Working out Statistical Profiles of Negative Polarity Items

Timm Lichte

Methods and Statistics for linguistic Research
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Outline

Introduction:

- Polarity Items
- Degrees of Negation - Classes of NPI’s
- Extraction of NPI candidates
- Classification of NPI’s
Introduction: Polarity Items

Negative Polarity Item (NPI):

- He hasn't seen any student.
  * He has seen any student.

- Niemand von uns war jemals im Jemen.
  * Jeder von uns war jemals im Jemen.
Introduction: Polarity Items

Negative Polarity Item (NPI):

- Niemand von uns war jemals im Jemen.
  * Jeder von uns war jemals im Jemen.

Positive Polarity Item (PPI):

- Bill has already arrived in Munich.
  * Bill has not already arrived in Munich.

- Bill ist bereits in München angekommen.
  * Bill ist nicht bereits in München angekommen.
Introduction: Polarity Items

- A NPI must be within the scope of a trigger for negation.
- A PPI must **not** be within the scope of a trigger for negation.

⇒ Collocational behaviour
State of documentation

- Rich linguistical literature (formal semantics)
- No systematic documentation of PI’s in German (Welte 75, Kürschner 83)
Degrees of negation

Negation (antimorphic contexts):

\[ f(X \cap Y) = f(X) \cup f(Y) \]
\[ f(X \cup Y) = f(X) \cap f(Y) \]

Deutschland habe nicht die Absicht, jemals Belgien oder Frankreich anzugreifen.

Mehrmals war es ihr schon so ergangen, ohne dass sie 
... jemals davon gesprochen hätte.

Aus diesem Dokument kann man keinesfalls ersehen, ... daß 
sie es jemals gesehen hat.
Degrees of negation

- Negation (antimorphic c.): *nicht, ohne*

- N-words (anti-additive contexts):
  
  \[ f(X \cup Y) = f(X) \cap f(Y) \]

  
  … und *niemand* von der CDU/CSU-Fraktion hat *jemals* erklärt, daß diese Verträge nicht existent seien.

  Nein, diese Gedichte darf *kein* Fremder *jemals* erblicken.
Degrees of negation

- Negation (antimorphic c.): \textit{nicht, ohne}
- N-words (anti-additive c.): \textit{niemand, kein-}
- Monotone decreasing contexts:
  \[ f(X \subseteq Y) \rightarrow f(Y) \subseteq f(X) \]

Sehr wenige Männer oder Frauen haben \textit{jemals} die Gelegenheit, so viel Gutes zu tun wie James Grant.

In seiner Heimat sei \textit{kaum jemals} ein großer dramatischer Stil entstanden, . . .

Aber wie \textit{jeder} weiß, der \textit{jemals} einem hölzernen Kuckuck gelauscht hat, . . .
Degrees of negation

- Negation (antimorphic c.): nicht, ohne
- N-words (anti-additive c.): niemand, kein-
- Monotone decreasing c.: wenige, kaum
- Further contexts
Further contexts for *jemals*

Adversative predicates:

Bis zum vergangenen Sonntag **weigerte** sich sein Vater vehement, *jemals* CDU zu wählen.
Further contexts for *jemals*

- Adversative predicates: *s. weigern*

- *if*-clauses:
  
  *wenn* ich *jemals* einen Anflug von Moralität . . . verspürte, jetzt ist jeder Gedanke daran verschwunden.

- Questions:
  
  Hat Cäsar *jemals* germanische Kohorten gehabt?
Further contexts for *jemals*

- Adversative predicates: *s. weigern*
- *if*-clauses, questions
- Comparative/superlative degrees:
  - er war so in Angst, dass er sich toter stellte *als jemals* vorher.
  - Es soll die größte ... Ausstellung werden, *die jemals* abgehalten wurde.
  - er ist *zu* weit fort, um ihn *jemals* zu finden.
**Further contexts for jemals**

- Adversative predicates: *s. weigern*
- *if*-clauses, questions
- Comparative/superlative degrees
- *nur*:
  - In ganz Schleswig-Hostein gibt es nur einen Mann, der jemals die Meisterprüfung abgelegt hat.
  - Nur ein Drittel von ihnen nimmt jemals psychiatrische Hilfe in Anspruch.
Further contexts for *jemals*

- Adversative predicates: *s. weigern*
- *if*-clauses, questions
- Comparative/superlative degrees
- *nur*
- Certain temporal conjunctions:
  - Er hatte ... den Titel geholt, noch *bevor* er *jemals* australischer Meister war.
NPI classes

- **Superstrong**: only antimorphic c.
- **Strong**: antimorphic and anti-additive c.
- **Weak**: monotone decreasing c.
- **Class of the other contexts unclear**
Superstrong NPI’s

Example: *mals* (ndl.)

Distribution:

- Antimorphic (AM):
  Zijn oordelen waren vaak *niet mals*.

- Anit-additive (AA):
  * Niet één van zijn oordelen was *mals*.

- Monotone decreasing (DE):
  * Weinig van zijn oordelen waren *mals*.

- German: no superstrong NPI?
Strong NPI’s

Example: *sonderlich, beileibe, auch nur irgendw-

Distribution:

- AM: Der Lehrer war *nicht sonderlich* erfreut.
- AA: *Kein* einziger Lehrer ist *sonderlich* erfreut gewesen.
- Monoton decreasing:
  - *Nur wenige* Kaufleute sind *sonderlich* zufrieden gewesen.
- Further contexts:
  - *Sind die Kaufleute *sonderlich* zufrieden gewesen?*
Weak NPI’s

Example: *brauchen*+zu-Inf., *ausstehen können*, *ein Auge zutun*, *viel davon halten*

Distribution:

- Monoton decreasing:

  Höchstens eine Frau wird sich zu verantworten *brauchen*.
Classification of licensing contexts and of NPIs available.

No systematic documentation of the NPI inventory for German.
Extraction of NPI candidates

Corpus: TüPP-D/Z (Tübingen Partially Parsed Corpus of Written German)

taz, 2.9.’86–7.5.’99; ca. 200 mio words.

Annotation: lemmatisation, part of speech, morphology, clause boundaries, topological fields, chunks.
Extraction of NPI candidates

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Cutout: 1998 (ca. 1,2 mio sentences)

- Context marking
- Extraction of lemmata
- Extraction of candidates
Context marking

Based on part of speech and lemmatisation.

Sentence-wise context marking:

|   |      |    |        
|---|------|----|-------|
| NEG | 129,027 | 11.0% | nich(t) |
| AM  | 133,338 | 11.4% | weder, , ohne |
| AA  | 176,540 | 15.1% | niemand, keiner, . . . |
| DE  | 245,464 | 21.0% | wenige, selten, bevor |
| DE? | 308,156 | 26.3% | ob, wer, ? |
| total | 1,170,618 |   |     |
### Extraction of Lemmata

#### Lemmata with an occurrence of min. 50 : 17,157

<table>
<thead>
<tr>
<th>context</th>
<th>#</th>
<th>ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEG</td>
<td>2,065,400</td>
<td>14.3%</td>
</tr>
<tr>
<td>AM</td>
<td>2,145,195</td>
<td>14.9%</td>
</tr>
<tr>
<td>AA</td>
<td>2,765,828</td>
<td>19.1%</td>
</tr>
<tr>
<td>DE</td>
<td>3,910,076</td>
<td>27.1%</td>
</tr>
<tr>
<td>DE?</td>
<td>4,681,993</td>
<td>32.3%</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>14,445,709</strong></td>
<td></td>
</tr>
</tbody>
</table>

Statistical Profiles of Negative Polarity Items – p.14/25
**Extraction of candidates**

- **z-scores of frequency-ratios**
  - frequency-ratio: \( \frac{\text{NegContext}(w)}{\text{Total}(w)} \)
  - \( z = \frac{x-\mu}{\text{sd}} \)

  (Deviation of observation and mean, scaled by the standard deviation)
Extraction of candidates

- z-scores of frequency-ratios
- Significance level at 1.96 (p=0.05)?
  - Distribution not normal, but skewed to the right.

<table>
<thead>
<tr>
<th></th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>≥ 1.96</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>-2.14607</td>
<td>12.35070</td>
<td>.0000000</td>
<td>1.00000000</td>
<td>554</td>
</tr>
<tr>
<td>DE</td>
<td>-2.78318</td>
<td>8.31527</td>
<td>.0000000</td>
<td>1.00000000</td>
<td>596</td>
</tr>
</tbody>
</table>
Extraction of candidates

- z-scores of frequency-ratios
- Significance level at 1.96 (p=0.05)?
  - Distribution not normal, but skewed to the right.
  - Low z-values of NPI's `beileibe` and `Hehl`:

<table>
<thead>
<tr>
<th>lemma</th>
<th>NEG</th>
<th>AM</th>
<th>AA</th>
<th>DE</th>
<th>DE?</th>
</tr>
</thead>
<tbody>
<tr>
<td>beileibe</td>
<td>8.2</td>
<td>7.9</td>
<td>6.8</td>
<td>4.9</td>
<td>3.9</td>
</tr>
</tbody>
</table>

⇒ higher significance level?
Extraction of candidates

- z-scores of frequency-ratios
- Significance level at 1.96 (p=0.05)?
- Considering the ranking by NEG z-score:

  hinweg täuschen, hinnehmbar, verhehlen, notwendigerweise, sondern, sonderlich, zimperlich, antasten, wahrhaben, zurückschrecken, beileibe

⇒ all reasonable candidates for NPI’s!
Application of associative measures

Mutual Information:

\[ I(w_1, w_2) = \log_2 \frac{P(w_1, w_2)}{P(w_1)P(w_2)} \]

Ranking by I-values for NEG:

\[ \begin{align*}
\text{hinwegtäuschen, verhehlen, hinnehmbar, sondern,} \\
\text{notwendigerweise, sonderlich, zimperlich, antasten,} \\
\text{wahrhaben, zurückschrecken, durchsetzbar}
\end{align*} \]

\[ \rightarrow \] just slightly different from ranking by NEG z-scores!
Application of associative measures

- Mutual Information
- Log-likelihood score:
  \[ H_1: P(w|c) = P(w|\neg c) \]
  \[ H_2: P(w|c) \neq P(w|\neg c) \]

Ranking by LL-score for NEG:

\[ \text{verhehlen, hinnehmbar, fechten, unerheblich, verderben, zurückschrecken, zimperlich, durchsetzbar, antasten, wahrhaben, unumstritten} \]

\[ \implies \text{quite reasonable NPI candidates!} \]
Application of associative measures

- Mutual Information
- Log-likelihood score
- Pearson’s $\chi^2$ test:

$$\chi^2 = \sum_{i,j} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

- Ranking by $\chi^2$-score for NEG:

  | sondern, mehr, sein, die, gar, können, daß, aber, der, es, auch |

  $\Rightarrow$ no reasonable NPI candidates!

  $\Rightarrow$ scale by occurrence of lemma!
Application of associative measures

- Mutual Information
- Log-likelihood score
- Pearson’s $\chi^2$ test

$$\chi^2 = \sum_{i,j} \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Ranking by $\chi^2$-score for NEG, scaled by occurrence of lemma:

```
 hinwegtäuschen, hinnehmbar, verhehlen, notwendigerweise, sondern, sonderlich, zimperlich, antasten, wahrhaben, zurückschrecken, beileibe
```

$\implies$ reasonable NPI candidates!
Extraction of NPI’s: Summary

Simple z-score of frequency-ratios seems to suffice.

List of NPI candidates looks promising.

But:

- Lists of candidates without compound NPI’s (*wahrhaben willen*)
- Class definitions of negation triggers are holey (*jemals* at place 5196)
- Small corpus
How can we decide the subclass of a NPI (superstrong, strong, weak)?
Classification of NPI’s

How can we decide the subclass of a NPI (superstrong, strong, weak)?

- \( \text{NEG} \subseteq \text{AM} \subseteq \text{AA} \subseteq \text{DE} \subseteq \text{DE} \)?

- In general we expect increasing frequencies along the enlargement of the contexts of negation.

- Find: Mean and standard deviation of increase.

- Find: z-score for steps of increase for every Lemma.
### Degree of increase

<table>
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<tr>
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<tr>
<td><strong>mean</strong></td>
<td>5.6</td>
<td>43</td>
<td>79</td>
<td>53</td>
</tr>
<tr>
<td><strong>sd</strong></td>
<td>8</td>
<td>28</td>
<td>39</td>
<td>30</td>
</tr>
<tr>
<td><strong>z max</strong></td>
<td>24.2</td>
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<td>20.9</td>
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<tr>
<td><strong>z min</strong></td>
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**H1** Superstrong NPI’s: Low z-scores for AM→AA, AA→DE and DE→DE?.
### Degree of increase

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**H2** Strong NPI’s: Only low z-scores for AA→DE and DE→DE?.
**Degree of increase**

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**H3** Weak NPI’s: z-scores at steps arbitrary.
### Degree of increase

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**H4** Nominal NPI’s: extreme high z-scores at AM→AA.
### H1: superstrong NPI’s

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<tbody>
<tr>
<td>hinwegtäuschen</td>
<td>0.68</td>
<td>-0.77</td>
<td>-1.49</td>
<td>-1.40</td>
</tr>
<tr>
<td>hinnehmbar</td>
<td>-0.71</td>
<td>-0.96</td>
<td>-2.01</td>
<td>-0.68</td>
</tr>
<tr>
<td>zimperlich</td>
<td>1.80</td>
<td>-0.85</td>
<td>-1.04</td>
<td>-0.47</td>
</tr>
<tr>
<td>verkneifen</td>
<td>-0.71</td>
<td>-1.56</td>
<td>0.33</td>
<td>-1.33</td>
</tr>
</tbody>
</table>
### H1: superstrong NPI’s

All candidates are weak NPI’s.

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### H2: strong NPI’s

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<tbody>
<tr>
<td>beileibe</td>
<td>-0.71</td>
<td>5.42</td>
<td>-2.06</td>
<td>-1.76</td>
</tr>
<tr>
<td>sondern</td>
<td>1.32</td>
<td>1.40</td>
<td>-1.82</td>
<td>-1.63</td>
</tr>
<tr>
<td>sonderlich</td>
<td>1.87</td>
<td>1.72</td>
<td>-1.66</td>
<td>-1.60</td>
</tr>
<tr>
<td>verhehlen</td>
<td>3.0</td>
<td>0.54</td>
<td>-0.93</td>
<td>-1.26</td>
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</table>
### H2: strong NPI’s

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⇒ Candidates seem to be strong NPI’s.
### H3: weak NPI’s

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<th>AM→AA</th>
<th>AA→DE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>scheren</td>
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<td>4.27</td>
<td>0.99</td>
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<td>unerheblich</td>
<td>0.45</td>
<td>-0.58</td>
<td>-0.42</td>
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</table>
### H3: Weak NPI’s

Weak NPI’s show diverse patterns of increase.

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## H4: nominal NPEs

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<th>AM→AA</th>
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<tbody>
<tr>
<td>Seltenheit</td>
<td>-0.71</td>
<td>23.91</td>
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<td>19.70</td>
<td>-1.68</td>
<td>-1.53</td>
</tr>
<tr>
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<td>1.75</td>
<td>16.59</td>
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### H4: nominal NPEs

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</tbody>
</table>

⇒ Negative cohesion is responsible for this pattern of increase.
Classification of NPI’s: Summary

- Promising method for strong and nominal NPI’s ...
- but again 'just' candidates.
- No superstrong NPI found.
- In preparation: Application of the mentioned associative measures.
Outlook

- Refinement of the classes of negation triggers
- Enlargement of corpus cutout
- Implementation of collocational modules to detect multi-word NPI’s
- PPI’s