Online processing of scalar implicatures in Chinese as revealed by event-related potentials

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Introduction

Terms like "some" have both logical and pragmatic readings:
1) "Some of the students there are hardworking."
   a) Logical: "Out of the set of students there, there exists some subset of students that are hardworking."
   b) Pragmatic: "Not all of the students there are hardworking."

Computing the pragmatic reading (1b) requires processing the speaker’s communicative intention (s/he chose not to say "all," thus must have meant "not all"). (Katsos & Cummins, 2010; Noveck & Sporzer, 2007; Tavano, 2009).

"In the picture, some of the girls are sitting on blankets."

Only are any ERP component associated with processing the pragmatic meaning of terms like "some"?

How quickly is the pragmatic meaning realized?

immediately (default approach, e.g., Levinson, 2000)

at a delay, after the logical meaning (context-driven approach e.g. Sporzer & Wilson, 1995)?

Previous ERP studies


- ERP responses to underinformative (logically correct but pragmatically infelicitous) sentence-final words
  2a) Patently true: "Some people have brothers."
  2b) Patently false: "Some couches have windows."
  2c) Underinformative: "Some turtles have shells."

- Underinformative sentences elicited a reduced N400 ERP component relative to other conditions.

Nieuwland et al. (2010)

- Addressed some methodological concerns from the previous study
- Compared underinformativeness effect to effect of lexicosemantic relatedness
  3a) Informativelated: "Some people have pets...".
  3b) Underinformative: "Some people have plants...".

- Increased N400 for underinformative sentences only in subjs. with high pragmatic ability; N400 for unrelated sentences in other subjs.

Limitations

- Violations became apparent only downstream of quantifier.
- No way to test whether pragmatic meaning of "some" was computed immediately when the quantifier was encountered
- Studies relied on real-world knowledge, perhapsinitiating memory search for exceptions (shell-less turtle, pit-less cherry?).
- For some participants, underinformativeness-related ERP is obscured by overlapping lexicosemantic N400 (Nieuwland et al., 2010).

Current study

Picture-sentence verification design (Wu & Tan, 2009; Tavano, 2010)

- Pictures provide controlled context for stimuli.
- Sentences are identical across violating and non-violating conditions.
- No differences in lexicosemantic relatedness
- Violation becomes apparent as soon as quantifier "some" is read.
- Possible to compare effects of underinformativeness versus "patent falsehood" without introducing semantic incongruity

Mandarin Chinese as language of study

- Previous investigations have focused on Indo-European languages.

Design and method

Materials

5 underinformative (4a) and "some"-type (4b) pictures, matched with "all"-type (5a) and "some"-type (5b) sentences:
5a) Some girls are sitting on blankets.
5b) Some of the girls are sitting on blankets.

Methods

- Participants: 9 native Chinese speakers from the University of Kansas
- Stimuli: 40 per condition, 148 fillers (74 correct "some" and "all", 37 incorrect object, 37 incorrect verb)
- Procedure: Picture displayed for 4000 ms, sentence displayed word-by-word (425 ms + 80 ms per character over 3; 4000 ms ISI)
- Task: 10% of trials followed by judgment probe ("Is that correct?"), 10% by irrelevant comprehension question (e.g. "Are they wearing sweatsuits?")

EEG recording: EEG continuously recorded using Synamps2 amplifier (Compumedics Neuroscan, Inc.) and 32-channel Ag/AgCl electrode cap (Electro-Cap International, Inc.); data recorded at 1kHz with a 20 Hz HF filter

Data processing: Artifacts (blinks, etc.) manually rejected; data re-referenced offline to average of both mastoids prior to epoching (~200 to 1000ms), baseline-correction, filtering, and averaging. ERPs were time-locked to point at which the quantifier appeared.

Statistical analysis: Calculated mean voltage amplitudes over selected time windows.

For some participants, underinformative-related repeated measures ANOVAs with factors Type (pragmatic, logic), Violation (violation, no violation), scalp Anteriority (anterior, posterior), and scalp Laterality (left, midline, right) were performed.

ERP results

- Relative to controls, both violation types elicited negativities from 150 to 900 msec.
- Based on waveforms and windowed ANOVAs, three time windows were identified:

150 – 300 ms: Anteriority*Violation (F(1,18)=11.627, p=0.009): violating sentences elicited more negative waveforms in the posterior region

300 – 500 ms: Anteriority*Violation (F(1,18)=12.196, p=0.008): violating sentences more negative in posterior region (N400)

600-900 ms: Latency*Type*Violation (F(2,35)=10.693, p=0.002): All violation elicits increased negativity relative to "some": effect broadly distributed anteriorly, left-centrally posteriorly;

- Effect of pragmatic violation greatest over right hemisphere
- Effect of logic violation greatest over midline

Discussion

Inference of implicature processing

- Pragmatic reading of "some" comes online immediately.
- Underinformativeness realizable on quantifier as well as on content word
- Consistent with findings from visual world eye-tracking (Tavano, 2010; Goode & Tanenhaus, 2003; but see Huang & Snedecker, 2009, 2010)
- P5 participants consistently made logical judgments; 1 consistently pragmatically; 2 inconsistent.
- In line with previous findings about consistency of responses to underinformativeness in experimental settings (Tavano & Naoi, 2010).

Pragmatic versus logical processing

- Both processes elicit similar ERPs in the early (150-300 ms) and N400 (300-500 ms) time windows.
- Late negativity (600-900 ms) differentiates implicature-based and logical processing, showing a more right-lateralized effect for the former.
- Late effect seems to index more than just encountering an unexpected word (since both violating quantifiers should be unexpected).
- Late effect may index different processes initiated to cope with or make decisions about pragmatically and logically unlicensed quantifiers.

Understanding language-relevant brain responses

- N400-like effect can be elicited even on frequently repeated words, even though repetition reduces N400 component (Kutas & Federmeier, 2000).
- ERP responses to underinformative sentences can be elicited independently of lexicosemantic manipulations.
- Functional significance of the late negativity requires further research. It cannot only reflect conflict control in inference cancellation (see Pinna et al., 2011) since it was also observed in the logic (supposedly inference-free) condition.

Limitations

- Small sample; a larger replication of this study is currently under way.
- High predictability of quantifier (no trials with other quantifiers; see Huang et al., 2010; Degen & Tanenhaus, 2010).
- Current design reveals electrophysiological activity associated with violating a scalar implicature, but not necessarily with generating one.

References

Patently false...