The incrementality of semantic interpretation – processing quantificational restriction

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The incrementality assumption applied to semantics and pragmatics

Each lexical item is immediately integrated into the discourse representation using all the information available from the context.

Consequently...

- Mid-sentence interpretations can be retracted in the light of further information
- Sentence meaning may undergo revisions during the comprehension process
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Consequently...

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- Sentence meaning may undergo **revisions** during the comprehension process
An example

(1) Sind alle Dreiecke blau . . .
    Are all triangles blue . . .

▶ answer: no
An example

context of utterance:

(1) *Sind alle Dreiecke blau, die im Kreis sind?*  
Are all triangles blue, which in the circle are?

▷ answer: yes

- Incremental semantic interpretation: answer is expected to change dynamically while processing the sentence.
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**context of utterance:**

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▷ answer: yes

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Natural language quantifiers require contextual restriction

(2)  a. Is everybody happy?
    b. = true iff all persons in a given context/situation are happy
    c. Still considered true if somebody not included in this situation is unhappy

Our research question:

What’s the time course of establishing contextual, quantificational restriction?
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Wijnen & Kaan (2006) and Kaan et al. (2007) investigated whether ‘semantic processing shares a distinguishing feature with parsing, viz. that it makes immediate, defeasible commitments’

(3) Twelve/Four flowers were put in a vase. Six had a broken stem.

- ‘Stops makes sense’ judgments: RT effect right at the numeral, subset condition read faster than ‘new’ condition
- ERP study: late effect; 900-1,500 ms positivity for the ‘new’ condition
  - Kaan et al. (2007): ‘The interpretation of quantifiers and the establishment of new discourse referents are rather slow processes’
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Incremental interpretation and the risk of reanalysis

Incremental interpretation of (1):
- Risky decision in first context; answer has to be revised
- Safe decision in second context; no matter what the continuation after blue may be, same answer
- Semantic processor may anticipate further restriction

(1) Sind alle Dreiecke blau, die im Kreis sind?
Are all triangles blue that in the circle are?
Dynamic answer generation while interpreting questions?

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How can we measure covert answer generation?

- We employ methods from cognitive psychology to measure motor response preparation
  - Dual task: probe detection while reading (this talk)
  - ERP: lateralized readiness potential (future research, see also van Turenout et al. (1998), Müller & Hagoort (2006))

- Dual task, sample trial:
  1) context
  2) reading & probe
  3) answering

- Expected facilitation effect when tone evaluation and truth evaluation trigger same motor response
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4×2×2 factorial within design

- Four kinds of **picture contexts**:

  - **A**
  - **B**
  - **C**
  - **D**

- **Two sentence types**:
  
  (4)  
  a. Are all triangles **blue** that are in the circle?  
  b. Are all triangles **blue** that are outside the circle?

- Either of two **tone probes** presented at the color adjective  
  - Tone presented to the left ear: left index finger  
  - Tone presented to the right ear: right index finger

- End of sentence truth value judgment with left and right index finger

- Dependent variables: tone RTs and % correct, truth value judgment RTs and % correct
Hypotheses and predictions

Strict incrementality (SI)

Faster reaction times for the tone evaluation in all contexts when the answer button for the tone task corresponds to the button for the locally adequate meaning.

Strict incrementality, anticipating revision costs (SI-Ant)

Facilitation for single-colored contexts, as the final semantic value is fully determined on the adjective. No facilitation for two-colored contexts, as potentially following linguistic information can induce shifts in meaning.

<table>
<thead>
<tr>
<th>local TV</th>
<th>SI</th>
<th>SI-Ant</th>
</tr>
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<tbody>
<tr>
<td>true</td>
<td>congr.&lt;incongr.</td>
<td>congr.&lt;incongr.</td>
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<tr>
<td>false</td>
<td>congr.&lt;incongr.</td>
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Methods

- 64 participants
- 128 items in 16 conditions + 72 Fillers (sentences without relative clauses and with other quantifiers)

Procedure

1. presentation of picture context (self-paced)
2. sentences presented using rapid serial visual presentation (500 ms per word), tone presented 400 ms post onset of color adjective
3. truth value judgment after each sentence

- Time limit for both, tone detection and truth value judgment task
- Buttons for ‘true’ and ‘false’ counterbalanced across participants
Questions about ‘complex’ contexts harder to answer than questions about simple contexts
Main effect *congruency*: congruent probes detected faster than incongruent ones \( (F(1, 63) = 5.2, p < .05) \)

Main effect *context*: faster probe detection in context A than in other contexts \( (F(3, 189) = 10.0, p < .01) \)

No sign. interaction, no sign. differences in error rates
Results – Tone detection, congruency effect

Contexts:

A)

B)

C)

D)

- Congruency effect only present in context B, i.e. negative answer in a safe context \((t(63) = 2.7; \text{all other contexts } t < 1)\)

- Contexts C and D: lack of effect expected under SI-Ant hypothesis

- What about context A?
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Contexts:

A) ![Graph showing data points]

B) ![Graph showing data points]

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Results – Tone detection, context effect

**Contexts:**

A) ![Image of context A]

B) ![Image of context B]

C) ![Image of context C]

D) ![Image of context D]

- Less cognitive load in context A
- Response preparation already finished in this type of context?
A replication

We ran a replication study (N=64) with arbitrary mapping of high vs. low tones onto right or left hand

Same pattern of effects, sign. interaction ($F(3, 189) = 2.8, p < .05$)

Contexts:

A)

B)

C)

D)
An explanation – The general idea

Recall that the tone was only presented 400 ms after the onset of the color adjective, thus the semantic task had a head start.

- Context : response preparation in the semantic task already finished at onset of tone detection task, thus no task interference

- Context : semantic task overlaps with tone detection (task interference), preparation of same response leads to congruency effect

- Contexts and : semantic task overlaps with tone detection task (task interference), no preparation of an answer in accordance with SI-Ant
One possible explanation

- Compute open question:
  \((\forall x[(\text{triangle}(x) \land c(x)) \rightarrow \text{blue}(x)])\), with \(c\) a continuation variable

- This open question could translate into the following algorithm (we expect an asymmetry for 'yes' vs. 'no' because all is left-monotone decreasing; all dots are big entails all red dots are big):
  1. check whether all triangles are blue. If so, return ‘yes’ and prepare response, otherwise go to step 2
  2. decide whether depending on possible values of \(c\) the answer could still turn out to be ‘yes’: If so, wait for further input, otherwise return ‘no’ and prepare response

Reconsidering our contexts

- Context A: only step 1 of the algorithm is required
- Context B: more complex, we need both steps
- Contexts C and D: we also need both steps, but here, no response is sent to motor preparation, yet
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Next steps

■ Interesting predictions for follow-up experiments:

■ if we choose the SOA between the color adjective and the tone probe in such a way that we tap into step 1 of the proposed algorithm, we should see response facilitation in context A but not in B

■ In contrast to all, some is left-monotone increasing. If the just outlined explanation is correct, we would expect to see the reverse pattern in the safe conditions: ‘no’ generally easy, ‘yes’ leads to difficulty

■ Similarly, we have rather precise predictions for the lateralized readiness potential. Early motor preparation in context A, somewhat delayed motor preparation in context B and no motor preparation in contexts C and D

■ Of course, given explanation is purely post hoc and needs to be tested further
Thank you very much for your attention!