EYETRACKING WORKSHOP

reading

CAnDA
Göttingen September 2022

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EYETRACKING WORKSHOP

reading

Canda is a comune (municipality) in the Province of Rovigo in the Italian region Veneto, located about 80 km southwest of Venice and about 20 kilometres (12 mi) west of Rovigo. As of 31 December 2004, it had a population of 958 and an area of 14.4 square kilometres (5.6 sq mi).

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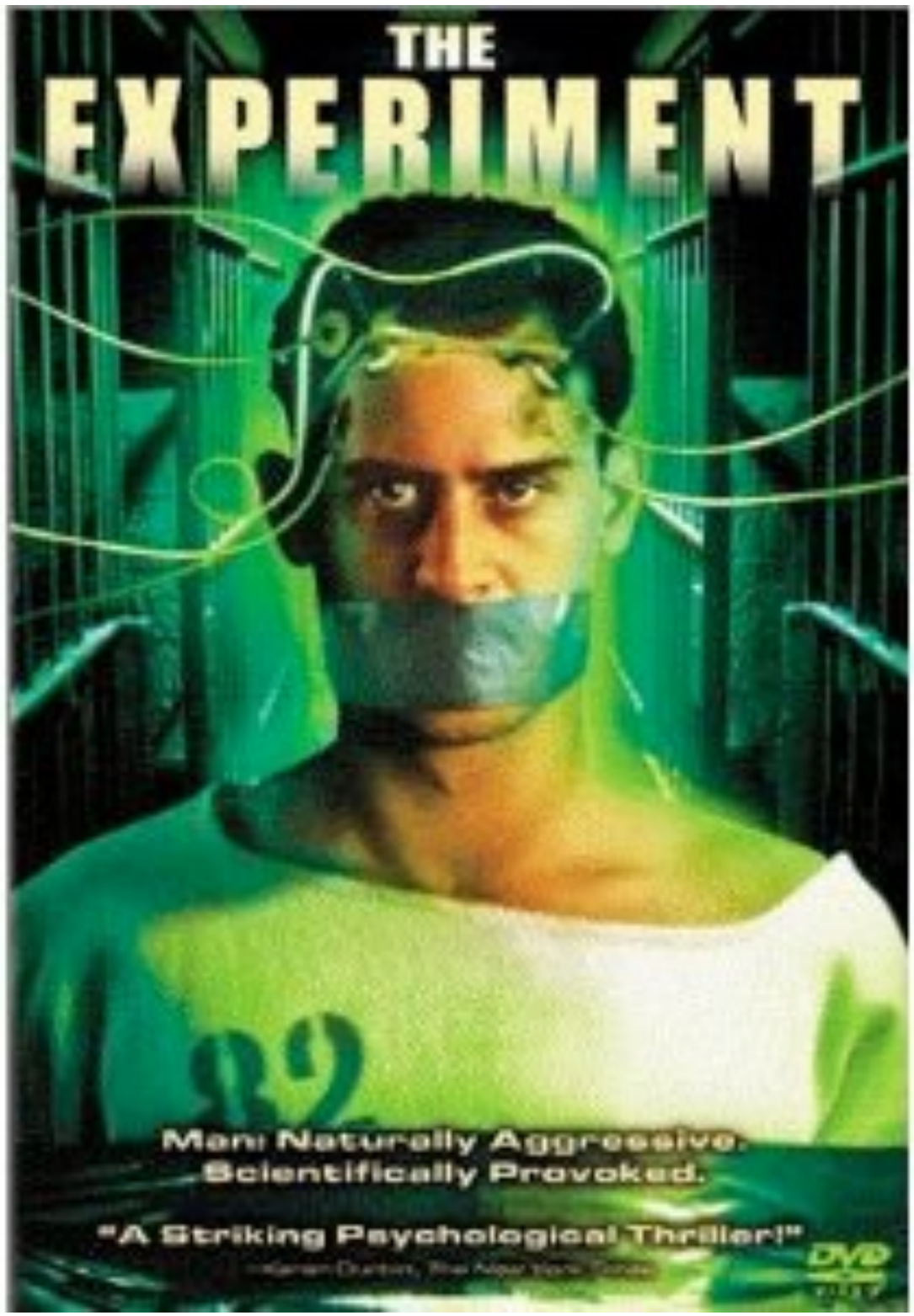
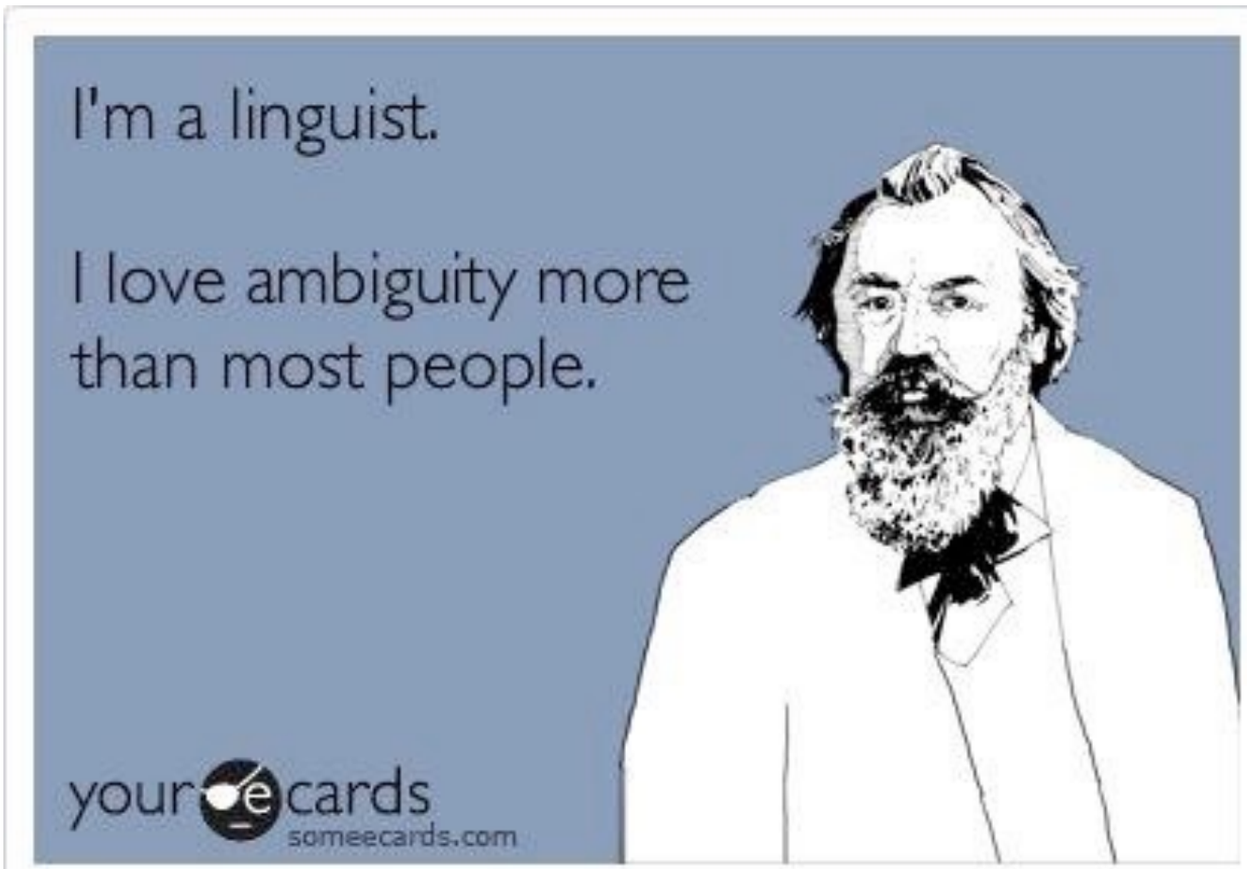
experimental background: good practices





experimental background: good practices

1 Identify the linguistic phenomenon to study

this seems trivial but.. are you 100% positive you know what you are studying?

2 Refine and optimize your linguistic model

improve your theory, read more papers, discuss with experts

3 Choose the optimal experimental methodology to investigate your phenomenon

the fancier <u>not</u> the better incremental plan: from the simpler to the more complex

(questionnaire > online judgment > eye tracking > EEG > intracranial recording > experiments on the moon)

4 Perform a deep analysis of the existing theoretical & experimental literature

alternative/competing theories?
existing processing models?

inspiration from other experiments/theories

that old paper whose existence I ignored...

that terrible moment in which I got to know that someone run the same experiment 20 years ago (and got better results..)

prepare for war: "why did not control for this factor, which was proven to dramatically affect the phenomenon you are studying by Pincopallino in 2010?"signed: the omniscient reviewer

experimental background: good practices

5 Dive into the hypothesis space

what are the hypotheses supported by your model?
what are the alternative hypotheses? which hyp. is linked to which model?
how can you test them through your experimental manipulation?

6 Make explicit the predictions following from your model wrt processing

in the best case you have direct implication for processing derived from your model (one-to-one)
more often you have a range of possible implications or a complex causal chain

7 Make explicit every possible experimental outcome (even those that you do not expect)

weird or unlikely experimental outcomes may index problems in your experimental material
unexpected results may suggest that other variables are affecting your exp. design

8 Put forward your expected results based on your model

in the best of the possible worlds: all the predictions are confirmed
very often this is not the case: the better you deal with surprise, the less headache you will have

experimental methods: on line

reading task with eye movements recording

assumption

language-related cognitive processes take time

the more complex they are
the more time they take

pros

more fine grained data

allows freedom of eye movements

→ reading patterns

cons

~~difficult to implement~~
~~difficult to analyze~~

costly instrument

Eye-tracking during reading

assumptions

language-related cognitive processes take time

the more complex they are
the more time they take

the eye-mind assumption

the eyes go where the mind goes

when a word is fixated the linguistic system is processing the cognitive operations that are necessary to interpret and integrate that word with the sentence, discourse, context etc.

Eye-tracking during reading

first pass reading measures	reflects the cognitive cost of processing a word/expression - specific to that word - related to integrating the word with the beginning of the sentence
second pass reading measures (regressions)	indexes the processing of the word plus the cognitive effort to integrate that word with the whole sentence - integration costs - additional operations - parsing strategies - re-analysis

Eye-tracking during reading

pros

- fine-grained processing measures
- detects very small differences (ms)
- sensitivity to linguistic operations at various levels

cons

it does not provide direct information about the nature of the linguistic or conceptual representation associated with the linguistic stimulus

levels

word level

lexical effects

morphological processing

sentence level

syntax: parsing operations

semantics: interpretation

discourse level

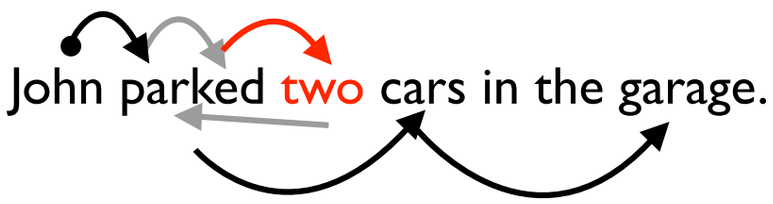
integration of speaker and addressee knowledge, communication, intentions etc.

Eye-tracking during reading

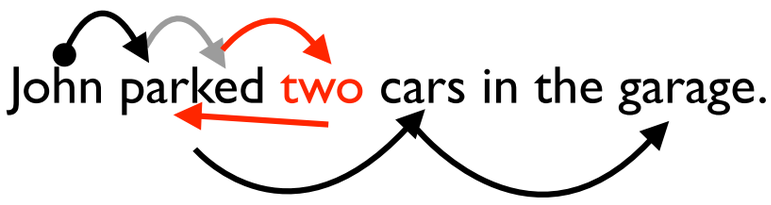
reading measures

first-pass measure: readers haven't seen the following verbal material yet.

first fixation duration takes into account only the first fixation made on a word



regression-path duration it takes into account every fixation made from the moment the reader enters into the region of interest until the reader leaves it,

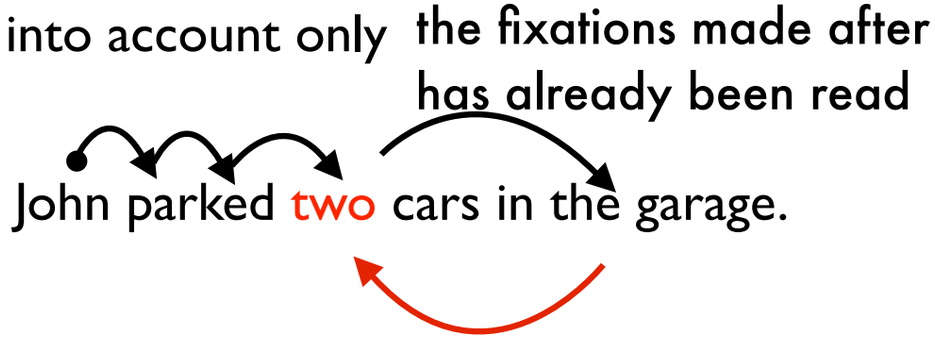


Eye-tracking during reading

reading measures

second-pass measure: readers have seen the following verbal material.

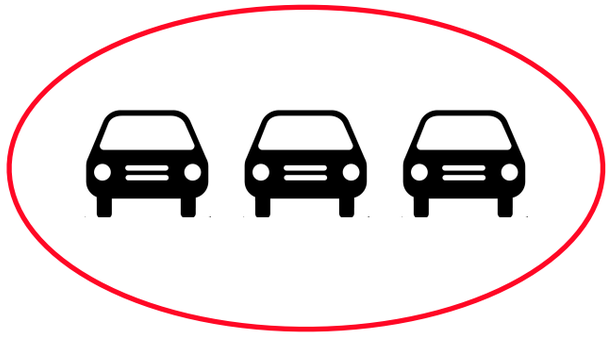
second pass fixations number — takes into account only the fixations made after the word has already been read



case study: numerals & implicatures

What is the meaning of numerals?

a numeral determiner denotes the cardinality of a SET



⟦three cars⟧ ⟶ 3(x) ^ cars(x)

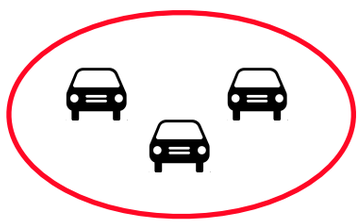
cardinality(x) = 3(x)

3(x) = x is a set with 3 members

problem: "John has 3 cars"

How many cars does John have?

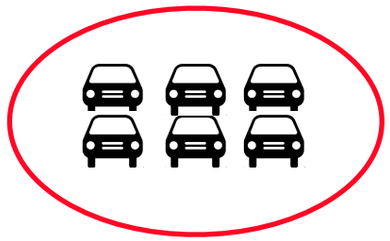
TRUE



exact reading

Who has three cars?

TRUE



"at least" reading

Some Hypotheses on numeral meaning

Lexical ambiguity

(Horn, Levinson)

3 lexical entries → at least N / at most N (?) / exactly N

'at least N obtained as pragmatic enrichment'

(Breheny)

NP & VP level: "*exactly N*" reading

↓

"*at least N*" ← pragmatic D-widening

Scalar Implicature Strengthening

(Chierchia, Fox, Horn, Levinson)

NP level: "*exactly N*" reading

↓

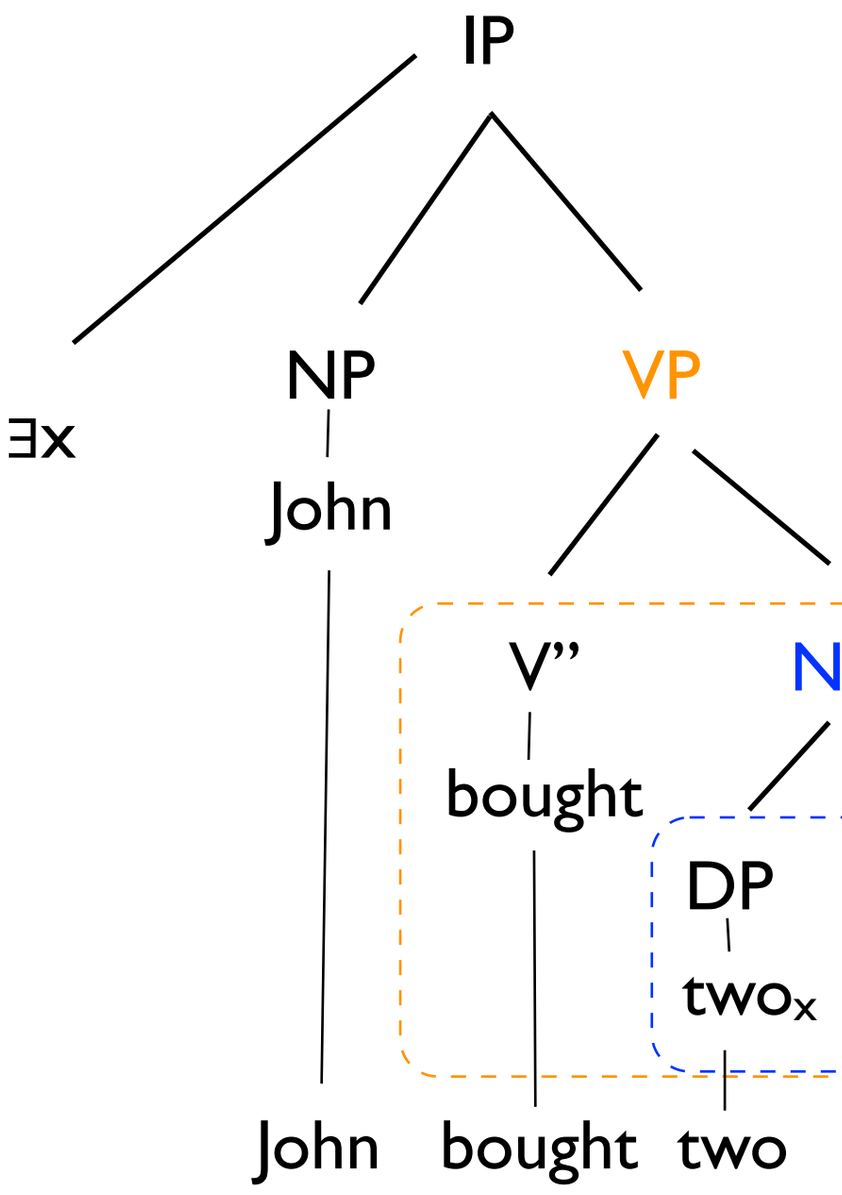
VP level: "*at least N*" reading ← existential closure

↓

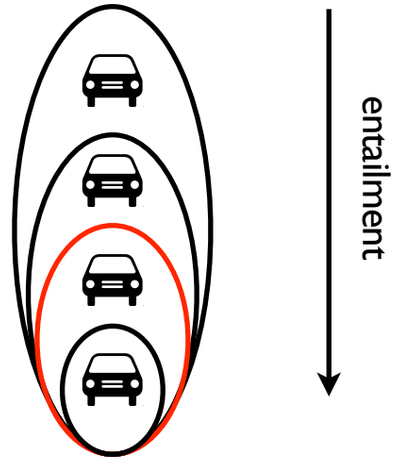
"*not more*" + "*at least*" = "*exactly N*"

Scalar Implicature

"at least" Semantic numeral interpretation



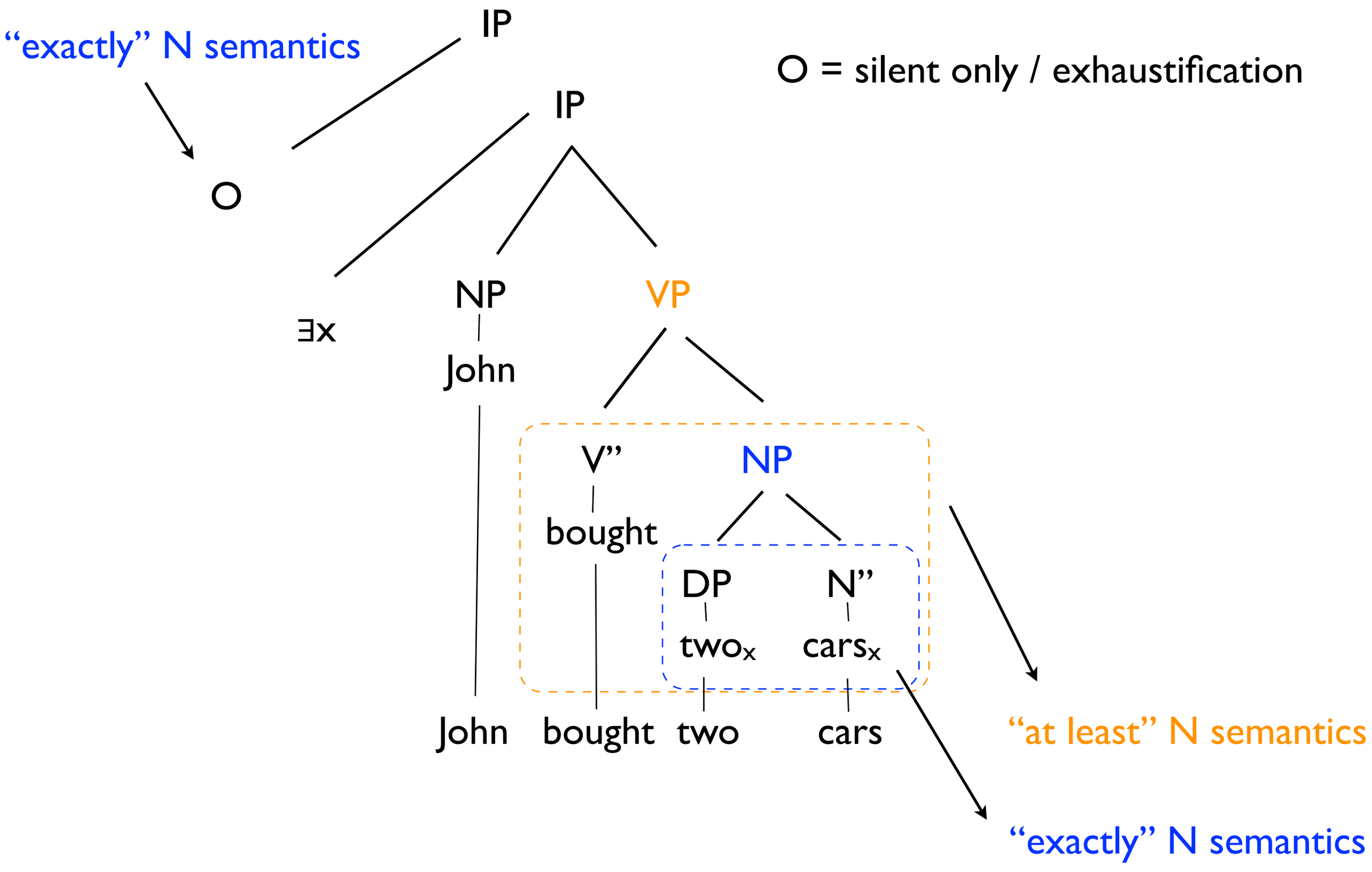
If John buys 4 cars, he also buys 3 cars and 2 and 1 car.



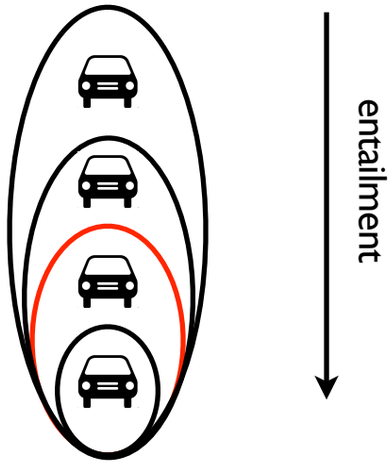
"at least" N semantics

"exactly" N semantics

“*exact*” Semantic numeral interpretation

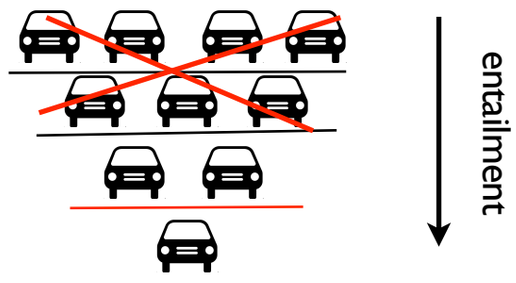


O = silent only / exhaustification

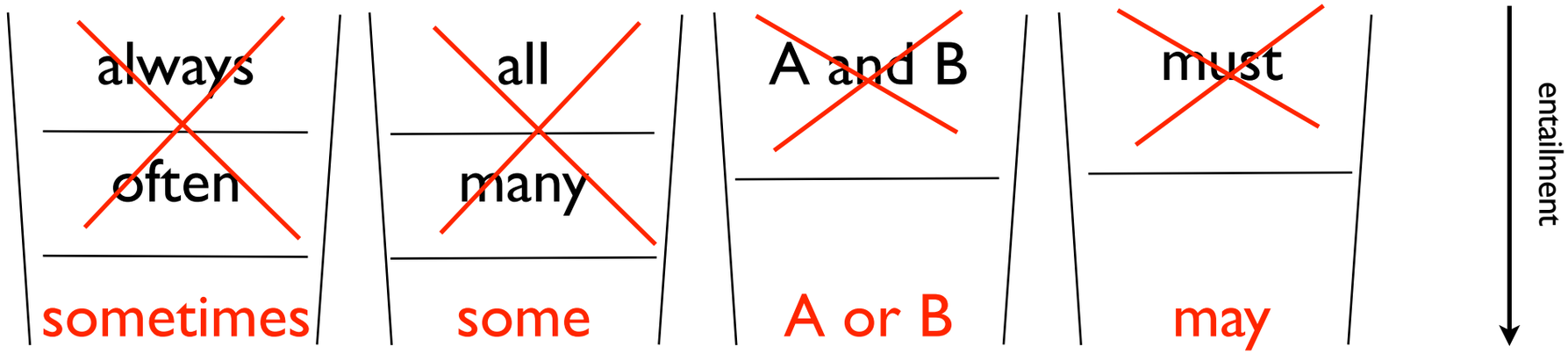


John bought two cars

scalar implicature (SI) = "John bought two and not more cars"

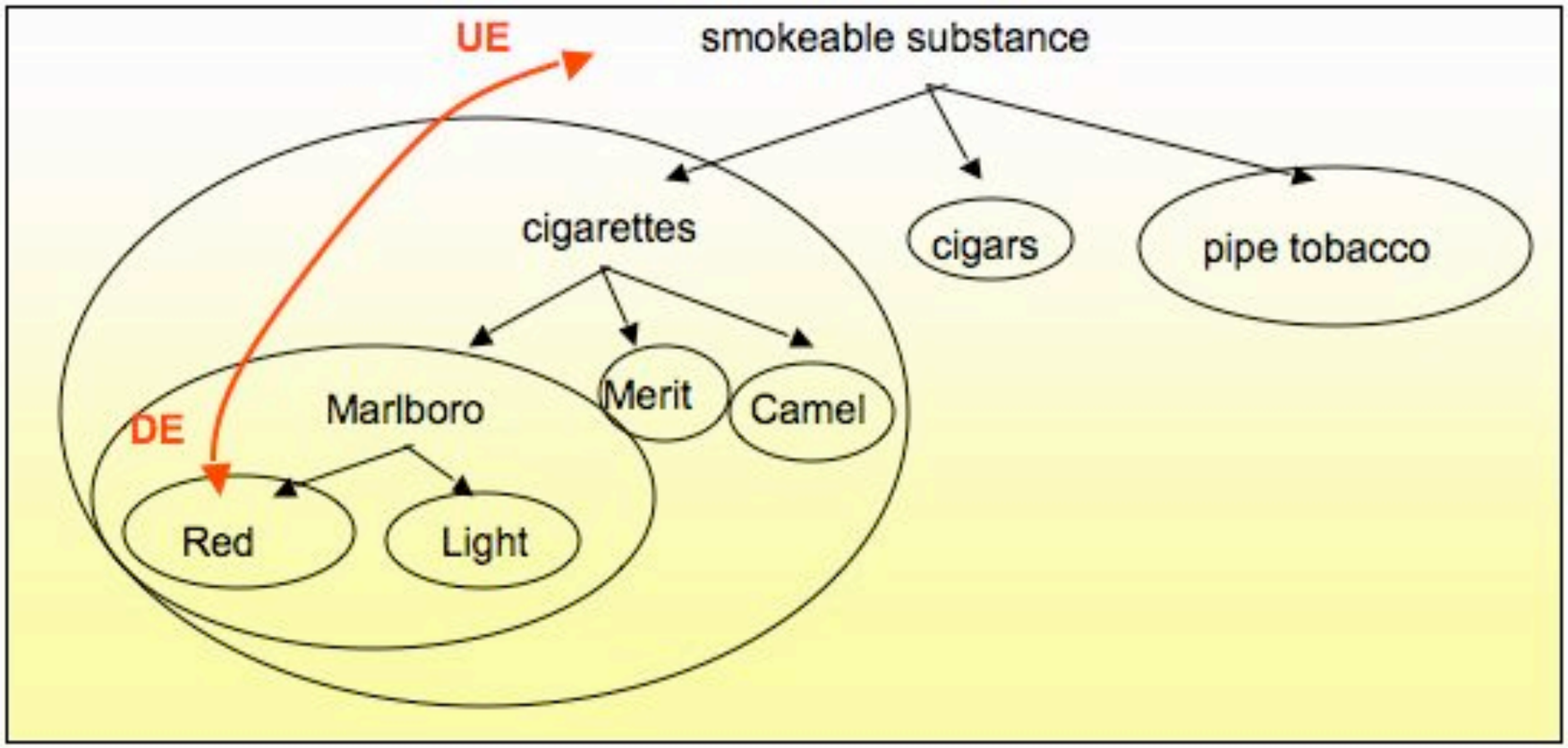


Scalar Implicature *"not more" + "at least" = "exactly N"*



scalar implicature (SI) in other linguistic dimensions

Upward Entailing & Downard Entailing



UE ----------

"I smoked a Marlboro"

DE ----------

"I didn't smoke a cigarette

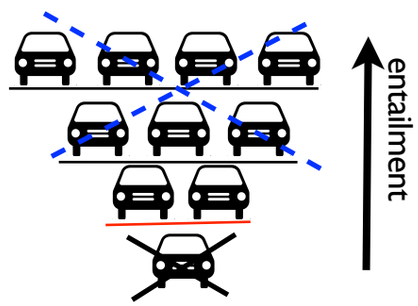
Entailing relation and strengthened meaning

Downward Entailing embedding

If John parked *two* cars in the garage
he will park a motorcycle in the courtyard

is stronger than

If John parked *exactly two* cars in the garage
he will park a motorcycle in the courtyard



situations about which
we know nothing

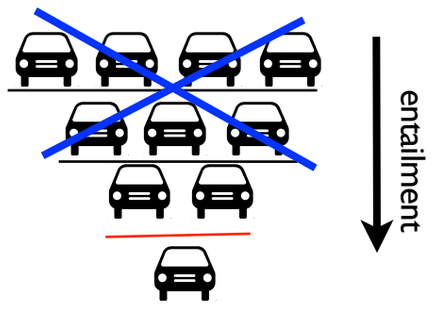
Upward Entailing embedding

John parked *two* cars in the garage
and he will park a motorcycle in the courtyard

is weaker than

John parked *exactly two* cars in the garage
and he will park a motorcycle in the courtyard

scalar implicature leads
to strengthening



situations excluded

Main Claim

The strong interpretation of number words occurs preferentially in Upward Entailing contexts. The weak interpretation occurs preferentially in Downward Entailing contexts (e.g. antecedent of conditionals, restriction of universal quantifier).

'Preferentially' here means both 'more often' and 'with less of a processing cost'.

we are saying nothing about...

how the scalar implicatures are precisely computed

whether or not they are computed by default

Predictions on the interpretation of the numerals

conditional antecedent

1 John parked *two* cars in the garage and he will park a motorcycle in the courtyard

exactly two — is less costly than in **2** (hence produced more often)

exactly two — is more costly than in **1** (hence produced less often)

DE

2 *If* John parked *two* cars in the garage he will park a motorcycle in the courtyard

---

universal quantifier restriction

3 In my neighborhood every girl has two older brothers and wants a younger sister

exactly two — is less costly than in **4** (hence produced more often)

exactly two — is more costly than in **3** (hence produced less often)

DE

4 In my neighborhood every girl *who* has *two* older brothers wants a younger sister

Experiment 1: semantic judgement task

48 participants, speakers of Italian

24 items: 12: conditional vs. non conditional

12: univ. quant. restr. vs. univ. quant. scope

type \ monotonicity	UE	DE
cond	A	B
quant	C	D

A John parked *two* cars in the garage and he will park a motorcycle in the courtyard

B *If* John parked *two* cars in the garage he will park a motorcycle in the courtyard

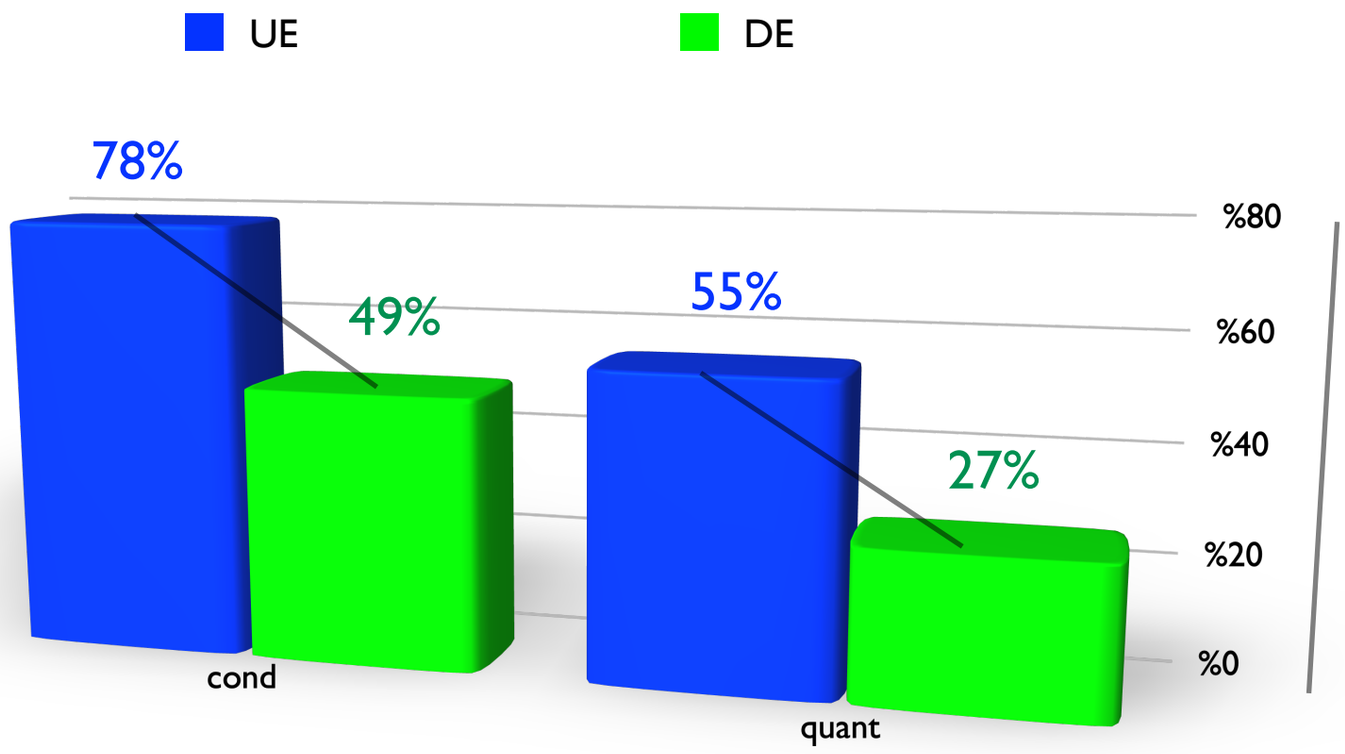
C In my neighborhood every girl has two older brothers and wants a younger sister

D In my neighborhood every girl *who* has *two* older brothers wants a younger sister

The cars we are talking about are...

exactly two ☐ at least two ☐

Experiment 1: semantic judgement task
Results



percentage of strenghtened (exactly N) answers

Factors:

1 entailment significant → logic matters:

LMM: $p < .000$

numerals were strengthened more often in UE contexts than DE ones

2 type significant → context matters:

LMM: $p < .000$

quantified items were generally strengthened less often

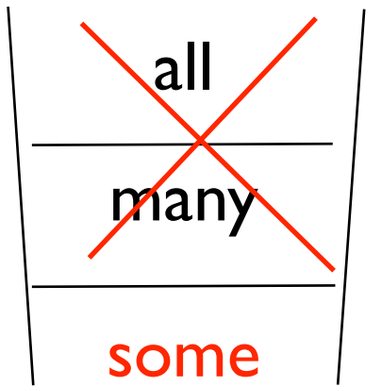
1*2 interaction non significant →

LMM: $p = 0.454$

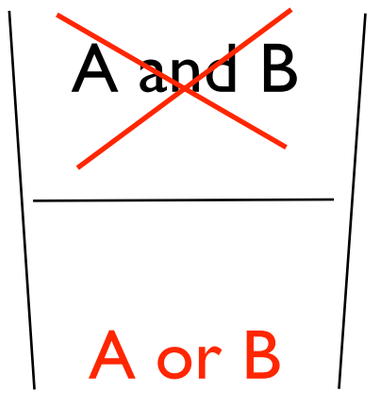
the influence of DE environment is orthogonal to the context effect

78% - 49% = 29% ⟷ 55% - 27% = 28%

similar findings in the literature on SIs



Noveck (2002)



Noveck, Chevaux, Guelminger, Sylvestre, Chierchia (2002)

Chierchia, Guasti, Gualmini, Meroni, Crain (2004)

Frazier, Chierchia, Clifton (2003)

% of strengthened choices

positive sentences > negative sentences

covert negative predicates

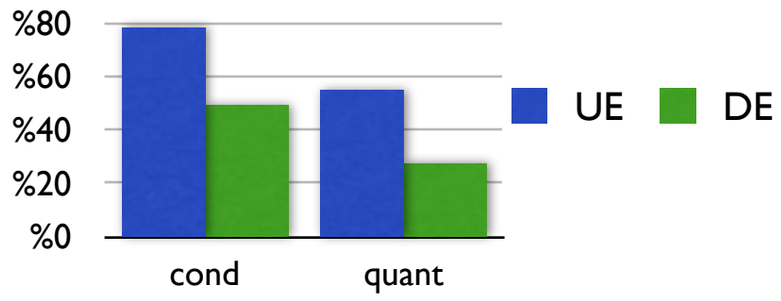
restriction of universal quantifiers

antecedent of conditionals

Interim conclusions and implication on processing

- The rate of strengthened choices ("exactly N") were significantly higher in UE contexts than in DE ones.
  No matter what was the kind of grammatical head (i.e. the type of DE function).

- scalar strengthening of numerals occurs more often in UE (positive) contexts.



- the I experiment addressed the question of *frequency*

  now we want to investigate the *processing cost* of the interpretation of numerals

- strategy: to force the strengthened meaning in both UE and DE context.

John parked *two* cars in the garage and he will park a third car/motorcycle in the courtyard

If John parked *two* cars in the garage he will park a third car/motorcycle in the courtyard

Experimental design

observed behaviour

=

dependent variable

- grammaticality judgment (acceptance rate)
- semantic judgment/choice
- reaction/decision time
- reading time
- number of regressions
- proportion of looks
- latency in shifting the gaze

Experimental design

experimental manipulation

=

independent variable ⇒ factors

levels

conditions

Experimental design

simple design

1 factor ⇨ 2 levels = 2 conditions

advantages
- easy to interpret (no interactions)
- most direct way to test empirical hypothesis

Experimental design

simple design

research question: how do people interpret numerals?
(Panizza, Chierchia & Clifton; 2009)

factor: ENTAILMENT

levels/conditions:

- Upward Entailing contexts (affirmative sentences)
- Downward Entailing contexts (conditionals antecedents)

Experimental design

simple design

UE John parked two cars in the garage and he will park a motorcycle in the courtyard

DE If John parked two cars in the garage, he will park a motorcycle in the courtyard

- hypothesis: less ‘exactly N’ interpretations in DE environments
- exp. evidence: the reading times of the numeral (two) will tell us which condition is more difficult to process
- assumption: the meaning ‘exactly two’ is derived through a pragmatic inference
- prediction: two yields higher reading times in the UE condition

Experimental design

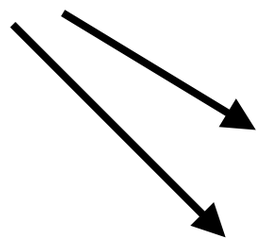
simple design

UE John parked two cars in the garage and he will park a motorcycle in the courtyard

DE If John parked two cars in the garage, he will park a motorcycle in the courtyard

hypothesis: less ‘exactly N’ interpretations in DE environments

semantic judgment questionnaire



does not modify experimental design

verifies the hypothesis

Experimental design

simple design

UE John parked two cars in the garage and he will park a motorcycle in the courtyard

DE If John parked two cars in the garage, he will park a motorcycle in the courtyard

problems

problematic assumption

↘ how can we be sure that the higher processing cost is caused by the derivation of a pragmatic inference?

alternative explanations

↘ affirmative sentences are more difficult to read

↘ different grammatical constructions (presence of ‘and’)

Experimental design

simple design

1 factor ⇨ 2 levels = 2 conditions

advantages
- easy to interpret (no interactions)
- most direct way to test empirical hypothesis

disadvantages
- other factors can be the cause of the effect that we observe
  - necessary to control for such factors

Experimental design

2 factors design

factor: ENTAILMENT

levels/conditions:

- Upward Entailing contexts
- Downward Entailing contexts

factor: TYPE OF SENTENCE

levels/conditions:

- affirmative/conditional
- universally quantified

Experimental design

2 factors design

affirmative/conditional

UE John parked two cars in the garage and he will park a motorcycle in the courtyard

DE If John parked two cars in the garage, he will park a motorcycle in the courtyard

universally quantified

UE In my neighboorhood every girl has two brothers and wants a younger sister

DE In my neighboorhood every girl who has two brothers wants a younger sister

Experimental design

alternative explanations

~~affirmative sentences are more difficult to read than conditionals~~

~~different grammatical constructions (presence of 'and')~~

the same effect is expected in different grammatical constructions!

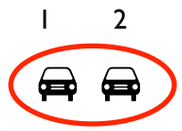
how can we be sure that the higher processing cost is caused by the derivation of a pragmatic inference?

⇩

contextual manipulation: bias vs. unbiased continuation

Experiment II: sentences

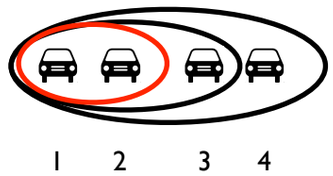
I strengthened more often than in 2



neutral continuation

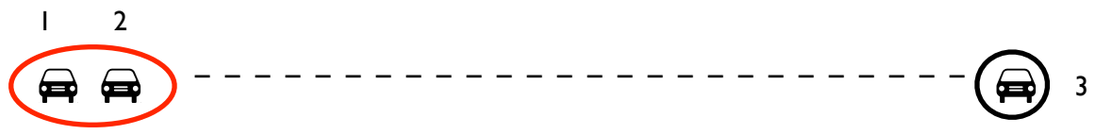
1 (UE) John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

2 (DE) *If* John parked *two* cars in the garage he will park a *motorcycle* in the courtyard



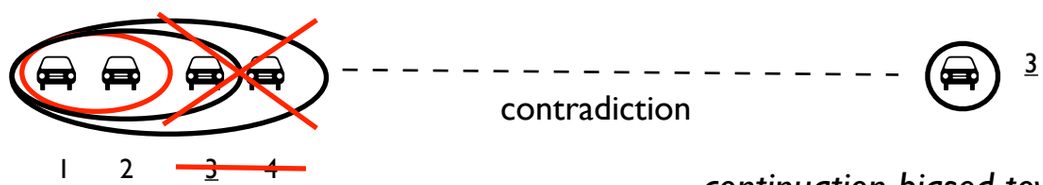
continuation compatible with the presence or absence of the 'exact' interpretation of 'two'

positive (biased) continuation



3 (UE) John parked *two* cars in the garage and he will park a *third car* in the courtyard

4 (DE) *If* John parked *two* cars in the garage he will park a *third car* in the courtyard

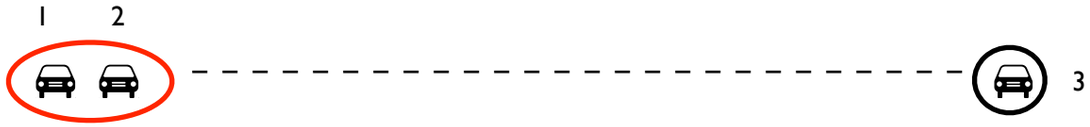


local strenthening forced late

continuation biased towards the 'exact' interpretation of 'two'

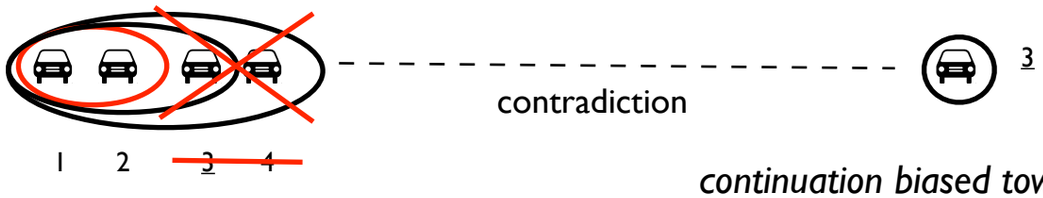
Experiment II: sentences

positive (biased) continuation



3 (UE) John parked *two* cars in the garage and he will park a *third car* in the courtyard

4 (DE) *If* John parked *two* cars in the garage he will park a *third car* in the courtyard



local strenthening forced late

continuation biased towards the 'exact' interpretation of 'two'

further control: with a unbiased form which is as close as possible to the positive (biased) continuation

negative (control) continuation

5 (UE) John parked *two* cars in the garage and he won't park a *third car* in the courtyard

6 (DE) *If* John parked *two* cars in the garage he won't park a *third car* in the courtyard

5 and 6 are TRUE in both situations (exactly N or at least N), therefore they don't require to be strengthened

Experiment 2: predictions

neutral continuation

UE

>

DE

John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

If John parked *two* cars in the garage he will park a *motorcycle* in the courtyard

positive continuation

UE

<

DE

John parked *two* cars in the garage and he will park a *third car* in the courtyard

If John parked *two* cars in the garage he will park a *third car* in the courtyard

negative continuation

UE

>

DE

John parked *two* cars in the garage and he won't park a *third car* in the courtyard

If John parked *two* cars in the garage he won't park a *third car* in the courtyard

Experimental design

3 factors design

factor: ENTAILMENT

levels/conditions:

- Upward Entailing contexts
- Downward Entailing contexts

factor: TYPE OF SENTENCE

levels/conditions:

- affirmative/conditional
- universally quantified

factor: CONTEXTUAL BIAS

levels/conditions:

- biased
- unbiased

how many conditions in total?

Experimental design

3 factors design

between items

within items

affirmative/conditionals

- UE
  - biased — 1
  - unbiased — 2
- DE
  - biased — 3
  - unbiased — 4

quantified sentences

- UE
  - biased — 5
  - unbiased — 6
- DE
  - biased — 7
  - unbiased — 8

Experiment 2: method

54 participants, speakers of Italian

24 sentences in 6 conditions
(the same sentences of the Experiment 1)

simple comprehension
questions and fillers

eye movements recording
during reading (EyeLink 2)

design

continuation \ monotonicity	UE	DE
positive	A	B
neutral	C	D
negative	E	F

Experimental design

3 factors design

- assumption: the meaning ‘exactly two’ is derived through a pragmatic inference

- exp. evidence: the reading times of the numeral (two) will tell us which condition is more difficult to process

- hypothesis: less ‘exactly N’ interpretations in DE environments

- prediction: two yields higher reading times in the UE condition

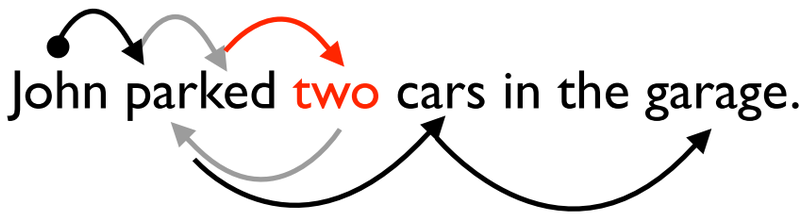
- new prediction: more regressive eye movements in the biased continuation (re-analysis) when the inference is not derived

Experiment 2: results

first line first pass measures

first-pass measure: readers haven't seen the following verbal material yet.

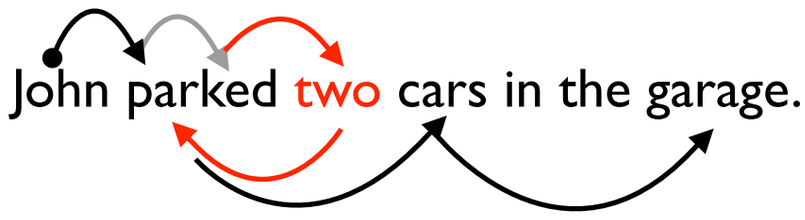
first fixation duration — takes into account only the first fixation made on a word



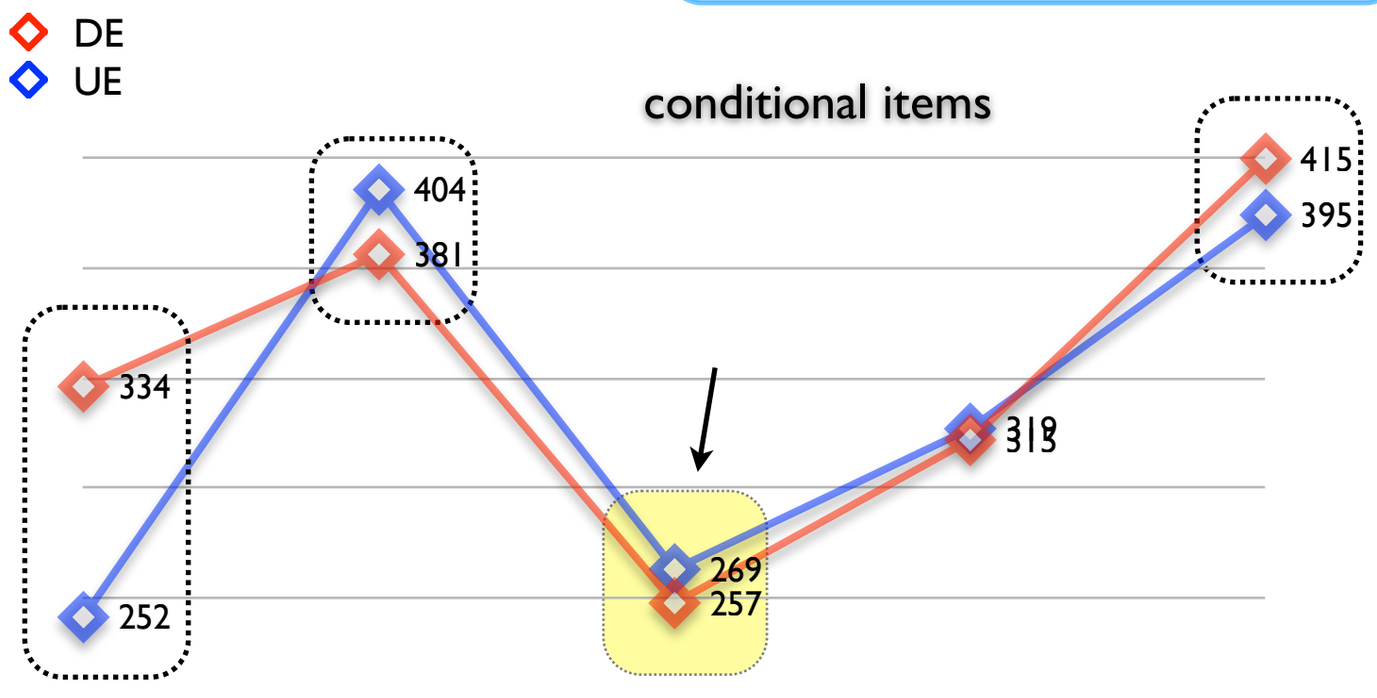
regression-path duration

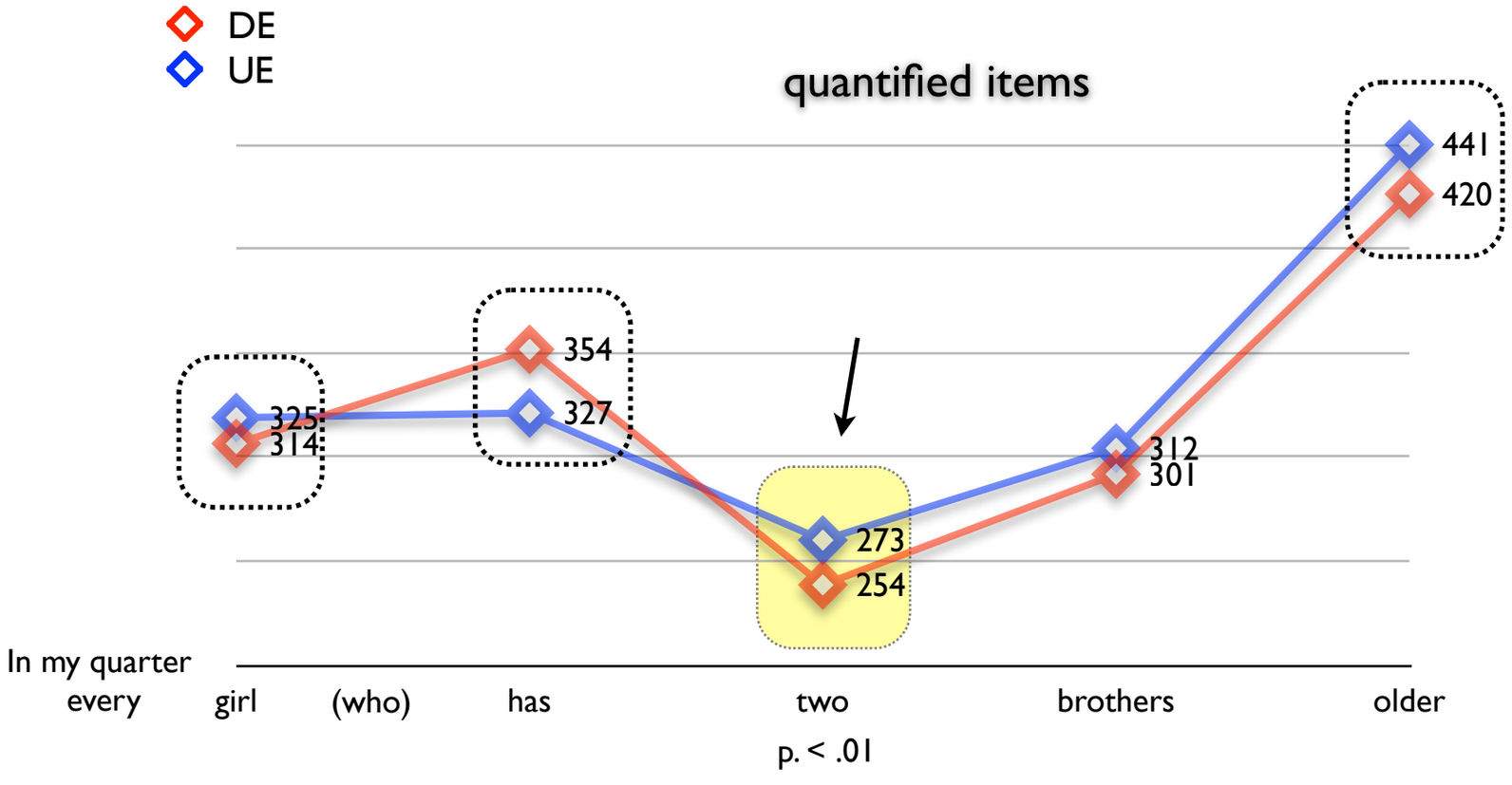
(conditioned on word n-1)

it takes into account every fixation made from the moment the reader enters into the region of interest until the reader leaves it, constrained to the previous word



Experiment 2: results





regression-path duration (condit. n-1)

LMM p. < .01

significant

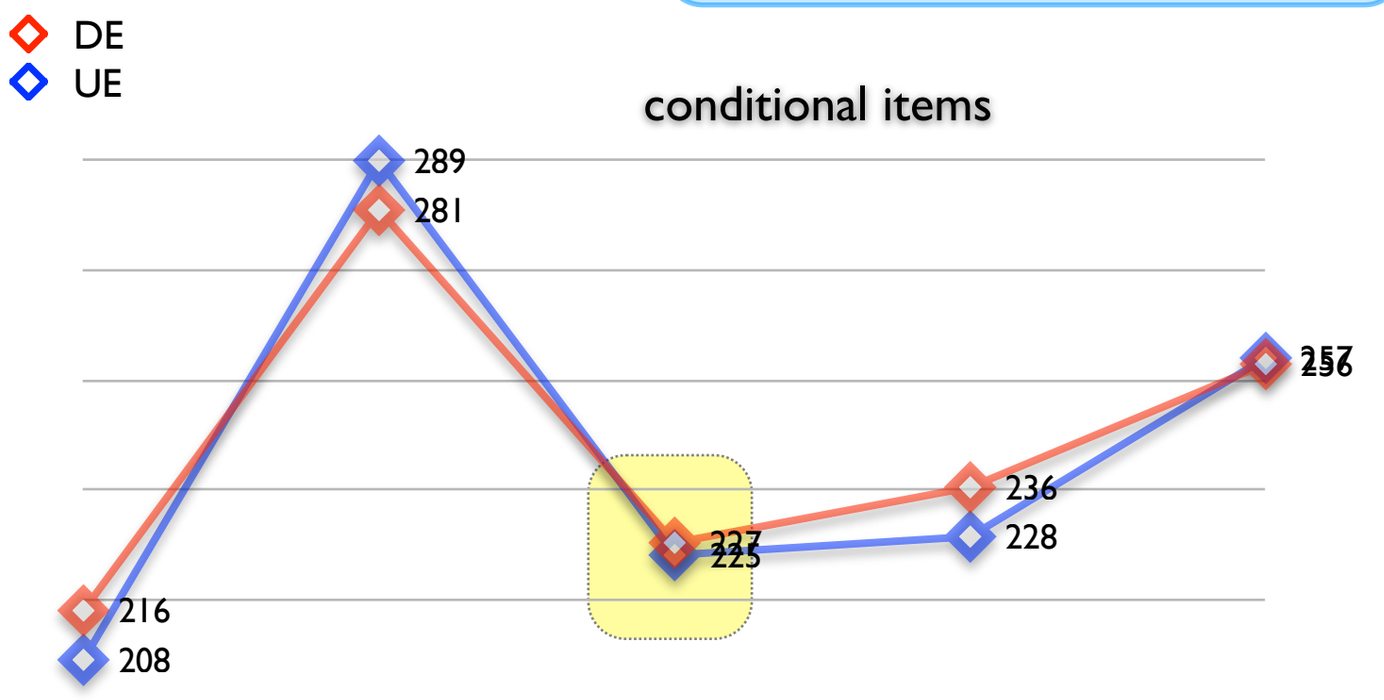
only the numeral region presents a significant difference

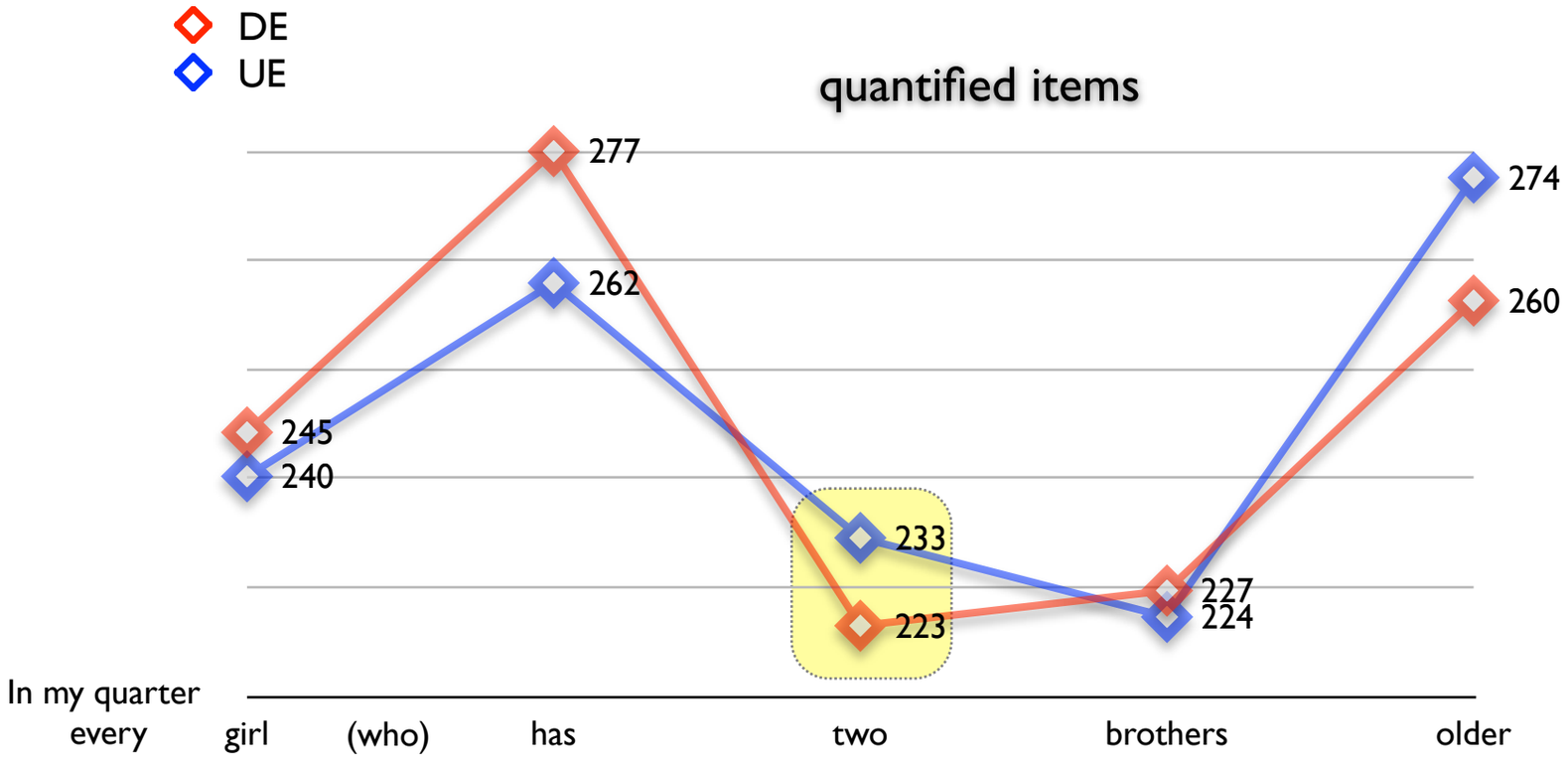
⇩

under UE, it was more difficult to read

the patter showed by the other first line regions was unstable across the two type of grammatical constructions.

Experiment 2: results





first fixation duration

LMM p. < .07

tendency

only the numeral region presents a significant difference

⇩

under UE, it was more difficult to read

the patter showed by the other first line regions was unstable across the two type of grammatical constructions.

interim conclusions on early first line processing

It's more difficult to embed a SI under a DE context than a UE one.

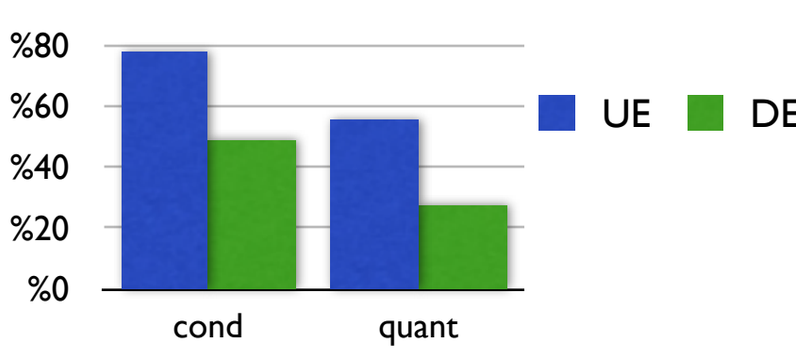
↓ the parser goes for the easiest way

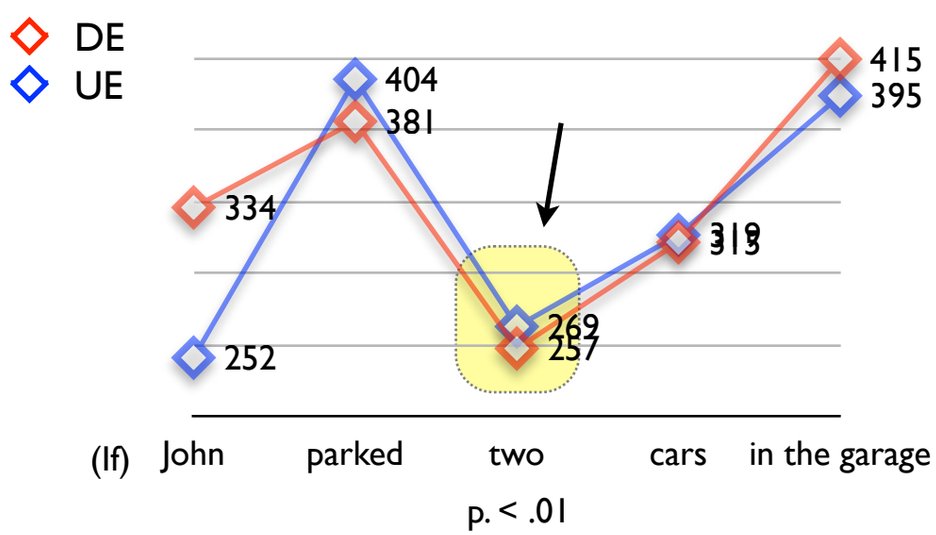
(following logical strength principles)

scalar strengthening of numerals occurs more often in UE (positive) contexts.

and

in the same contexts, numerals show a processing cost





Experiment 2: results

2 factors analysis

neutral continuation

UE

V

DE

John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

If John parked *two* cars in the garage he will park a *motorcycle* in the courtyard

positive continuation

UE

∧

DE

John parked *two* cars in the garage and he will park a *third car* in the courtyard

If John parked *two* cars in the garage he will park a *third car* in the courtyard

negative continuation

UE

∨

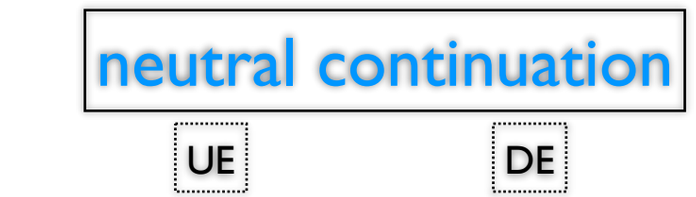
DE

John parked *two* cars in the garage and he won't park a *third car* in the courtyard

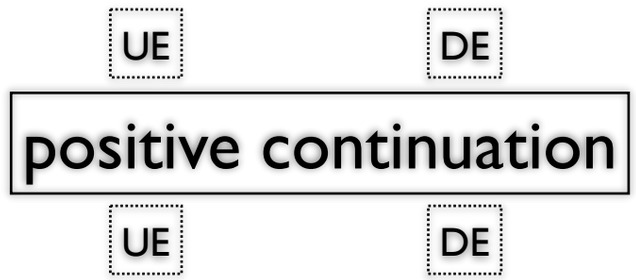
If John parked *two* cars in the garage he won't park a *third car* in the courtyard

Experiment 2: results

2 factors analysis predictions



interactions:
posDE - posUE > neuDE - neuUE



interactions:
posDE - posUE > negDE - negUE

NO interactions:
neuDE - neuUE = negDE - negUE

Experiment 2: results

2 factors analysis of **first-pass** measures

no significant interaction in any comparison

neutral continuation

John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

If John parked *two* cars in the garage he will park a *motorcycle* in the courtyard

no significant interactions

positive continuation

John parked *two* cars in the garage and he will park a *third car* in the courtyard

If John parked *two* cars in the garage he will park a *third car* in the courtyard

no significant interactions

negative continuation

John parked *two* cars in the garage and he won't park a *third car* in the courtyard

If John parked *two* cars in the garage he won't park a *third car* in the courtyard

Experiment 2: results

2 factors analysis of **second-pass** measures

on first line numeral region and
second line ordinal region

neutral continuation

John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

If John parked *two* cars in the garage he will park a *motorcycle* in the courtyard

significant interactions

positive continuation

John parked *two* cars in the garage and he will park a *third car* in the courtyard

If John parked *two* cars in the garage he will park a *third car* in the courtyard

significant interactions

significant interactions

negative continuation

John parked *two* cars in the garage and he won't park a *third car* in the courtyard

If John parked *two* cars in the garage he won't park a *third car* in the courtyard

significant interactions

no significant interactions

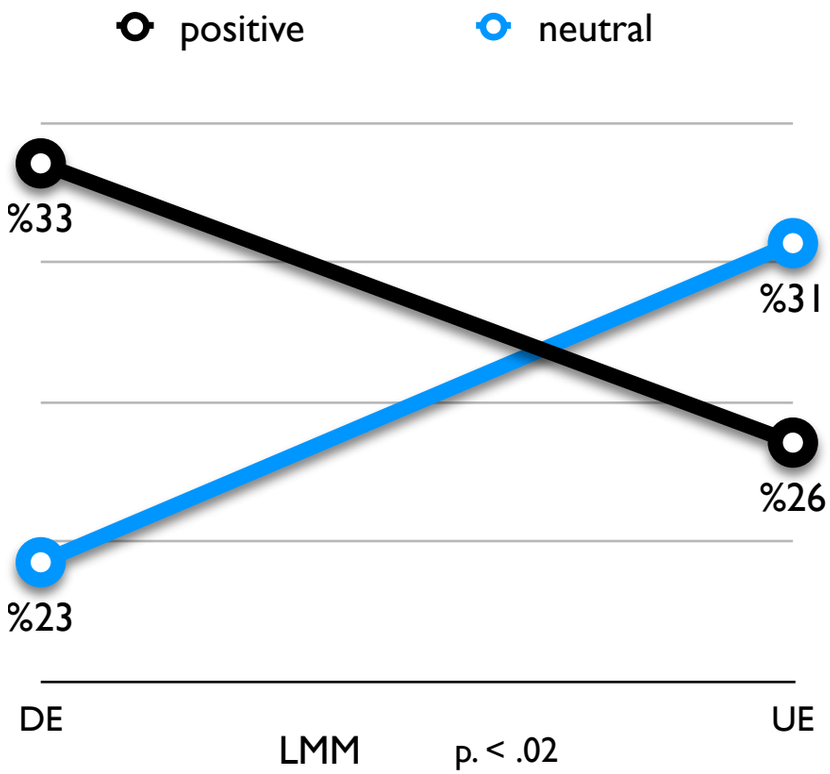
Experiment 2: results

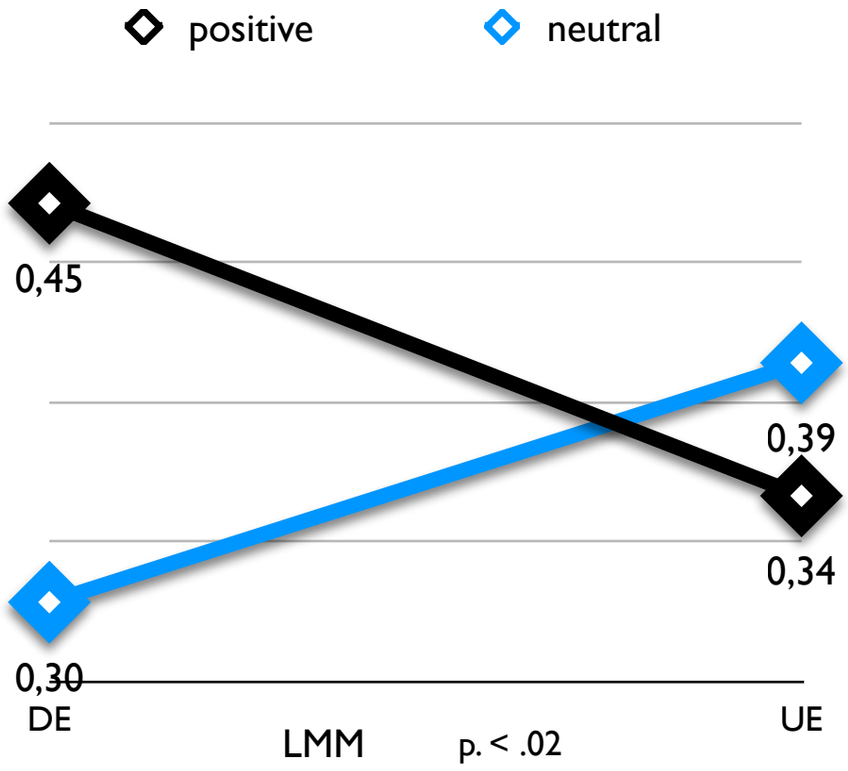
2 factors analysis of **second-pass** measures

second-pass fixation probability

on first line numeral region ("two")

second-pass fixations number





neutral continuation

(*If*) John parked *two* cars in the garage and he will park a *motorcycle* in the courtyard

positive continuation

(*If*) John parked *two* cars in the garage and he will park a *third car* in the courtyard

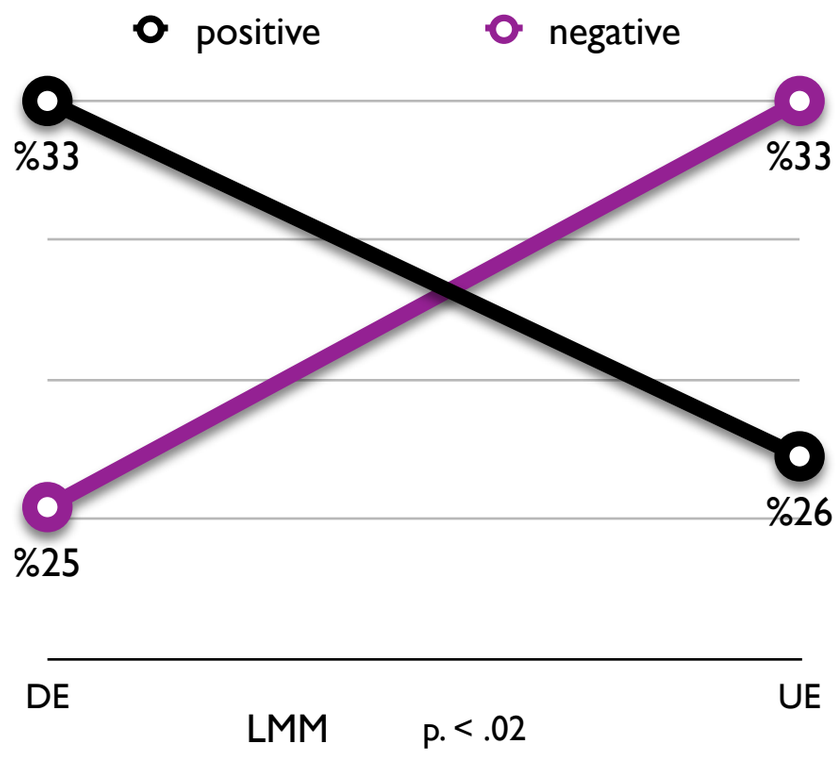
Experiment 2: results

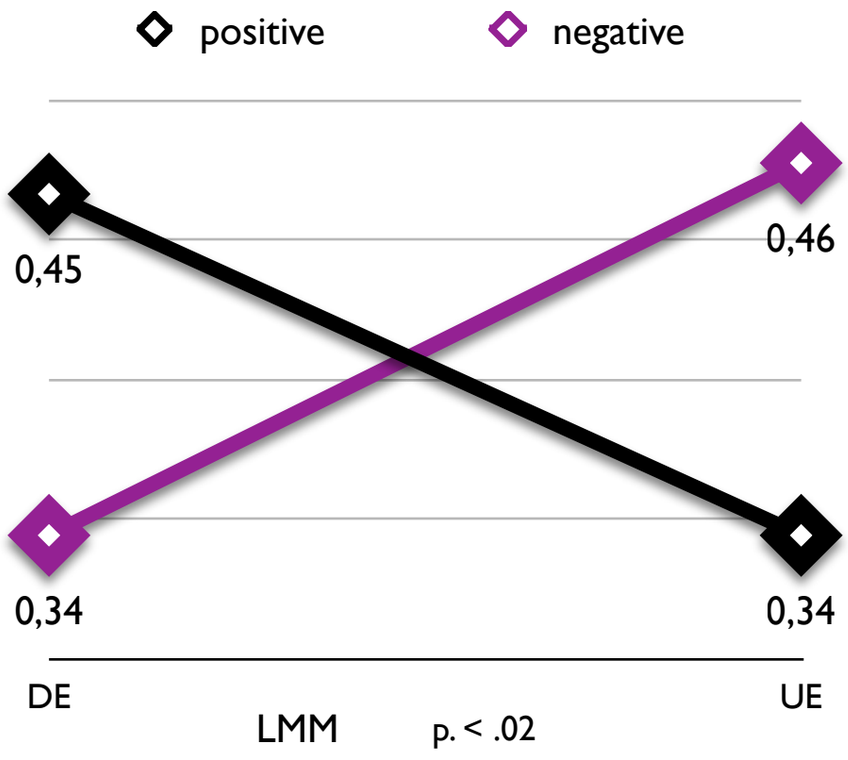
2 factors analysis of **second-pass** measures

second-pass fixation probability

on first line numeral region ("two")

second-pass fixations number





negative continuation

(*If*) John parked *two* cars in the garage and he won't park a *third car* in the courtyard

positive continuation

(*If*) John parked *two* cars in the garage and he will park a *third car* in the courtyard

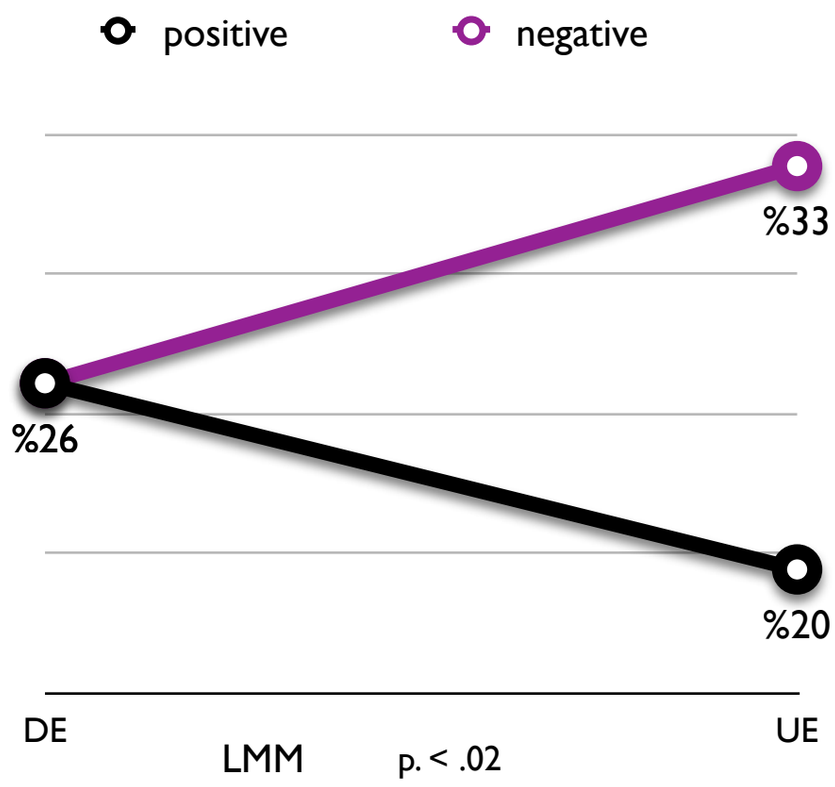
Experiment 2: results

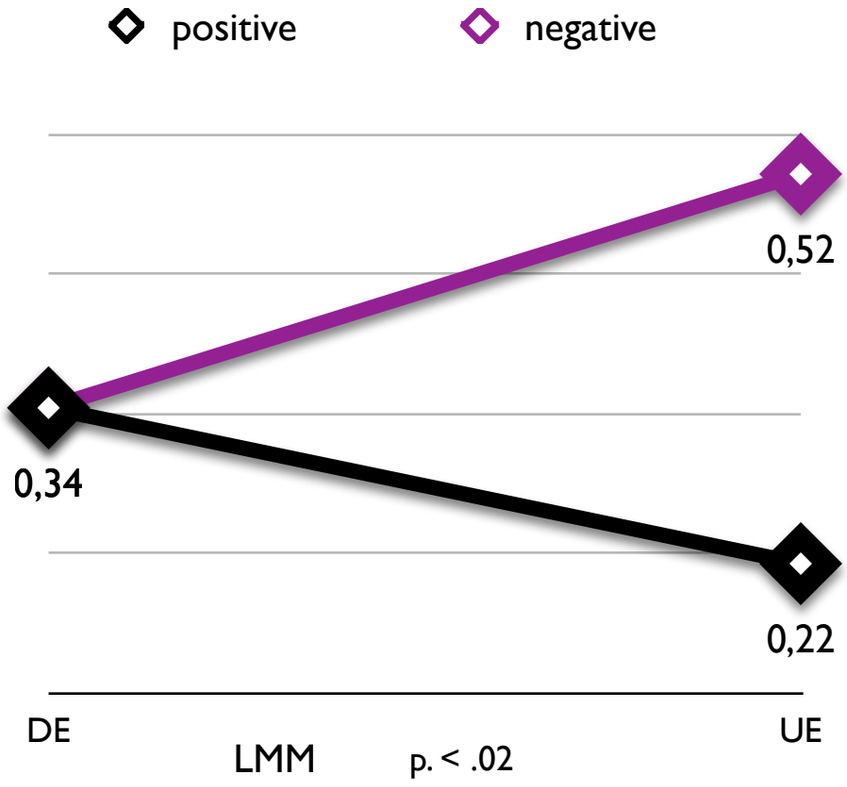
2 factors analysis of **second-pass** measures

second-pass fixation probability

on second line ordinal region ("third")

second-pass fixations number





negative continuation

John parked *two* cars in the garage and he won't park a *third car* in the courtyard

positive continuation

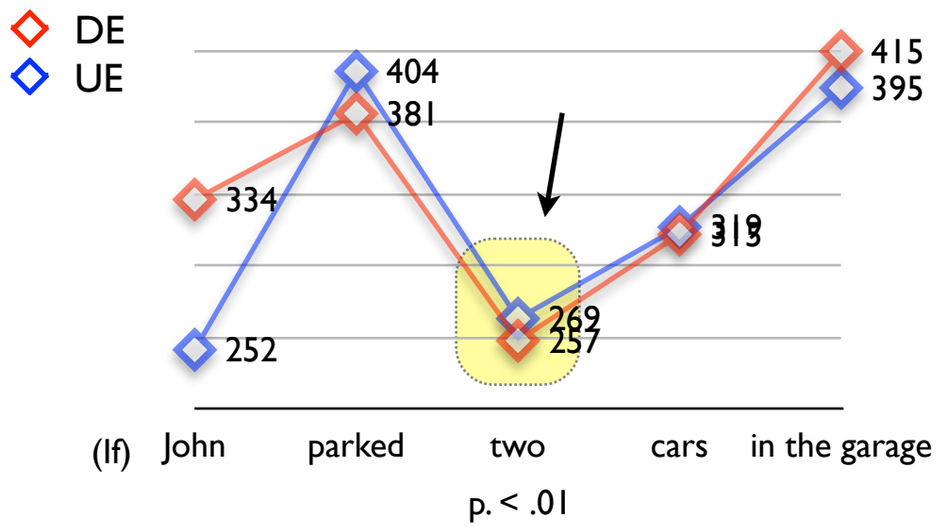
(*If*) John parked *two* cars in the garage and he will park a *third car* in the courtyard

Experiment 2: conclusions

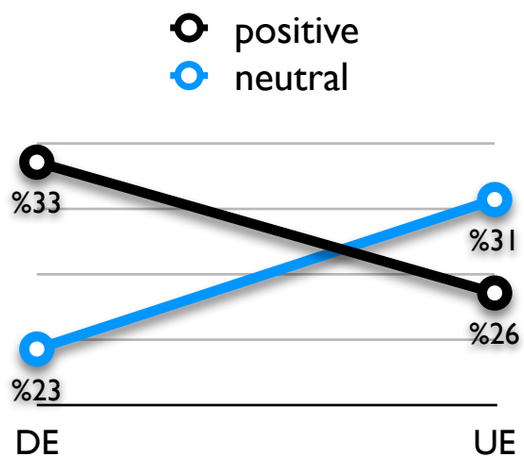
first-pass indices showed that numerals embedded under a UE function are read more slowly

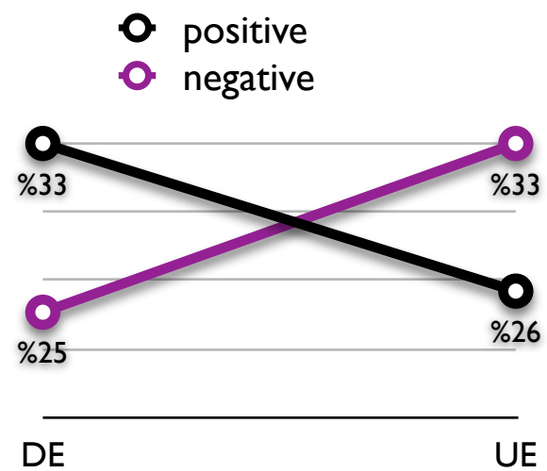
local SIs is more often computed

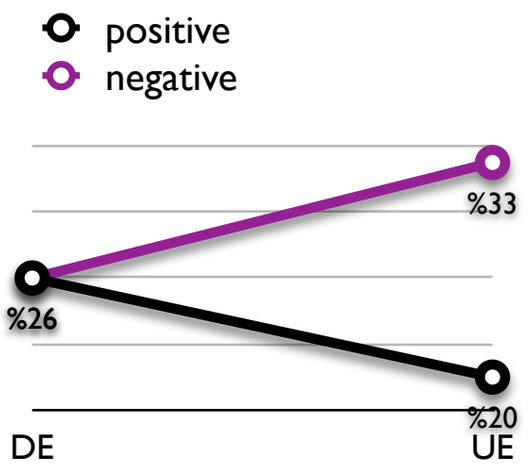
readers are more sensitive to the local semantic ambiguity



second-pass fixations displayed the same pattern among positive vs. neutral comparison and positive vs. negative one.
In the biased continuation the DE condition received more and more often second pass fixations than the UE condition. On the contrary in neutral and negative (control) continuations UE condition received more and more often second pass fixations than DE one.

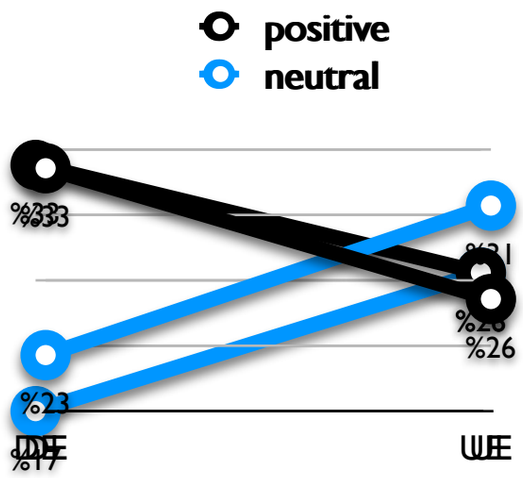


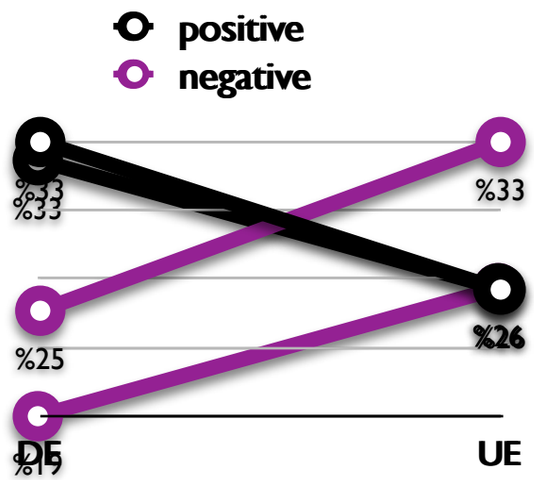




possible objection:

why was not the biased DE condition harder than every other condition of the experiment?





explanation:

both <u>negative</u> and <u>neutral</u> continuation elicited <u>more regressions to every region</u> after the reader completed the sentence reading.
In fact regression path duration on last region showed a significant type of continuation main effect.
(pos vs. neu: p. < .01 , pos vs. neg: p < .02)

Final conclusions

lexical ambiguity <--?--> there is no form of lexical ambiguity that is known to be sensitive to the monotonicty of the embedding context

underspecification + pragm. enrichment <--?--> relevance should be unaffected by structural and by logical strength principles.

SI approach

it is based on an account of the distribution of readings sensitive to strength.

under for it is the most directly consistent with the results

Final conclusions

exp 1

people selected **more often** the strengthened numeral meaning in UE contexts than in DE ones

exp 2 (first pass)

in the same contexts they displayed an early processing slowdown in the numeral region (**local computation**)

nonetheless...

exp 2 (second pass)

when people were forced to strengthen the meaning of the numeral in a DE context, they showed a **processing cost**

Logic vs. context in the processing and interpretation of Scalar Implicatures. A few results..

Implicatures inferences enriching the meaning of an utterance

Scalar Implicatures

↑ some

all

John ate (at least) some of the cookies

conversationally implicates ↘ John didn't eat all of the cookies

↑ and

or

John ate cookies or oranges

↘ John didn't eat cookies and oranges

↑ two

three

John ate two of the cookies

↘ John didn't eat three of the cookies (or more)

↑ few

none

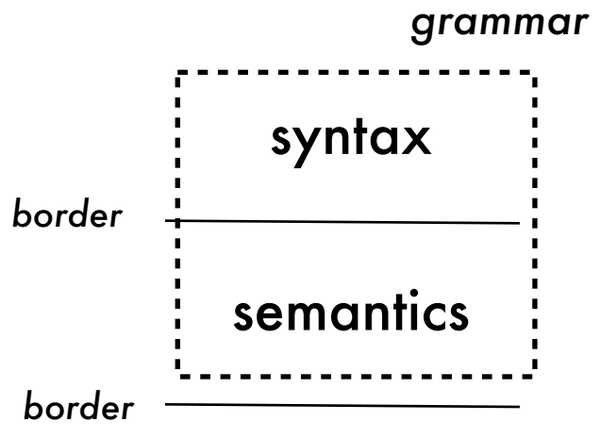
John ate few of the cookies he bought

↘ John didn't eat none of the cookies he bought

Big questions about scalar implicatures

Linguistics

are implicatures computed by the grammar?



Logical properties of the proposition

pragmatics

Upward Entailing contexts

entails ↑

some

all

entails ↑

John ate some of the cookies and he left.

John ate some but not all of the cookies and he left.

Downward Entailing contexts

entails ↓

some

all

entails ↓

If John ate some of the cookies he left.

If John ate some but not all of the cookies he left.

NEW questions about scalar implicatures

implicatures can be generated... OFF LINE & ON LINE

- when does *really* start the scalar computation?
- how does it unfold over time?

- first fixation (100-300ms)
- regression path (200-500ms)
- 2nd pass (re-readings)

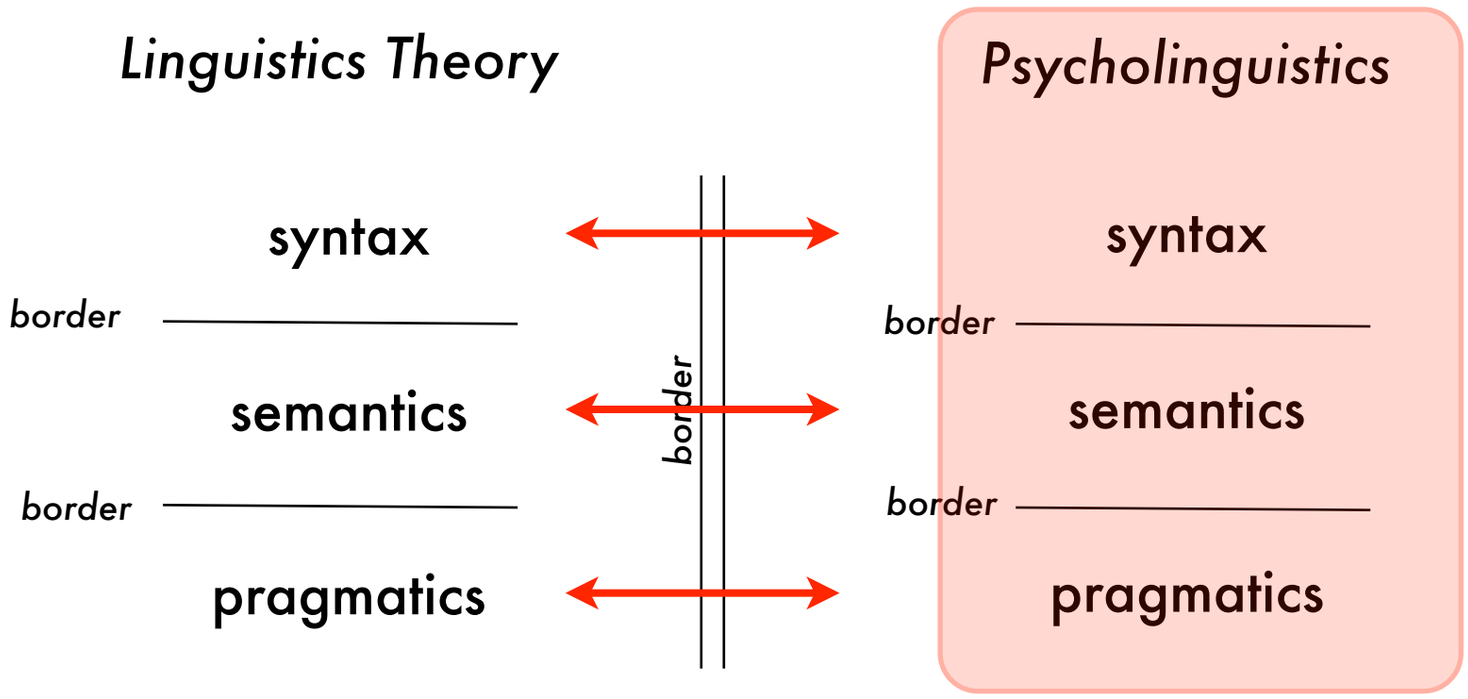
implicatures are sensitive to both the logic of the proposition (grammar) AND the utterance context (knowledge)

- how do grammar and context interplay in generating scalar implicatures?

- parallel interaction
- dominance of one source of information
- separate stages

NEW questions about scalar implicatures (across the borders)

when does *really* start the scalar computation?



how do grammar and context interplay in generating scalar implicatures?

The Experiment

investigation on the interpretation and processing of ‘pochi’ (few)

few

- negative quantifier
- means ‘a quantity/number of things minor than a contextually determined threshold’

  ‘few US presidents have been murdered’

- lays on a negative scale with *no*

  no ⟶ few

  logically entails

  Gilardino scored few goals in the world cup so far, in fact he scored no goals at all.

- its existential interpretation is due to a scalar implicature (just like *many*)

Gilardino will score *few* goals in the last matches, if not no goals at all.

Messi will score *many* goals in the final, if not all the goals.

The Experiment

investigation on the interpretation and processing of ‘pochi’ (few)

few

- extremely strong trigger
- unexplored so far
- positive implicatures never investigated

Gianni ha mangiato pochi hamburger nella sua vita

Gianni ha comido pocas hamburguesas in su vida

John ate few hamburgers in his life …but he ate some

N.B.

- few ≠ a few (*some*)
- in English ‘few’ is less acceptable in object position than ‘pochi’ (Italian)

The Experiment

novel paradigm: sentence reading with eye-movement recording + semantic judgment

★ *read the first sentence (containing the critical item)*

Ogni regista che ha assunto attori
scadenti nei suoi film
ha vinto pochi Oscar.

Every director who hired bad actors in his movies
won few Oscars.

reading time
1st sentence

★ *read the second sentence and answer the question*

Herbert, un regista, ha assunto attori
scadenti nei suoi film.

Ha vinto qualche Oscar? sì no

Herbert, a director, hired bad actors in
his movies.

Did he win any Oscar? yes no

reading time
2nd sentence

off line interpretation

The Experiment

novel paradigm: sentence reading with eye-movement recording + semantic judgment

advantages

reading time
1st sentence → permits to manipulate the utterance context

reading time
2nd sentence → may be affected by the first sentence

off line interpretation → on the same sentences from which we obtain the on line data

experimental design

context (knowledge) manipulation

plausible

under non-existential interpretation (compatible with 'no', no implicature)

implausible

under non-existential interpretation

forces existential interpretation ('few but some') via implicature

Ogni regista che ha assunto attori scadenti nei suoi film
ha vinto pochi Oscar.

Every director who hired bad actors in his movies won few Oscars.

Herbert, un regista, ha assunto attori scadenti nei suoi film.

Ha vinto qualche Oscar? sì no

Herbert, a director, hired bad actors in his movies.

Did he win any Oscar? yes no

Ogni pompiere che ha rischiato la vita a causa del fumo
ha spento pochi incendi.

Every fireman who risked his life because of the smoke put off few fires.

Giacomo, un pompiere, ha rischiato la vita a causa del fumo.

ha spento qualche incendio? sì no

John, a fireman, risked his life because of the smoke.

Did he put off any fire? yes no

experimental design

context (knowledge) manipulation

negation inverts plausibility using the same verbal material

implausible

under non-existential interpretation

forces existential interpretation ('few but some')

plausible

under non-existential interpretation

Ogni regista che **non** ha assunto attori scadenti nei suoi film
ha vinto pochi Oscar.

Every director who **didn't** hire bad actors in his movies
won few Oscars.

Herbert, un regista, non ha assunto attori scadenti nei suoi film.

Ha vinto qualche Oscar? sì no

Herbert, a director, didn't hire bad actors in his movies.

Did he win any Oscar? yes no

Ogni pompiere che **non** ha rischiato la vita a causa del fumo
ha spento pochi incendi.

Every fireman who **didn't** risk his life because of the smoke
put off few fires.

Giacomo, un pompiere, non ha rischiato la vita a causa del fumo.

ha spento qualche incendio? sì no

John, a fireman, didn't risk his life because of the smoke.

Did he put off any fire? yes no

experimental design

entailment (logic) manipulation

upward entailing

Ogni regista che ha assunto attori scadenti nei suoi film

ha vinto *pochi* Oscar.

Every director who hired bad actors in his movies

won *few* Oscars.

Herbert, un regista, ha assunto attori scadenti nei suoi film.

Ha vinto qualche Oscar? sì no

Herbert, a director, hired bad actors in his movies.

Did he win any Oscar? yes no

downward entailing

Ogni regista ha assunto attori scadenti nei suoi film

se ha vinto *pochi* Oscar.

Every director hired bad actors in his movies

if he won *few* Oscars.

Herbert, un regista, non ha vinto nessun Oscar.

Ha assunto attori scadenti nei suoi film? sì no

Herbert, a director, didn't win any Oscar.

Did he hire bad actors in his movies? yes no

summary

experimental manipulation:

- plausibility (plausible vs. implausible under non-existential reading)
- entailing properties (upward vs. downward entailing)

experimental effect:

- implausible items should force the scalar implicature (existential reading, 'few but some') in both upward and downward entailing conditions

↓

this should be harder in downward entailing conditions

they lead to a less informative sentence

Scalar Implicatures are generated less often

when does the impact of ENTAILMENT is expected to show up?

possible results

plausible upward entailing

Every director who hired bad actors in his movies won few Oscars.

Herbert, a director, hired bad actors in his movies.

Did he win any Oscar? yes no

implausible upward entailing

Every fireman who risked his life because of the smoke put off few fires.

John, a fireman, risked his life because of the smoke.

Did he put off any fire? yes no

plausible downward entailing

Every director hired bad actors in his movies **if** he won few Oscars.

Herbert, a director, didn't win any Oscar.

Did he hire bad actors in his movies? yes no

implausible downward entailing

Every fireman risked his life because of the smoke **if** he put off few fires.

John, a fireman, didn't put any fire.

Did he risk his life because of the smoke? yes no

when does the impact of ENTAILMENT is expected to show up?

FIRST SENTENCE (on line computation of scalar implicature)

possible results

plausible upward entailing

Every director who hired bad actors in his movies won few Oscars.

Herbert, a director, hired bad actors in his movies.

Did he win any Oscar? yes no

implausible upward entailing

Every fireman who risked his life because of the smoke put off few fires.

John, a fireman, risked his life because of the smoke.

Did he put off any fire? yes no

plausible downward entailing

Every director hired bad actors in his movies **if** he won few Oscars.

Herbert, a director, didn't win any Oscar.

Did he hire bad actors in his movies? yes no

does PLAUSIBILITY affect reading times of the *second sentence* in both upward and downward entailing conditions ?

implausible downward entailing

Every fireman risked his life because of the smoke **if** he put off few fires.

John, a fireman, didn't put any fire.

Did he risk his life because of the smoke? yes no

does PLAUSIBILITY interact with the ENTAILMENT (*first* sentence)?

off line results (semantic judgments)

plausible upward entailing

Every director who hired bad actors in his movies won few Oscars.

Herbert, a director, hired bad actors in his movies.

Did he win any Oscar? yes 75%

existential reading
(Scalar Implicature 75%)

implausible upward entailing

Every fireman who risked his life because of the smoke put off few fires.

John, a fireman, risked his life because of the smoke.

Did he put off any fire? yes 79%

existential reading
(Scalar Implicature 79%)

plausible downward entailing

Every director hired bad actors in his movies **if** he won few Oscars.

Herbert, a director, didn't win any Oscar.

Did he hire bad actors in his movies? yes 73%

non-existential reading
(Scalar Implicature 27%)

implausible downward entailing

Every fireman risked his life because of the smoke **if** he put off few fires.

John, a fireman, didn't put any fire.

Did he risk his life because of the smoke? yes 36%

non-existential reading
(Scalar Implicature 64%)

off line results (semantic judgments)

upward entailing conditions:

participant computed the scalar implicature on *few* very often, regardless of plausibility

75%

existential reading
(Scalar Implicature 75%)

vs.

79%

existential reading
(Scalar Implicature 79%)

downward entailing conditions:

participant computed the scalar implicature on *few* more often when forced by the context (implausible items)

73%

non-existential reading
(Scalar Implicature 27%)

vs.

36%

non-existential reading
(Scalar Implicature 64%)

on line results (reading times)

FIRST SENTENCE

plausible

upward entailing

Every director who hired bad actors in his movies won few Oscars.

Every director hired bad actors in his movies **if** he won few Oscars.

downward entailing

implausible

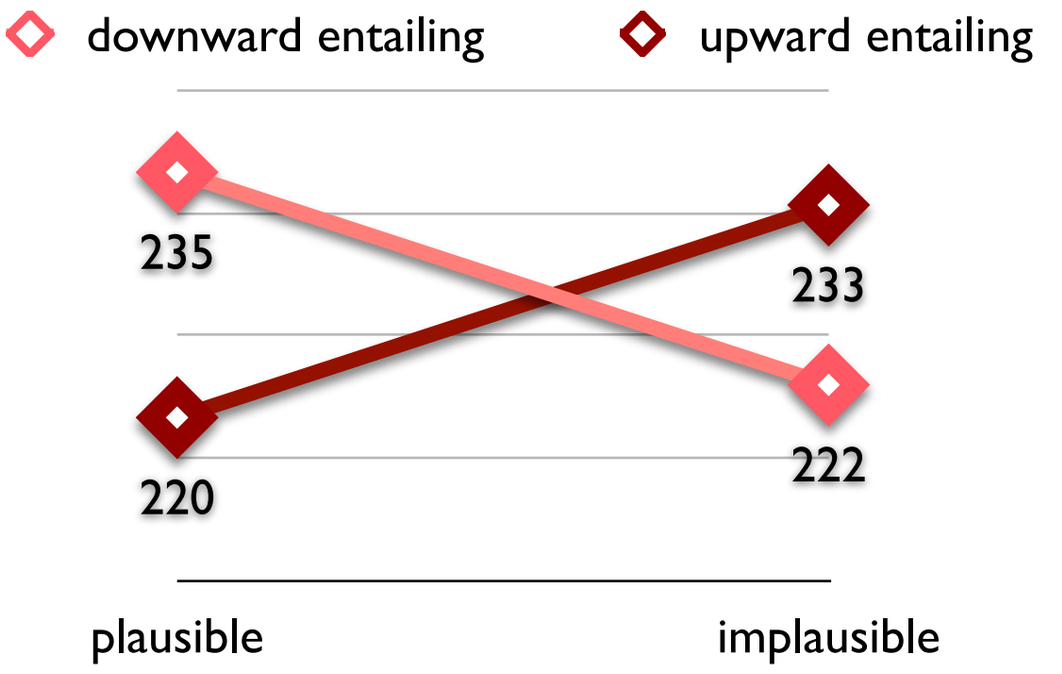
upward entailing

Every fireman who risked his life because of the smoke put off few fires.

Every fireman risked his life because of the smoke **if** he put off few fires.

downward entailing

first fixation duration on 'few'



interaction entailment*plausibility

context and logic interact from the very first stages

higher RT in upward entailing implausible condition might index greater strain in calculating the scalar implicature

but... why differences in downward entailing conditions?
baseline?

difficult interpretation of this result

on line results (reading times)

FIRST SENTENCE

plausible

upward entailing

Every director who hired bad actors in his movies won few Oscars.

Every director hired bad actors in his movies **if** he won few Oscars.

downward entailing

implausible

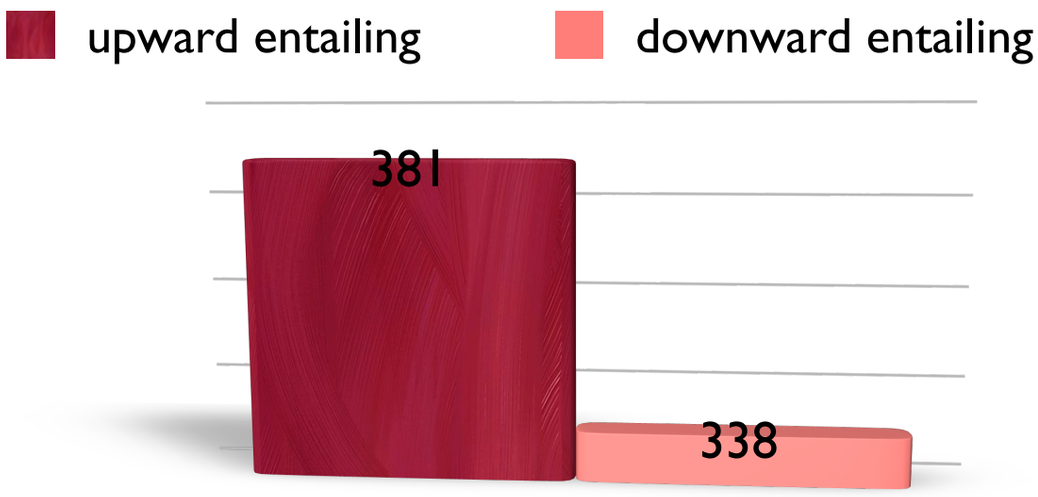
upward entailing

Every fireman who risked his life because of the smoke put off few fires.

Every fireman risked his life because of the smoke **if** he put off few fires.

downward entailing

regression path duration on ‘few’



main effect of entailment

scalar implicature affects reg. path, higher in upward entailing conditions regardless of plausibility

replicates Panizza et al. (2009)

on line results (reading times)

FIRST SENTENCE

plausible

upward entailing

Every director who hired bad actors in his movies won few Oscars.

Every director hired bad actors in his movies **if** he won few Oscars.

downward entailing

implausible

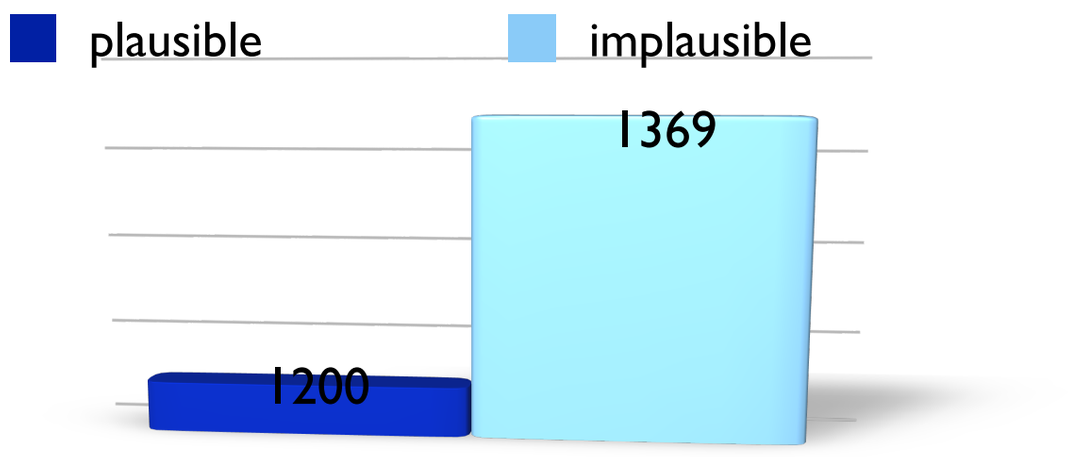
upward entailing

Every fireman who risked his life because of the smoke put off few fires.

Every fireman risked his life because of the smoke **if** he put off few fires.

downward entailing

regression path duration on 'Oscars/fires'



main effect of plausibility

more regression towards the whole sentence in implausible sentences

scalar implicature calculation regardless of entailment?

more likely, greater difficulty of processing implausible propositions

SECOND SENTENCE

on line results (reading times)

plausible

downward entailing

Herbert, a director, didn't win any Oscar.

Did he hire bad actors in his movies?

implausible

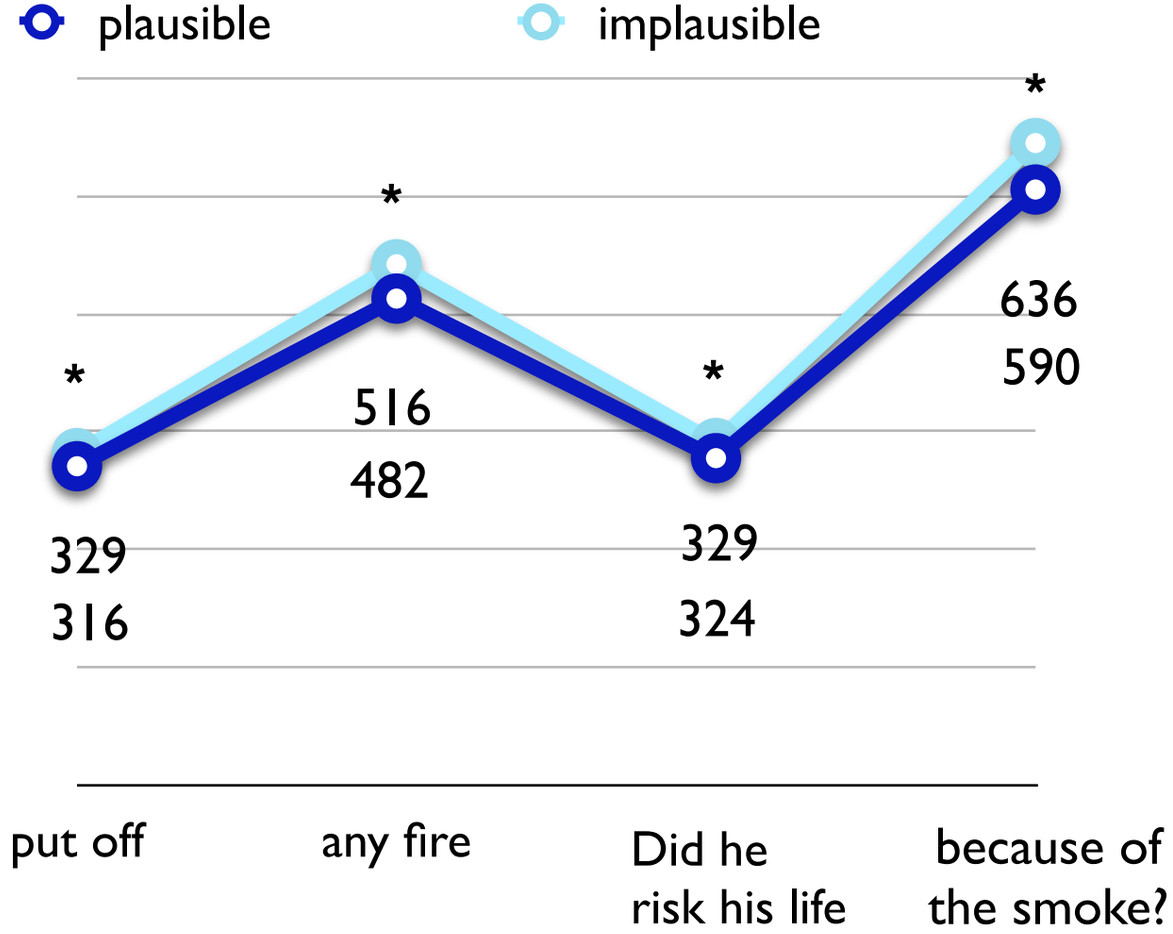
downward entailing

John, a fireman, didn't put any fire.

Did he risk his life because of the smoke?

---

first pass reading time (same effects on reg. path time)



main effect of plausibility

scalar implicatures, when forced by implausible sentences, were computed during the reading of the second sentence in downward entailing conditions

no effect in upward entailing second sentences

NEW questions about scalar implicatures

when does *really* start the scalar computation? how does it unfold over time?

- first pass (100-300ms)
- regression path (200-500ms)
- re-readings

how do grammar and context interplay in generating scalar implicatures?

- parallel interaction
- dominance of one source of information
- separate stages

NEW questions about scalar implicatures

when does *really* start the scalar computation? how does it unfold over time?

how do grammar and context interplay in generating scalar implicatures?

first pass (100-300ms) → parallel interaction of logic and context

regression path (200-500ms) → dominance of one source of information (logic properties, entailment)

re-readings → separate stages

in downward entailing conditions scalar implicatures on *few* are computed on the second sentence

how do grammar and context interplay in generating scalar implicatures?

role of the grammar (logic):

upward entailing conditions:

- scalar implicatures are always computed (off line results)
- affect first sentence RTs

downward entailing conditions:

- scalar implicatures are computed only when forced by the context (off line results)
- affect second sentence RTs

role of the context (knowledge):

predominant in downward entailing conditions inducing the generation of the existential reading (scalar implicature)

Conclusions

- entailing patterns (logic, grammar) dominate the context (knowledge) with respect to scalar implicatures computation on *few*

↘ Optimize Informativeness!

- context and logic interacts from the earliest stage (first fixation RT)
- context forces scalar implicatures in downward entailing propositions
- scalar implicature calculation may start very early (at least first pass RT)
- regression path duration extremely sensitive to scalar implicatures computation