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Evidence from eye movements
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The processing cost of negation in sentence comprehension: Evidence from eye movements
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Introduction
Previous research on negation supports the view that negation involves a processing cost. A good number of studies suggest that any kind of negation adds a processing cost to comprehension. Some even showed that words with negative semantics such as free, a small proportion and forget also take longer to process than affirmatives (Clark, 1969; Just & Carpenter, 1971). Other studies have presented contrasting results as to whether or not morphological negation adds a processing cost to comprehension (Sherman, 1973; Hoosain, 1973).

Sherman (1973) in his first study found that negative prefixes are more difficult to process compared to non-negated forms, but that they are not as difficult as negated forms with not. However, in another study (Sherman, 1976b), he did not find any cost associated with negative prefixes on their own, but increased processing times were found when these prefixed forms were in the presence of one or two other negatives (multiply negated statements). Hoosain (1976) also tested prefixed negation in his experiment and did not find any significant differences between negatively-prefixed forms and their base forms.

In this study, three forms of negation namely, SENTENTIAL NEGATION (negator nd), PREFIXAL NEGATION (not) and DOUBLE NEGATION (not not) were compared to the so-called BASE form (with no negation). Comprehension of these negated forms was tested through reading a congruent or incongruent subsequent context while participants’ eye movements were recorded. See the example below:

<table>
<thead>
<tr>
<th>Negation conditions</th>
<th>Contextual manipulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the evidence shows that the fire in the school was intentional</td>
<td>the jury will find guilty in court.</td>
</tr>
<tr>
<td>not intentional/ not indifferent</td>
<td>the headmasterannounced</td>
</tr>
</tbody>
</table>

Research questions
1. Does negation add a cost to the integration of negated information?
2. To what extent do sentential negation, prefixed negation and double negation differ in their contribution towards increased processing difficulty reflected in the eye movements of participants?

Procedure
- 25 native speakers of English (16 females, mean age of 27.4, range 21-42)
- 200 trials: 160 experimental + 40 fillers
- 45-50 minute task
- Sentences accompanied by comprehension questions
- Apparatus: EyeLink 1000

Results
1. Total dwell time on the contextually manipulated word

<table>
<thead>
<tr>
<th>Differences In</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
</tr>
</tbody>
</table>

2. Probability of regressions backwards to the negated adjectives

<table>
<thead>
<tr>
<th>Base form est.</th>
<th>Not form est.</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>0.35</td>
<td>.07</td>
</tr>
</tbody>
</table>

3. Residual first-pass reading times on the negated adjectives

<table>
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<th>p</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.35</td>
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</tr>
</tbody>
</table>

4. Residual second-pass reading times on the negated adjectives

<table>
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<th>Not form est.</th>
<th>p</th>
</tr>
</thead>
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</tr>
</tbody>
</table>

5. Residual Total dwell times on the negated adjectives

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<th>Not form est.</th>
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</tr>
</thead>
<tbody>
<tr>
<td>0.33</td>
<td>0.35</td>
<td>.07</td>
</tr>
</tbody>
</table>

Design & Materials
- 4 × 2 full factorial, within-subject
- 20 antonym pairs extracted from COCA
- Rounded adjectives were used in the construction of the stimuli in order to minimize differences in meaning interpretations across the four conditions
- 3 ranges of frequencies: base > prefixed, base < prefixed and base = prefixed
- Examples: authorized-anauthorized, employed-employmented, paid-unpaid

Analysis
- Areas of interest and measures:
  - Contextually manipulated word: Total dwell time
  - Negated adjective: Total dwell time, first-pass reading time, second-pass reading time, regression-in
  - Residual reading times were calculated and used in order to account for frequency and length differences
  - Linear mixed-effects model [R software]

Discussion
- Higher number of regressions back to the negated adjectives, and increased processing time found in first-pass, second-pass and total reading times for these forms (base=not, not=not) suggest that participants had difficulty with processing the negated forms and needed to go back and reread and reprocess the meanings of these forms.
- No differences were found in the total dwell time on the manipulated words for negation or consistency. This could suggest a good-enough approach to the comprehension of the sentences in which incongruities did not disrupt the eye movements. However, this result is merely tentative as there is no behavioral data available to support it.

Conclusions
- This study provides further support for the processing cost of negation
- Unlike Sherman (1976) and Hoosain (1973), the results of this study suggest that there is a processing cost associated with negatively-prefixed adjectives compared to their base forms, but that these prefixed forms are not as difficult as negated forms with not.
- Double negation proved to be the most difficult and problematic form of negation.

References