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Farshchi, Sara; Andersson, Richard; Paradis, Carita

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

The processing cost of negation in sentence comprehension: Evidence from eye movements

Sara Farshchi, Richard Andersson & Carita Paradis
Lund University
Contact: sara.farshchi@englund.lu.se

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 *few*, *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, 1976; 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, 1976), 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 prefixal 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 *not*), PREFIXAL NEGATION (*un-*) and DOUBLE NEGATION (*not un-*) 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:

	Negation conditions		Contextual manipulations	
If the evidence shows that the fire in the school was	*intentional* *unintentional* *not intentional* *not unintentional*	the jury will find the headmaster	*guilty* *innocent*	in court.

Research questions

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

Design & Materials

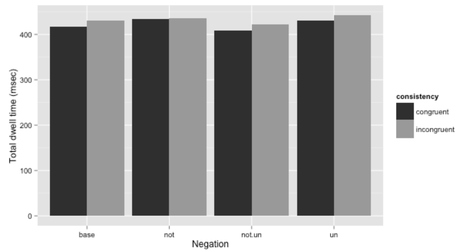
- 4 × 2 full factorial, within-subject
  - Negation (*base*, *un-*, *not*, *not un-*) × consistency (*congruent*, *incongruent*)
- 20 antonym pairs extracted from COCA
  - Bounded adjectives were used in the construction of the stimuli in order to minimize differences in meaning interpretations across the four conditions
  - 3 ranges of frequencies: base > prefixed, base < prefixed and base ~ prefixed
  - Examples: *authorized-unauthorized*, *employed-unemployed*, *paid-unpaid*

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

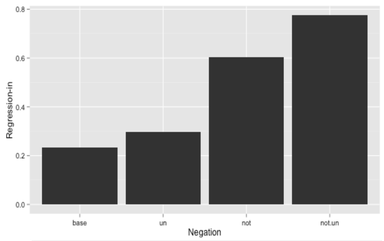
Results

1. Total dwell time on the contextually manipulated word



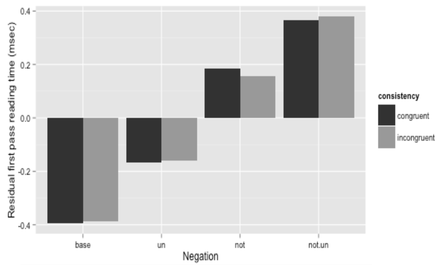
All differences NS

2. Probability of regressions back to the negated adjectives



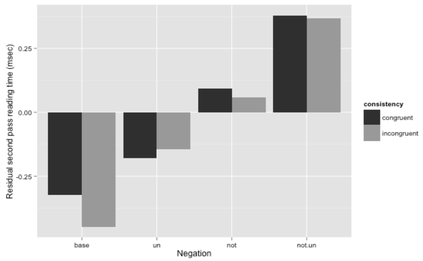
base<un: est.=0.39, SE=0.14, , z=2.65, $p < .01$
un<not: est.=1.4, SE=0.14, , z=10.11, $p < .001$
not<not un: est.=0.91, SE=0.14, z=6.24, $p < .001$

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



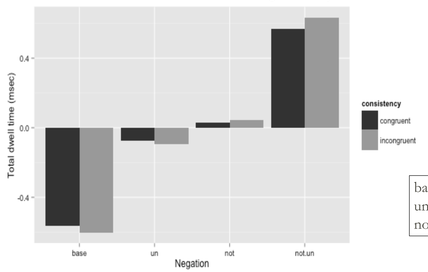
base<un: est.=0.26, SE=0.07, , t=3.34, $p < .001$
un<not: est.=0.31, SE=0.07, , t=4.04, $p < .001$
not<not un= est.=0.21, SE=0.07, t=2.86, $p < .001$

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



base<un: est.=0.27, SE=0.06, , t=4.08, $p < .001$
un<not: est.=0.19, SE=0.06, , t=2.91, $p < .001$
not<not un= est.=0.33, SE=0.07 , t=4.71, $p < .001$

5. Residual Total dwell times on the negated adjectives



base<un: est.=0.54, SE=0.11, , t=4.63, $p < .001$
un<not: est.=0.07, SE=0.11, , t=0.63, p =NS
not<not un= est.=0.56, SE=0.11, t=4.98, $p < .001$

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 differencs
- 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<un<not<not un*) 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 the 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

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