Computing implicatures under QUDs

Eszter Ronai & Ming Xiang

The University of Chicago

49th Annual Meeting of the North East Linguistic Society

Proposal and roadmap

Main claim

Questions Under Discussion, rather than e.g. the complexity of alternatives, determine the (reaction time) cost of implicature calculation.

1. Background
   - Processing implicatures
   - Lexical Access
   - The role of context
2. Experiment 1: QUD elicitation
3. Experiment 2: QUD manipulation
4. Discussion

Background

Implicatures

Messages that hearers infer do not always equal literal messages, e.g. implicatures.

(1) Mary ate some of the cookies. *scalar inference*

a. Literal: Mary ate some and possibly all of the cookies.

b. Inference: Mary ate some but **not all** of the cookies.

(2) It is a cookie that Mary ate. *it-cleft exhaustivity*

a. Literal: Mary ate a cookie and possibly other things too.

b. Inference: Mary **only** ate a cookie.

Background

Processing implicatures

Implicatures: window into the **integration of semantic and pragmatic knowledge**.

Time delay cost for the inference-enriched as compared to the literal reading.

- Reaction time (Bott & Noveck, 2004).
- Eye-tracking (Huang & Snedeker, 2009).
- ERP (Noveck & Posada, 2003).

Though cf. Grodner *et al.* (2010) who find immediate and effortless calculation (Default hypothesis) and Degen & Tanenhaus (2015) for the Constraint-Based approach.

Background

Lexical Access

What makes implicature calculation a **costly** process?

Idea from the theoretical literature: how do we **construct the alternatives** the speaker could have? Use **complexity of alternatives** to characterise them (Katzir, 2007; Fox & Katzir, 2011).

- deletion
- contraction
- substitution, from e.g. the lexicon

No processing claims though - how would this manifest?

Van Tiel & Schaeken (2017, following Chemla & Bott, 2014) present a particular implementation:

Lexical Access hypothesis

Retrieving items from the lexicon to construct the relevant alternatives is what triggers cost.

Background

Lexical Access

Van Tiel & Schaeken (2017):

Lexical Access hypothesis

Retrieving items from the lexicon to construct the relevant alternatives is what triggers cost.

They compare: scalar inference, *it*-cleft exhaustivity, free choice inference, conditional perfection.

- **Only scalar inference** shows a reaction time **cost**.
- Support for Lexical Access: retrieving *all* to construct relevant alternative (*some but not all*) is what triggers cost.
- The other inference types: no (lexical) alternatives, or alternative construction via deletion.

Key predictions and findings

Scalar inference incurs a reaction time **cost**, but ***it*-cleft exhaustivity does not**.

The role of context

A potential problem: sentences were presented in isolation, and previous research has highlighted the **importance of context**.

QUDs modulate how likely a scalar inference is to arise.

- explicit questions (Zondervan *et al.*, 2008)
- background story (Degen, 2013)
- focus prosody (Cummins & Rohde, 2015)

We might **predict this effect to extend to** a) other types of inferences, b) **cost** of computation.

Our study

Hypothesis

Context is what determines the cost of implicature calculation.

We **compare scalar inference** (SI) and ***it*-cleft exhaustivity** (EXH), embedded under QUDs.

In contrast to earlier studies, **QUDs are elicited empirically**.
→ more systematic comparison

Known problem: how can we track down the QUDs relevant for a given context, other than relying on our own intuition? This is a first attempt at using elicitation.

General experimental design

Background story: Anne is asking questions from Bob, about pictures that only Bob can see.

- Control: Bob's answers unambiguously good/bad descriptions of the picture.
- Target: descriptions either good (on literal reading) or bad (inference-enriched).

Bob: *Some of the shapes are blue.*

Control: Good

Control: Bad

Target: Underinformative

Bob: *It is the square that is blue.*

Control: Good

Control: Bad

Target: Underinformative

Experiment 1: QUD elicitation

Participants, procedure and task

- 40 native monolingual speakers of American English.
- Participants saw SI and EXH target sentences paired with pictures, and were told that the sentences were Bob's answers to Anne's questions.

(3) Anne: _____*?*
Bob: *Some of the...*, *It is the...*
Picture (Good Control or Target, between-participants)

- **Task**: guess what Anne's question was.

Experiment 1: QUD elicitation

Results

Dominant SI questions:

- what: *What color are the shapes?*
- any: *Are any (of the) shapes black? Are there (any) red shapes?*
- all: *Are all of the shapes yellow?*
- some: *Are some of the shapes yellow?*

Dominant EXH questions:

- which: *Which/what shape is black? Which one (of them) is blue?*
- any: *Are any of the shapes yellow? Are there any black shapes?*
- what: *What color are the shapes? What color is the square?*

	SI				EXH		
	what	any	all	some	which	any	what
Target	42%	25%	6%	12%	54%	9%	8%
Good Control	32%	33%	20%	2%	67%	14%	6%

Experiment 2: QUD manipulation

Participants, procedure and task

- 85 native monolingual speakers of American English (different from Exp. 1).
  - 25-30 in each of the QUD conditions.
- **Sentence-picture verification task**: participants saw a **dialogue** between Anne and Bob, together with a picture.
- Task: make a **binary judgment** about whether Bob gave a good answer to Anne's question, given the picture he saw.
- We are interested in their response (Good/Not Good) and reaction time.

Experiment 2: QUD manipulation

Participants, procedure and task

3 × 3 design: Picture (within-participants) × QUD (between-participants)

Anne's questions: most frequent questions elicited from Exp. 1.:

(4) QUD manipulation in SI
wh-word: **What** color are the shapes?
indefinite: Are there **any** blue shapes?/Are any shapes blue?
quantifier: Are **all** shapes blue?

(5) QUD manipulation in EXH
wh-word: **Which**/What shape is blue?
indefinite: Are there **any** blue shapes?
quantifier: Are **both** shapes blue?

Experiment 2: QUD manipulation

SI example trial

QUD condition: Any, Picture condition: Target

(6) Anne: *Are any shapes blue?*
Bob: *Some of the shapes are blue.*

Task: choose “Good” or “Not Good”.

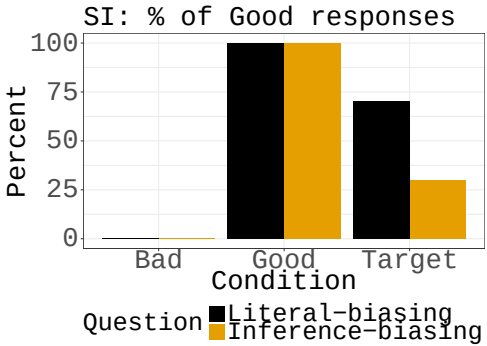
Experiment 2: QUD manipulation

Predictions

"Good" responses to Target: higher % indicate a lower rate of implicature calculation.

Some of the shapes are blue.

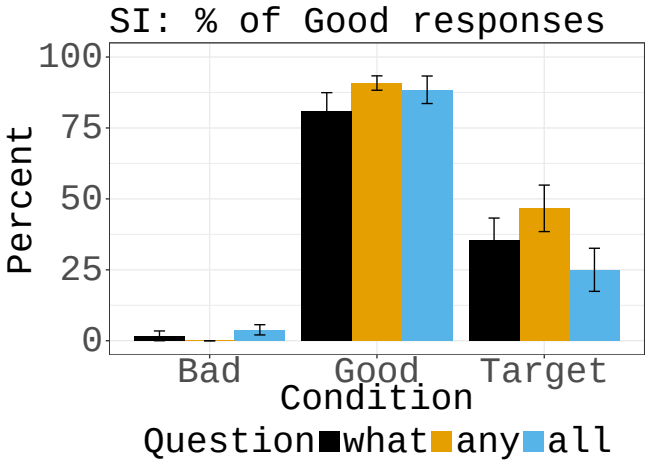
Literal-biasing QUD → higher %
Inference-biasing QUD → lower %



Experiment 2: QUD manipulation

Calculation rate results

"Good" responses to Target: higher % indicate a lower rate of implicature calculation.



significant Target differences:

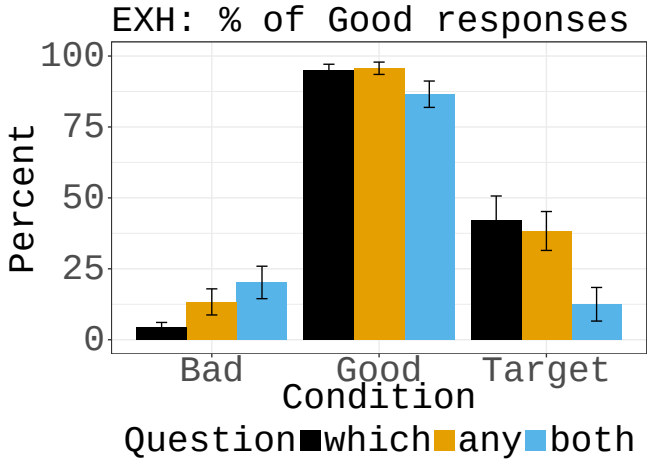
- any vs. all ($p<0.001$)
- any vs. what ($p<0.05$)

replication of earlier findings

Experiment 2: QUD manipulation

Calculation rate results

"Good" responses to Target: higher % indicate a lower rate of implicature calculation.



significant Target differences:

- both vs. any ($p<0.001$)
- both vs. which ($p<0.001$)

extends earlier findings to EXH

Experiment 2: QUD manipulation

Calculation rate results

Interim finding

- SI: any is a **Literal-biasing**, while what, all are **Inference-biasing QUDs**
- EXH: any and which are **Literal-biasing**, while both is an **Inference-biasing QUD**

Hypothesis: this is reflected in reaction time cost.

Experiment 2: QUD manipulation

Reaction time results

Cost of implicature calculation: longer reaction time when responding **Not Good (NG) to Target, relative to** the reaction time when responding **NG to Control**.

- Bad Control: target sentence is unambiguously a bad description.
- Target: responding "Not Good" implies the participant has gone through the inference calculation process.

Some of the shapes are blue.

Control: Bad

Target: Underinformative

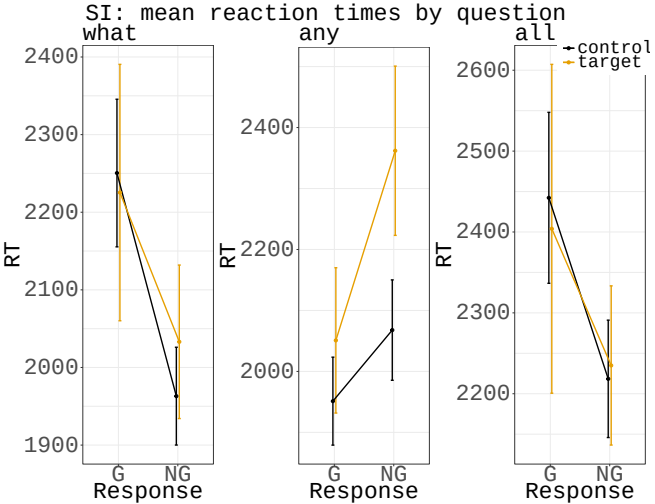
It is the square that is blue.

Control: Bad

Target: Underinformative

Experiment 2: QUD manipulation

Reaction time results



Cost: difference in NG to Target vs. NG to Control.

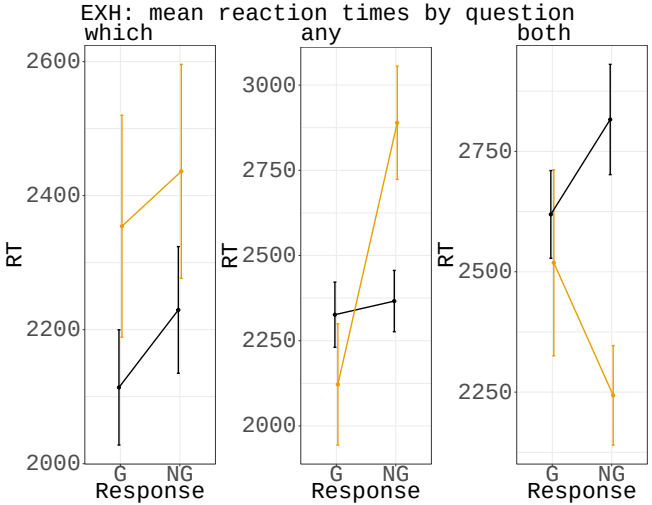
significant interaction of QUD-Response ($p<0.01$):

- any: cost
- what, all: no cost

→ **SI computation is only costly** when preceded by **non-supportive QUDs**.

Experiment 2: QUD manipulation

Reaction time results



Cost: difference in NG to Target vs. NG to Control.

- any: cost (RT for NG, Target vs. Control, $p<0.05$)
- which: similar but not exactly the same pattern
- both: unexpected cost for responding NG to Control

Discussion

Main findings

For both SI and EXH, calculation rates and **processing cost** are **strongly modulated by QUD**.

- QUDs that bias towards deriving the implicature make it a cost-free process.
- QUDs that bias against it make it incur a processing cost.

Differences signal cost of inference calculation, not just naturalness of dialogues:

- QUDs were empirically elicited.
- In the binary task, acceptance rates ("Good" response) are at ceiling in the Good Control picture condition, no matter the QUD.

Discussion

Cost predicted?

		SI	EXH
Lexical Access		✓	×
QUD	Literal-biasing	✓	✓
	Inference-biasing	×	×

Our findings: processing cost of implicature calculation is **not** directly/uniquely accounted for by **alternative construction** and the complexity of alternatives, rather it is **context-dependent**.

Conclusion

A QUD-based account better explains the current findings than a Lexical Access-based account.

Thank you!

We would like to thank Chris Kennedy for his support throughout the whole project, Bob van Tiel for the experimental materials and Zsolt Veraszto for technical help.

Eszter Ronai - ronai@uchicago.edu
Ming Xiang - mxiang@uchicago.edu

References I

Bott, Lewis, & Noveck, Ira A. 2004. Some utterances are underinformative: The onset and time course of scalar inferences. *Journal of Memory and Language*, **51**(3), 437 – 457.

Chemla, Emmanuel, & Bott, Lewis. 2014. Processing inferences at the semantics/pragmatics frontier: disjunctions and free choice. *Cognition*, **130**(3).

Cummins, Chris, & Rohde, Hannah. 2015. Evoking Context with Contrastive Stress: Effects on Pragmatic Enrichment. *Frontiers in Psychology*, **6**, 1779.

Degen, Judith. 2013. *Alternatives in Pragmatic Reasoning*. Ph.D. thesis, University of Rochester.

Degen, Judith, & Tanenhaus, Michael K. 2015. Processing Scalar Implicature: A Constraint-Based Approach. *Cognitive Science*, **39**(4), 667–710.

Fox, Danny, & Katzir, Roni. 2011. On the characterization of alternatives. *Natural Language Semantics*, **19**(1), 87–107.

Grodner, Daniel J., Klein, Natalie M., Carbary, Kathleen M., & Tanenhaus, Michael K. 2010. "Some," and possibly all, scalar inferences are not delayed: Evidence for immediate pragmatic enrichment. *Cognition*, **116**(1), 42 – 55.

References II

Huang, Yi Ting, & Snedeker, Jesse. 2009. Online interpretation of scalar quantifiers: Insight into the semantics–pragmatics interface. *Cognitive Psychology*, **58**(3), 376 – 415.

Katzir, Roni. 2007. Structurally-defined alternatives. *Linguistics and Philosophy*, **30**(6), 669–690.

Noveck, Ira A., & Posada, Andres. 2003. Characterizing the time course of an implicature: An evoked potentials study. *Brain and Language*, **85**(2), 203 – 210.

van Tiel, Bob, & Schaeken, Walter. 2017. Processing conversational implicatures: alternatives and counterfactual reasoning. **41**, 1119–1154.

Zondervan, Arjen, Meroni, Luisa, & Gualmini, Andrea. 2008. Experiments on the Role of the Question Under Discussion for Ambiguity Resolution and Implicature Computation in Adults. *Pages 765–777 of:* Friedman, Tova, & Ito, Satoshi (eds), *Proceedings of SALT 18*.

Experiment 2: QUD manipulation

Reaction time results

Why are the EXH results less clear?

Unexpected cost for responding NG to Control may be a "side-effect" of the picture stimuli.

- Two-step verification process for Bad Control - something is indeed blue, but not the correct thing. In SI, nothing is blue.
- Evidence: rate of "Good" responses to Bad Control is higher in EXH than SI.

Some of the shapes are blue.

Control: Bad

It is the square that is blue.

Control: Bad

Problem with "fixing" this: existential presupposition - there *is* something that is blue.