and Two-Stage Models

PART 2

Reading through the Decades: Influential Papers in Psycholinguistics – Seminar

MSc Language Science and Technology
Dept. of Computational Linguistics and Phonetics
Saarland University, Saarbrücken (DE)
About van Gompel et al. (2001) – Introduction and Background
- How do humans understand sentences?

- How do humans deal with ambiguities?

- How do humans recover from mistakes?
Three Orders of (Contrasting) Models
# of Interpretation/Analyses at once:
- **one** by one: *Serial/Two-stage* models;
- **more** than one: *Parallel* models.

Type of Information Resources:
- first *syntax*, then *thematic* info;
- *syntactic* and *thematic* info together.

Mechanism for Ambiguity resolution:
- **same** analysis: *Fixed-choice* two-stage models;
- **different** analyses: *Variable-choice* two-stage models.
How do humans understand sentences?
1. Two-Stage Models (e.g., Frazier & Rayner, 1982)

- **Serial** processing, 2 stages, **fixed-choice:**

  - **1st stage**
    - 1st: based on **syntax** alone
    - 2nd: use of **thematic** info, too

  - **2nd stage**
2. Constraint-Based Lexicalist Models (e.g., McRae et al., 1998)

- **Parallel processing, 1 stage:**

- Use both **syntactic** and **thematic** info together
3. Unrestricted Race Model (e.g., Traxler et al., 1998)

- ‘Unrestricted’: use of any sources of info
- ‘Race’: parallel structures engage in a race (fastest >> adopted)

Reanalysis: 2 stages

Variable-choice: strategies affected by individual differences and source of info
How do humans deal with ambiguities?
1. Two-Stage Models: Ambiguity Resolution

- Deployed strategies:
  - Late Closure
  - Minimal Attachment

- Higher Processing Difficulty:
  - Early Closure
  - Non-minimal Attachment
2. Constraint-based Models: Ambiguity Resolution

- Deployed strategies:
  - Multiple analyses according to constraints

- Higher Processing Difficulty:
  - initial constr. favour analysis A, later constr. favour analysis B
  - initial constr. favour an. A + B, later constr. do not favour either
3. Unrestricted Race Model: Ambiguity Resolution

- Deployed strategies:
  - Multiple analyses

- Higher Processing Difficulty:
  - initial analysis X, but sentence is disambiguated towards analysis Y
  - initial analysis Y, but sentence is disambiguated towards analysis X
How did van Gompel et al. (2001) test Ambiguity?
van Gompel et al. (2001)
– Experimental Design
Two Experiments: Rationale

Experiment 1
- VP-NP attachment Ambiguities:
  - bias towards VP-att.

Experiment 2
- VP-NP attachment Ambiguities:
  - no initial bias
Experiments 1 & 2
– Method
Subjects

- Exp. 1
  - # 36 Uni-Studs

- Exp. 2
  - # 27 Uni-Studs
Materials (Exp. 1)

# 30 VP-NP attach. like:

- **Ambig.**: The hunter **killed** the dangerous poacher **with the rifle** not long after sunset.

- **VP-Att.**: The hunter **killed** the dangerous leopard **with the rifle** not long after sunset.

- **NP-Att.**: The hunter **killed** the dangerous leopard **with the scars** not long after sunset.
Materials (Exp. 2)

# 30 VP-NP attach. like:

- **Ambig.**: The hunter killed only the poacher with the rifle not long after sunset.
- **VP-Att.**: The hunter killed only the leopard with the rifle not long after sunset.
- **NP-Att.**: The hunter killed only the leopard with the scars not long after sunset.
Pretests (Exp. 1 & 2)

- **Plausibility pretest:**
  - rating of *how realistic* were different interpretations for each sentence;
  - **VP** plaus. for **VP-att.**; **NP** plaus. for **NP-att.**; **VP-** and **NP-att.** both plaus. for Ambig.

- **Off-line preference task:**
  - tested *items’ bias* (preference for attach. **PP** to **VP** or **NP**)
  - Exp. 1: bias towards **VP**; Exp. 2: **no** bias.

- **Completion task:**
  - testing bias by **completing PP** with meaningful continuation;
  - Exp. 1: bias towards **VP**; Exp. 2: **no** bias.
Procedure (Exp. 1 & 2)

- **Eye-tracking** experiment:
  - *Self-paced reading* of whole sentences
  - Periodical *comprehension questions*
  - *30-min* sessions per subj. (much better)
Experiments 1 & 2
– Results and Discussion
Data Analysis
Measured variables (Dep. Var.):  
1. Fixation Times for Different Regions (7 in total)

Manipulated variables (Indep. Var.):  
- Reg. 1, Sbj NP;
- Reg. 2, V;
- Reg. 3, Obj NP;
- Reg. 4, “with the”;
- Reg. 5, critical noun region (PP’s N);
- Reg. 6, postcritical region (AdvP).
Data Analysis (Exp. 1 & 2)

- **Measured** variables (Dep. Var.):
  
  1. Fixation Times for Different Regions

- **Manipulated** variables (Indep. Var.):
  
  - First-pass time: all fixations on a region for 1\textsuperscript{st} time;
  
  - Firs-pass regression: all repeated leftward fixations for 2\textsuperscript{nd} time;
  
  - Regression-path time: all (first) fixation times within the same region.
  
  - Total time: sum of all (first and second) fixations within the same region.
Results: Experiment 1
## Results (Exp. 1)

### Mean Reading Times and Percentage of Regressions

<table>
<thead>
<tr>
<th></th>
<th>1 The hunter</th>
<th>2 killed</th>
<th>3 the dangerous poacher</th>
<th>4 with the</th>
<th>5 rifle</th>
<th>6 not long after</th>
<th>7 sunset</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First-pass reading times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>502</td>
<td>378</td>
<td>672</td>
<td>300</td>
<td>374</td>
<td>500</td>
<td>565</td>
</tr>
<tr>
<td>VP attachment</td>
<td>491</td>
<td>357</td>
<td>683</td>
<td>305</td>
<td>376</td>
<td>509</td>
<td>553</td>
</tr>
<tr>
<td>NP attachment</td>
<td>490</td>
<td>370</td>
<td>656</td>
<td>302</td>
<td>373</td>
<td>543</td>
<td>539</td>
</tr>
<tr>
<td><strong>First-pass regressions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>5.0</td>
<td>14.0</td>
<td>6.0</td>
<td>8.8</td>
<td>11.3</td>
<td>42.7</td>
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</tr>
<tr>
<td>VP attachment</td>
<td>6.5</td>
<td>6.6</td>
<td>3.9</td>
<td>11.4</td>
<td>11.4</td>
<td>52.1</td>
<td></td>
</tr>
<tr>
<td>NP attachment</td>
<td>7.8</td>
<td>10.0</td>
<td>3.6</td>
<td>12.2</td>
<td>25.8</td>
<td>51.2</td>
<td></td>
</tr>
<tr>
<td><strong>Regression-path times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>502</td>
<td>417</td>
<td>818</td>
<td>354</td>
<td>420</td>
<td>684</td>
<td>1198</td>
</tr>
<tr>
<td>VP attachment</td>
<td>491</td>
<td>401</td>
<td>748</td>
<td>330</td>
<td>444</td>
<td>663</td>
<td>1252</td>
</tr>
<tr>
<td>NP attachment</td>
<td>490</td>
<td>408</td>
<td>750</td>
<td>328</td>
<td>431</td>
<td>841</td>
<td>1491</td>
</tr>
<tr>
<td><strong>Total times</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambiguous</td>
<td>622</td>
<td>532</td>
<td>947</td>
<td>379</td>
<td>451</td>
<td>699</td>
<td>698</td>
</tr>
<tr>
<td>VP attachment</td>
<td>593</td>
<td>476</td>
<td>890</td>
<td>394</td>
<td>468</td>
<td>721</td>
<td>663</td>
</tr>
<tr>
<td>NP attachment</td>
<td>619</td>
<td>529</td>
<td>922</td>
<td>459</td>
<td>567</td>
<td>829</td>
<td>685</td>
</tr>
</tbody>
</table>

*Note.* First pass, regression path, and total times are reported in milliseconds and first-pass regressions as the percentage of saccades leaving the region to the left after a first-pass fixation.
Results:
Experiment 2
## Results (Exp. 2)

### Mean Reading Times and Percentage of Regressions

<table>
<thead>
<tr>
<th>Region</th>
<th>1 The hunter</th>
<th>2 killed</th>
<th>3 only the poacher</th>
<th>4 with the</th>
<th>5 rifle</th>
<th>6 not long after</th>
<th>7 sunset</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguous</td>
<td>371</td>
<td>331</td>
<td>520</td>
<td>265</td>
<td>310</td>
<td>448</td>
<td>464</td>
</tr>
<tr>
<td>VP attachment</td>
<td>398</td>
<td>315</td>
<td>555</td>
<td>272</td>
<td>317</td>
<td>463</td>
<td>479</td>
</tr>
<tr>
<td>NP attachment</td>
<td>405</td>
<td>312</td>
<td>560</td>
<td>286</td>
<td>314</td>
<td>442</td>
<td>491</td>
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</tbody>
</table>

### First-pass regressions

<table>
<thead>
<tr>
<th>Region</th>
<th>Ambiguous</th>
<th>VP attachment</th>
<th>NP attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguous</td>
<td>6.2</td>
<td>9.0</td>
<td>6.0</td>
</tr>
<tr>
<td>VP attachment</td>
<td>9.8</td>
<td>9.0</td>
<td>7.4</td>
</tr>
<tr>
<td>NP attachment</td>
<td>6.5</td>
<td>9.5</td>
<td>9.1</td>
</tr>
</tbody>
</table>

### Regression-path times

<table>
<thead>
<tr>
<th>Region</th>
<th>Ambiguous</th>
<th>VP attachment</th>
<th>NP attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguous</td>
<td>371</td>
<td>363</td>
<td>620</td>
</tr>
<tr>
<td>VP attachment</td>
<td>398</td>
<td>374</td>
<td>626</td>
</tr>
<tr>
<td>NP attachment</td>
<td>405</td>
<td>342</td>
<td>645</td>
</tr>
</tbody>
</table>

### Total times

<table>
<thead>
<tr>
<th>Region</th>
<th>Ambiguous</th>
<th>VP attachment</th>
<th>NP attachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguous</td>
<td>421</td>
<td>425</td>
<td>706</td>
</tr>
<tr>
<td>VP attachment</td>
<td>469</td>
<td>435</td>
<td>795</td>
</tr>
<tr>
<td>NP attachment</td>
<td>456</td>
<td>412</td>
<td>764</td>
</tr>
</tbody>
</table>

*Note. First pass, regression path, and total times are reported in milliseconds and first-pass regressions as the percentage of saccades leaving the region to the left after a first pass fixation.*
Van Gompel et al. (2001)
– Overall Findings
Overall Findings

- **Exp. 1:**
  - **Predictions:** preference for VP-att.
  - **Evidence:** RTs (on regressions) for NP-att. > RTs for VP-att. and Ambig.
  - **Consequence:** consistent with G-P Th. and URM.

- **Exp. 2:**
  - **Predictions:** no preference for either NP- or VP-att. (more strategies as in variable-choice models)
  - **Evidence:**
    1) RTs for NP- & VP-att. > RTs for Ambig.
    2) No pref. for either NP- or VP-att.
  - **Consequence:** consistent with URM.
Frazier & Rayner (1982)
Van Gompel et al. (2001)
– The Three Models Compared
<table>
<thead>
<tr>
<th>Garden-Path Model</th>
<th>Constraint-Based Model</th>
<th>Unrestricted Race Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial/Two-Stage (no compet., but rean.)</td>
<td>Parallel (competition)</td>
<td>Parallel (competition)</td>
</tr>
<tr>
<td>Fixed-choice</td>
<td></td>
<td>Variable-choice</td>
</tr>
<tr>
<td>Resources: First syntax, then thematic</td>
<td>Resources: Syntactic + thematic</td>
<td>Resources: Various</td>
</tr>
<tr>
<td>Strategies: LC &amp; MA</td>
<td>Strategies: Multiple</td>
<td>Strategies: Multiple</td>
</tr>
</tbody>
</table>

Who wins??
Who wins??

Thanks for your kind attention!