Differentiating benefits and burdens of intervening material in German

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Easy and difficult sentences

(1) The horse raced past the barn fell.
(2) A person who, when riding a cycle, not being a motor vehicle, on a road or other public place, is unfit to ride through drinks or drugs shall be guilty of an offence.
(3) The reporter who the senator attacked quit.
(4) a. The reporter who the senator attacked quit.
   b. The reporter who attacked the senator quit.
(5) The administrator who the nurse (who was from the clinic) supervised scolded the medic while . . .
(6) The player that the coach met at (near the gym (by the river)) at 8 o’clock bought the house . . .
Locality effect

Intervening material hampers processing: X Y Z
RTs for Z increase when Y intervenes.

- penalty for O-RCs (e.g. King & Just, 1991, cf. Gibson, 1998)
- penalty for intervening material (Grodner & Gibson, 2005)

(4) a. The administrator who the nurse \textit{supervised} scolded the medic while . . .
    b. The administrator who the nurse \textit{from the clinic} \textit{supervised} scolded the medic while . . .
    c. The administrator who the nurse \textit{who was from the clinic} \textit{supervised} scolded the medic while . . .
**Anti-locality effect**

Intervening material facilitates processing: $X \quad Y \quad Z$

RTs for Z decrease when Y intervenes

- Konieczny (2000): verbs are read faster when an RC precedes

(7) Er hat das Buch, *das Lisa gestern gekauft hatte*, hingelegt.
he has the book that Lisa yesterday bought had laid.down
‘He has laid down the book that Lisa had bought yesterday.’

- Konieczny (2000): verbs are read faster when an RC precedes
- Hindi (Vasishth, 2003; Vasishth & Lewis, 2006)
- English: Jaeger et al. (2008)

(5) a. The player that the coach met at 8 o’clock *bought* the house . . .
   b. The player that the coach met near the gym at 8 o’clock *bought* the house . . .
Ich weiß, dass Peter das alte Haus aufwändig renoviert hat, was sehr schwierig war.

‘I know that Peter costly renovated the old house, which was quite difficult (to do).’

adverbial

Ich weiß, dass Peter das alte Haus letztes Jahr mit Hilfe von Susanne aufwändig renoviert hat, . . .

‘I know that Peter costly renovated the old house last year, with help from Susanne.’

relative clause
Experiments

(7) ... dass P. das alte Haus aufwändig renoviert hat... that P. the old house costly renovated has

Predictions

First approximation ...
Experiments

Predictions

(7) ... dass P. das alte Haus [ ] aufwändig renoviert hat ... that P. the old house costly renovated has

Memory-based predictions: Dependency-Locality Theory (Gibson, 2000)

modifier additional new DRs

[ ]  +0

[Adv]  'last year with help from S.'  +3

[RC]  'which he bought'  +1

[R[Adv]C]  'which he bought last yr. with help from S.'  +4

[RC][Adv]  'which he bought ... last yr. with help from S.'  +4

→ longer reading times for verb cluster in long sentences:
  \[ R[Adv]C = [RC][Adv] > [Adv] > [RC] > [ ] \]

→ longer reading times for RC verb when the RC contains the adverbial
Memory-based predictions: Dependency-Locality Theory (Gibson, 2000)

Figure: Reading time pattern predicted by DLT.
Expectation-based predictions: Surprisal Theory (Hale, 2001; Levy, 2008)


preliminary corpus data (derived from deWaC):

\[
p(v|c|\text{comp np np adv}) = .63
\]
\[
p(v|c|\text{comp np np RC adv}) = .72
\]
Experiments

Predictions

(7) . . . , dass P. das alte Haus [ ] aufwändig renoviert hat . . .
that P. the old house costly renovated has

Expectation-based predictions

Figure: Reading time pattern predicted by frequency-based expectations.
Experiments

(7) . . . , dass Peter das alte Haus [ ] aufwändig renoviert hat . . .
that Peter the old house [ ] costly renovated has

Modifier

Expt 1  Expt 2
✓   ✓   [   ]  no further material
✓   –   [Adv]  Adverbials (NP + PP)
✓   ✓   [RC]  Relative Clause
✓   ✓   [RC][Adv]  Relative clause followed by the adverbials
–   ✓   [R[Adv]C]  Relative clause containing the adverbials

20 sentences in each experiment; 4 lists
103 participants in Expt 1, 116 in Expt 2
Experiments

(7) . . ., dass Peter das alte Haus [ ] aufwändig renoviert hat . . .
that Peter the old house [ ] costly renovated has

- self-paced reading
- word-by-word
- non-cumulative
- masked pre-presentation of each word (understrokes)
- comprehension questions

analysis

- residual reading times
- no outlier correction, except for absolute cut-off (3000 ms)
- aggregated over regions
(7) . . ., dass P. das alte Haus [ ] aufwändig renoviert hat, . . .
that P. the old house costly renovated has

adv VC tag

RC das er ersteigert hat
which he bought has

RC-ini RC-end

Adv letztes Jahr mit Hilfe von S.
last year with help from S.

AdvP-ini AdvP-end
Experiment 1

Results

Figure: Residual Reading Times in Experiment 1.
Experiment 1

Results

(7) . . . dass P. das alte Haus aufwändig renoviert hat, . . .

that P. the old house costly renovated has

RTs for the adverb show no effect:

\[
\begin{array}{ccc}
\text{adv} & \text{RC} & \text{Adv} \\
4 & 11 & 12 \\
\text{RC} & 6 & 6 \\
\end{array}
\]

F-values < 1

Residual Reading Times in Experiment 1.
Experiment 1

Results

(7) . . . , dass P. das alte Haus [ ] aufwändig renoviert hat, . . .
that P. the old house costly renovated has

VC

Shorter RTs for the verb cluster when RC or Adv is present:

[ ] 133 [Adv] 85

Residual Reading Times in Experiment 1.

RC*Adv-interaction:
$F_1 = 9.7$, $p < .01$; $F_2 = 8.1$, $p < .05$
### Experiment 2 Results

<table>
<thead>
<tr>
<th>RC−ini</th>
<th>RC−end</th>
<th>AdvP−ini</th>
<th>AdvP−end</th>
<th>adv</th>
<th>VC</th>
<th>tag</th>
</tr>
</thead>
<tbody>
<tr>
<td>−100</td>
<td>−50</td>
<td>0</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
</tr>
</tbody>
</table>

**Figure:** Residual Reading Times in Experiment 2.
(7) ... dass P. das alte Haus [ ] aufwändig renoviert hat, ...

that P. the old house costly renovated has

RTs for the adverb show no effect:

\[
\begin{array}{c|c|c}
[ ] & 0 & -5 \\
[RC] & -18 & -5
\end{array}
\]

\[ F_1 = 1.5, \ p = .2; \ F_2 = 1.9; \ p = .15 \]
(7) . . . , dass P. das alte Haus aufwändig renoviert hat, . . .
that P. the old house costly renovated has

RTs for the verb cluster are shorter when it (almost) immediately follows an RC:

\[
\begin{array}{|c|c|c|}
\hline
& 122 & 139 \\
\hline
\hline
\end{array}
\]

\[
\begin{array}{|c|c|}
\hline
[R[Adv]C] & 35 \\
\hline
\end{array}
\]

\(F_1=9.3; \ F_2=11.8; \ p\text{-values } < .001\)
Summary and Conclusion

\[ [\text{Adv}] < [ ] \quad \text{anti-locality} \]
\[ [\text{RC}] < [ ] \quad \text{anti-locality} \]
\[ [\text{R[Adv]C}] < [ ] \quad \text{anti-locality} \]
\[ [\text{RC}] [\text{Adv}] = [ ] \quad \text{locality} \]

⇒ Reading time patterns in the Experiments evidence anti-locality-effects and simultaneously locality effects:

for comparable findings, Levy & Keller (2012)
The observed reading times conflict with both memory-based predictions and expectation-based predictions.
⇒ Integration costs are determined by effort of retrieval AND predictability.

⇒ We need a model that includes both retrieval cost and expectations.

⇒ We need a distance metrics that is sensitive to structure.
Thank you
Figure: Residual Reading Times inside the RC of Experiment 2.
Corpus data

preliminary) corpus data (derived from *deWaC*):

\[ p(\text{vc}|\text{comp np np \[\ldots\] adv}) \]

<table>
<thead>
<tr>
<th>modifier</th>
<th>(p(\text{vc}))</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>[\ldots]</td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td>[Adv]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[RC][Adv]</td>
<td></td>
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</table>
References


