Effect of sensory impairment on language processing

“The influence of language deprivation in early childhood on L2 processing: An ERP comparison of deaf native signers and deaf signers with a delayed language acquisition“

Skotara, Salden, Kügow, Hänel-Faulhaber & Röder, 2012
Outline

1. Background
2. Hypotheses
3. Methods
4. Results
5. Discussion
6. Conclusion
Do you remember?

LANGUAGE

THE PIZZA WAS TOO HOT TO....

CRY

DRINK

EAT

5µV

Congruous
Incongruous
Incongruous related

0 200 400 600 800 ms
## Background

<table>
<thead>
<tr>
<th>Deaf children with hearing parents</th>
<th>Deaf children with deaf parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>No access to spoken language of parents</td>
<td>Sign language from parents</td>
</tr>
<tr>
<td>→ no language acquisition from birth</td>
<td>→ from birth</td>
</tr>
<tr>
<td>Germany: DGS in primary school (or later)</td>
<td></td>
</tr>
<tr>
<td>“homesign” (no real natural language)</td>
<td>Complete, natural, fully realised language (phonology, syntax...)</td>
</tr>
<tr>
<td>→ no language development support</td>
<td>Language development similar to hearing children of hearing parents</td>
</tr>
</tbody>
</table>
Background

- Effects of a delayed L1 acquisition in a violation paradigm
- Semantic violations: N400 + positive ERP
- Syntactic violations: LAN + P600
- L2 learners: negative correlation between age of onset of acquisition of L2 and achieved grammatical competence
- Lexical-semantic < syntactical & phonological
Background

• N400: robust to effects of AoA
• LAN: more effected
• Compare L2 processing of ESL and LSL
  → effects of delayed L1 acquisition compared to a timely one in signers tested in their L2 German
Hypotheses

- Performance: LSL < ESL
- EEG:

<table>
<thead>
<tr>
<th></th>
<th>EGL</th>
<th>ESL</th>
<th>LSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semantic condition</td>
<td>N400 (centro-parietal)</td>
<td>N400 (centro-parietal)</td>
<td>N400</td>
</tr>
<tr>
<td>Syntactic condition</td>
<td>LAN (Cluster L1/+L2) → P600 (posterior)</td>
<td>LAN (Cluster L1/+L2) → P600 (posterior)</td>
<td>No LAN</td>
</tr>
</tbody>
</table>
Methods

- Participants: 3 groups (1.) ESL, (2.) LSL & (3.) EGL
- Excluded: with < 60% correct responses in all three conditions
  → 8 ESL & 8 LSL & 12 EGL
Methods: Material

- (1.) Language tests (ATBG) to access language abilities in German and DGS
- (2.) EEG: written German sentences

<table>
<thead>
<tr>
<th>Condition</th>
<th>Example sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>Der Mann <em>kocht</em> das Essen in der Küche. Engl.: The man cooks the meal in the kitchen.</td>
</tr>
<tr>
<td>Syntactic verb-agreement violation</td>
<td>*Der Mann <em>kochen</em> das Essen in der Küche. Engl.: *The man cook the meal in the kitchen.</td>
</tr>
<tr>
<td>Semantic violation</td>
<td>*Der Mann kocht das * in der Küche. Engl.: *The man cooks the picture in the kitchen.</td>
</tr>
</tbody>
</table>

- Each sentence: 3 different conditions
Methods: Procedure

- Decision: Correct or incorrect
- 5 blocks with 80 sentences
- Sentences shown for 600ms in random order
Methods: EEG recording

Figure 4 Electrode montage and clustering. Four adjacent electrodes each were averaged into the 14 marked clusters, seven over the left (clusters L1–L7) and seven over the right (clusters R1–R7) hemisphere.
Methods: Data analysis

- Mean amplitudes for **300-500ms** and **600-800ms** (semantics and syntax separately) were analysed
- Syntax: first interval divided into 3 segments each 66ms
Results: ATBG

- ESL > LSL in
  - grammatical competence in written German,
  - Comprehension of written German vocabulary,
  - Comprehension of DGS
Results: Behavioural data

- Main effect: Group; Condition
- Interaction between Group and Condition

<table>
<thead>
<tr>
<th>Correct condition</th>
<th>Semantic condition</th>
<th>Syntactic condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSL &lt; EGL</td>
<td>No group differences</td>
<td>EGL &gt; LSL</td>
</tr>
<tr>
<td>LSL &lt; ESL</td>
<td></td>
<td>EGL &gt; ESL</td>
</tr>
</tbody>
</table>
Results: EEG data

- With-in factors: Condition (CO), Hemisphere (HE), Cluster (CL)

### Table 3 ANOVAs for the semantic condition

<table>
<thead>
<tr>
<th>Semantics groups</th>
<th>effects</th>
<th>Time epoch 300–500 ms</th>
<th>600–800 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>p</td>
<td>F</td>
</tr>
<tr>
<td>EGL</td>
<td>CO</td>
<td>46.717 ( \leq 0.001 )</td>
<td>22.307 ( \leq 0.001 )</td>
</tr>
<tr>
<td></td>
<td>CO,HE</td>
<td>2.183</td>
<td>0.168</td>
</tr>
<tr>
<td></td>
<td>CO,CL</td>
<td>17.399 ( \leq 0.001 )</td>
<td>16.294 ( \leq 0.001 )</td>
</tr>
<tr>
<td></td>
<td>CO,HE,CL</td>
<td>0.545</td>
<td>0.612</td>
</tr>
<tr>
<td>LSL</td>
<td>CO</td>
<td>32.549 ( \leq 0.001 )</td>
<td>28.762 ( 0.001 )</td>
</tr>
<tr>
<td></td>
<td>CO,HE</td>
<td>5.572</td>
<td>0.050</td>
</tr>
<tr>
<td></td>
<td>CO,CL</td>
<td>11.111</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>CO,HE,CL</td>
<td>5.239</td>
<td>0.020</td>
</tr>
<tr>
<td>ESL</td>
<td>CO</td>
<td>4.943</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>CO,HE</td>
<td>9.011</td>
<td>0.020</td>
</tr>
<tr>
<td></td>
<td>CO,CL</td>
<td>6.883</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>CO,HE,CL</td>
<td>5.416</td>
<td>0.026</td>
</tr>
</tbody>
</table>

CO: Condition, HE: Hemisphere, CL: Cluster; p \( \leq 0.05 \); p \( \leq 0.01 \); p \( \leq 0.001 \); EGL: hearing early German language learners, ESL: deaf early sign language learners, LSL: deaf late sign language learners.
Results: EEG data

Figure 1 Overview of the ERP results for all clusters. Averaged ERPs of the semantic (first row) and syntactic (second row) condition for EGL (first column), ESL (second column), and LSL (third column) on all clusters. The dotted line denotes the ERP after the incorrect condition, the solid line the correct condition.
Results: EEG data

**Figure 2** Overview of the topographic distributions of the ERPs. Topographies of the N400 (first row), semantic positivity (second row), LAN for 300–500 ms (third row), LAN for 66 ms each (fourth row), and P600 (fifth row) for EGL (first column), ESL (second column), and LSL (third column). Blue denotes negative differences of incorrect minus correct words and red denotes positive differences in μV. The annotation ‘66 ms each’ denotes 366–433 ms for EGL, 433–500 ms for LSL, and 300–366 ms for ESL.
Discussion

• Acquisition of semantic aspects of a language (L2) not linked to a sensitive period within the first years of life

• Acquisition of a sign language results in the establishment of brain systems important to process the syntax of a human language (sensitive developmental periods)?

• LSL: no sign of cerebral organisation of syntactic language aspects comparable to people who grew up with a natural language
Discussion

- Higher L2 competence in deaf native signers compared to LSL
  - access to a natural language = requirement for the syntactic aspects of a written L2

- General disadvantage of deaf people in Germany:
  - overall effects of late acquisition
  - available impoverished German language input
  - educational situation of deaf people in Germany
Conclusion

• Semantic aspects of an L2 = attainable

• Syntactic: cerebral organisation highly vulnerable to a delayed L1 acquisition

→ learning a natural language (incl. syntactic complexity) seems crucial for acquisition of further languages in later life
Thank you for your attention! Questions?
How can we enhance the situation of deaf born children with hearing parents, so that they learn a natural and fully realised language from birth?
References