German relative clauses: 
The missing-VP effect in double and triple embeddings

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Overview

1. The missing-VP effect
   - Definition
   - Previous studies

2. The missing-VP effect in German relative clauses
   - Current Experiments
   - Self-paced reading
   - Eye-tracking
The missing-VP effect

a) The patient who the nurse who the clinic had hired met Jack.
The missing-VP effect

a) The patient who the nurse who the clinic had hired met Jack.

b) [The patient [who the nurse [who the clinic had hired] admitted] met Jack.]
The missing-VP effect

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b) [The patient [who the nurse [who the clinic had hired] admitted] met Jack.]

→ Grammaticality illusion

- Complex ungrammatical sentences perceived as grammatical

(Frazier (1985) ascribed observation to Fodor; Gibson & Thomas (1999))
The missing-VP effect

a) The patient who the nurse who the clinic had hired met Jack.

b) [The patient [who the nurse [who the clinic had hired] admitted] met Jack.]

→ **Grammaticality illusion**
  
  Complex ungrammatical sentences perceived as grammatical

  (Frazier (1985) ascribed observation to Fodor; Gibson & Thomas (1999))

→ **Grammaticality illusion in SVO languages**

  in double embeddings in English and French
  
  when middle verb missing

  (Gibson & Thomas, 1999; Gimenes, 2009)
Previous research: SVO languages

Working memory based explanation:

- memory load too high → V2 prediction forgotten
  (as associated with greatest memory cost)

(Gibson & Thomas, 1999)
Double centre-embeddings in German:

[M Der Junge, [C-1 den das Haus,[C-2 welches abgerissen wurde], verängstigt hatte], lächelte.]

'The boy that the house that was demolished frightened smiled.'
Multiple embeddings in German

Double centre-embeddings in German:

[M Der Junge, [C-1 den das Haus,[C-2 welches abgerissen wurde], verängstigt hatte], lächelte.]

'The boy that the house that was demolished frightened smiled.'

Multiple centre-embeddings in German:

[M Der Ritter von Malzahn, [C-1 dem der Junker sich als einen Fremden, [C-2 der bei seiner Durchreise den seltsamen Mann, [C-3 den er mit sich führe,] in Augenschein zu nehmen wünschte,] vorstellte,] nötigte ihn ...]

'The rider from Malzahn to whom the Junker had introduced himself as a stranger who during his journey wanted to have a look at the strange man whom he would bring with him urged him . . .'  

(H. von Kleist, Michael Kohlhaas; Schneider 1959: 469)
Previous research: SOV languages

Several SPR and ET experiments:

- **English**: grammaticality illusion
  ⇒ in line with working memory based ”forgetting” account
  (Gibson & Thomas, 1999)

- **German**: no grammaticality illusion
  ⇒ slowdown in ungrammatical sentences in SPR and ET experiments
  (Vasishth et al., 2010; Frank et al., 2015 for Dutch; cf. Häussler & Bader for German, 2015)
Previous research: SOV languages

- **German**: Slowdown in ungrammatical (middle verb missing) sentences (≠ English)

  *Why?*

- German parser adapted to complex structures
  ⇒ prediction of verb "preserved" more easily than in English

  (Vasisht et al., 2010)
**Hypothesis**

**SOV languages:**

- Higher frequency of memory-straining structures
  → parser "trained" to more efficiently use WM resources for these structures
  ⇒ *no grammaticality illusion detected in German*

(Vasishth et al., 2010)
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**SOV languages:**

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- Idea: Increase of WM load ⇒ grammaticality illusion also in German (SOV)
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- Idea: Increase of WM load ⇒ grammaticality illusion also in German (SOV)

- add third embedding to German ORCs
  - Grammaticality illusion in triple embeddings
    ⇒ in support of working memory "forgetting" account
Current experiment: Method & Design

Method  Self-paced reading and eye-tracking

**SPR**  Exp. 1 (N=40): comprehension questions  
Exp. 2 (N=40): grammaticality judgements

**ET**  Exp. 3 (N=40): comprehension questions  
Exp. 4 (N=40): grammaticality judgements
Current experiment: Method & Design

**Method**  Self-paced reading and eye-tracking

**SPR**  Exp. 1 (N=40): comprehension questions  
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Exp. 4 (N=40): grammaticality judgements

**Design**  2 x 2 fully-crossed factorial design

Factor 1: Number of embeddings (two vs. three)  
Factor 2: Grammaticality (V2 present vs. V2 missing)
Experimental items, $N=48$

<table>
<thead>
<tr>
<th>NP1</th>
<th>NP2</th>
<th>NP3</th>
<th>NP4</th>
<th>V4</th>
<th>V3</th>
<th>V2</th>
<th>V1</th>
<th>NP5...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>erreichte das Versteck</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>reached the den</strong></td>
<td></td>
</tr>
</tbody>
</table>

a) two embeddings, grammatical

Der Hase, den der Fuchs, den der Hund

The rabbit that the fox that the dog

jagte, biss, erreichte das Versteck

chased, bit, reached the den

d) three embeddings, ungrammatical

Der Hase, den der Fuchs, den der Hund, den der Jäger sah, jagte, biss,

The rabbit that the fox that the dog that the hunter saw, chased, bit,

erreichte das Versteck

reached the den

V1 = critical, NP5 = postcritical
Predictions: Double embeddings

No grammaticality illusion (replication of Vasishth et al., 2010) → *Ungrammatical sentences (V2 missing)* read slower than *grammatical sentences (V2 present)* at V1 (critical).

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**Double**

**Triple**

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>Double</th>
<th>Triple</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>gram</em></td>
<td><img src="#" alt="Graph" /></td>
<td><img src="#" alt="Graph" /></td>
</tr>
<tr>
<td><em>ungram</em></td>
<td><img src="#" alt="Graph" /></td>
<td><img src="#" alt="Graph" /></td>
</tr>
</tbody>
</table>

RTs

Embedding

- [ ] double
- [x] triple

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Predictions: Triple embeddings

Grammaticality illusion due to memory overload → *Ungrammatical sentences* read faster than *grammatical sentences* at V1 (critical)

![Graph showing grammaticality illusion]

- Embedding
  - double
  - triple

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Predictions: Interaction between *number of embeddings* and *grammaticality*

Grammaticality illusion $\rightarrow$

*Speed-up for ungrammatical sent. in triple embeddings* (＝ English double emb.) or at least *smaller slowdown than in double embeddings at V1*

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Double embeddings:
Grammatical sentences judged correctly
Ungrammaticality detected

Triple embeddings:
Grammatical sentences misjudged as ungrammatical more frequently
Ungrammaticality remains undetected more frequently
Results: Comprehension questions

Response accuracy, Exp. 1 (SPR) and Exp. 3 (ET)

Exp. 1

Exp. 3

Grammaticality
- gram
- ungram

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Results: Grammaticality judgements

Proportions of trials judged as 'grammatical', Exp. 2 (SPR) and Exp. 4 (ET)
SPR Results

Mean RTs SPR Exp.1

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>RTs in ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>gram</td>
<td>700</td>
</tr>
<tr>
<td>ungram</td>
<td>800</td>
</tr>
<tr>
<td>gram</td>
<td>900</td>
</tr>
<tr>
<td>ungram</td>
<td>1000</td>
</tr>
</tbody>
</table>

Embedding
- double
- triple
Mean RTs SPR Exp.2

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>critical</th>
<th>postcritical</th>
</tr>
</thead>
<tbody>
<tr>
<td>gram ungram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>gram ungram</td>
<td></td>
<td></td>
</tr>
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Embedding
- double
- triple

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ET Results

Regression–path duration ET Exp.3

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>Critical</th>
<th>Postcritical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ungram</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RPD in ms

Embedding
- double
- triple
ET Results

Re-reading time ET Exp.3

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>RRT in ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>critical</td>
<td></td>
</tr>
<tr>
<td>postcritical</td>
<td></td>
</tr>
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</table>

Embedding
- double
- triple

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ET Results

Regression–path duration ET Exp.4

<table>
<thead>
<tr>
<th>Grammaticality</th>
<th>critical</th>
<th>postcritical</th>
</tr>
</thead>
<tbody>
<tr>
<td>gram</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ungram</td>
<td></td>
<td></td>
</tr>
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RPD in ms

Embedding
- double
- triple

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ET Results

Total Reading Time ET Exp.4

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>critical</td>
</tr>
<tr>
<td>postcritical</td>
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</tbody>
</table>

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>double</td>
</tr>
<tr>
<td>triple</td>
</tr>
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Discussion

Summary of results

- **SPR Exp. 1 and 2:**
  Slowdown in ungrammatical sentences at critical and postcritical region
  ⇒ no grammaticality illusion (≠ English)

- **ET Exp. 3 and 4:**
  Speed-up in ungrammatical sentences at critical region in early reading measures independent of number of embeddings (driven by double embeddings)
  Interaction (Exp. 3):
  higher FPRP for grammatical sentences in double embeddings only
  ⇒ facilitation in ungrammatical sentences
  Effect reversed in late reading measures and at postcritical region
  ⇒ ungrammaticality detected
Summary of results

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  ⇒ *momentary grammaticality illusion*
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  $\Rightarrow$ **no grammaticality illusion** ($\neq$ English)

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    $\rightarrow$ facilitation in ungrammatical sentences
  $\Rightarrow$ **momentary grammaticality illusion**

- Effect reversed in late reading measures and at postcritical region
  $\rightarrow$ **ungrammaticality detected**
Novel finding in eye-tracking:

- **momentary grammaticality illusion** (early reading, critical)
  - German data compatible with working memory "forgetting" account
  - unclear why illusion more prominent in double than triple embeddings (≠ predictions)
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- delayed detection of ungrammaticality in German (late reading, postcritical)
  - main difference between English and German
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- German parser "trained" to more efficiently use WM resources to deal with complex structures
  - recovery from illusion
Thank you.
References

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