Logic in Grammar:
an experimental investigation

Emmanuel Chemla (CNRS)

Based on joint work with Vincent Homer and Daniel Rothschild

SALT at NYU – May 2014

Linguistic Generalizations

S is well-formed	iff	S satisfies property P

Examples

- Polarity items (syntax/semantics)
S(*NPI*) is felicitous only if S(…) is a DE environment

- Definiteness effect (semantics)
There are Q students is felicitous if *Q* is symmetrical (e.g.)

- Scalar implicatures (semantics/pragmatic)
S(*some*) implies not-S(*All*) iff S(*All*) entails S(*some*)

From a psychological point of view

S is well-formed	iff	S satisfies property P

Grammar ? **Logic**

Linguistic Property	Logical Property
subjective graded intuitive « easy »	objective binary artificial, unconscious « hard »

Purely formal version

S is well-formed	iff	S satisfies property P

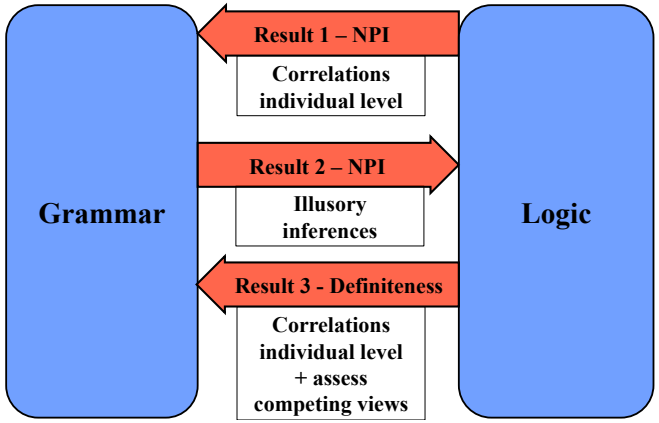
Psychological version

S is well-formed	**to the extent that**	S **subjectively** satisfies P

Finer-grained predictions: e.g., variations btw speakers
Modularity: make underlying view explicit

Result: new tools to validate and extend the enterprise

Goals for today: three studies



Study 1:

Negative Polarity Items

Correlations between well-formedness and inferences

With Vincent Homer and Daniel Rothschild, L&P 2012

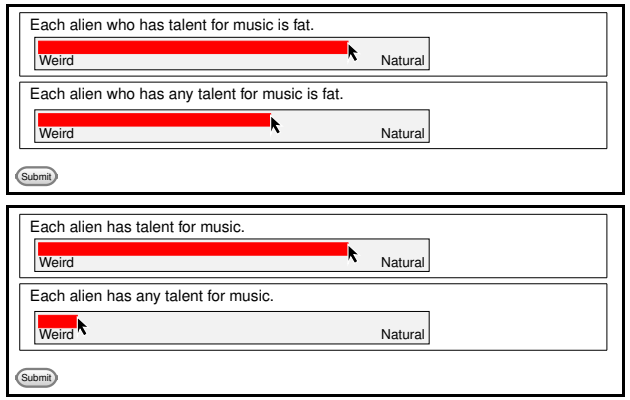
Negative Polarity Items

Distribution of *any*	Downward Monotonicity
✗ John has **any** talent.	↓ John saw **doves**. John saw **birds**.
✓ John doesn't have **any** talent.	↑ John did not see **doves**. John did not see **birds**.
✗ Each alien has **any** talent.	↓ Each alien saw **doves**. Each alien saw **birds**.
✓ Each alien who has **any** talent died.	↑ Each alien who saw **doves** died. Each alien who saw **birds** died.
Intuition	***Hard, logical property*** (e.g., van der Slik & Geurts, 2005)

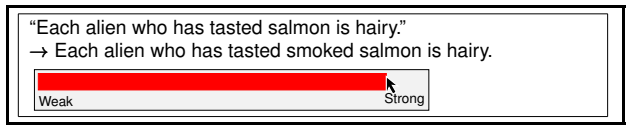
S(NPI) is well-formed	*to the extent that*	S(…) **subjectively** is Down-Entailing

- Task 1: Collect judgments about NPI acceptability [*le moindre*]

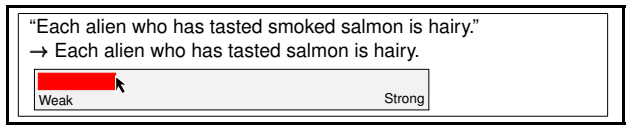
The top sentence is always a control without the NPI



- Task 1: Collect judgments about NPI grammaticality [*le moindre*]
- Task 2: Collect judgments about monotonicity inferences
  - Downward monotonicity:



  - Upward monotonicity: same sentences in the reverse order



- Task 1: Collect judgments about NPI grammaticality [*le moindre*]
- Task 2: Collect judgments about monotonicity inferences
- Task 3: Collect judgments about scalar implicatures [⟨*plusieurs,tous*⟩]
  - Direct scalar implicatures ["φ(*several*)" → not-φ(*all*)]

"Each alien who visited several Parisian museums is red."
→ Some visited all Parisian museums and aren't red.

  - Indirect scalar implicatures ["φ(*all*)" → not-φ(*some*)]

"Each alien who visited all Parisian museums is red."
→ Some visited Parisian museums (one or more) and aren't red.

Experiment

- Cover story

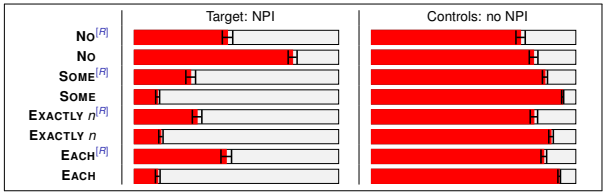
  Aliens arrived on Earth! This is obviously what everyone talks about and we ask you to imagine that the sentences you are going to see are uttered in a conversation about these aliens.
  - participants like it!
  - no (or little) belief bias
  - reduce constraints on the construction of the sentences
- 2 sets of 7 or 8 environments:

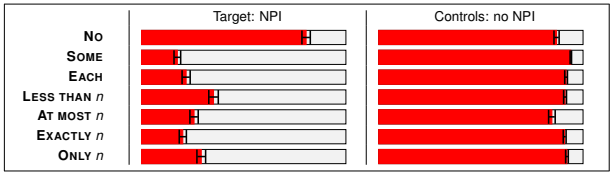
  S1 Comparing Scopes and Restrictors systematically

  S2 Comparing Scopes of similar quantifiers (e.g., 'Less than' vs. 'At most')
- 3 blocks: NPI, Monotonicity, Scalar Implicatures
- 2×24 participants: 6 for each order of presentation of the 3 blocks

  (the NPI block was never last)
- Number of items ≈ 250: 7/8 (env.) × 6 (judgments) × 6 (repetitions)

Bare results: NPI (acceptability)

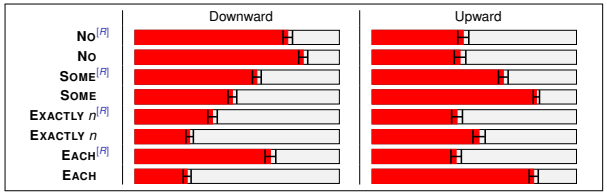


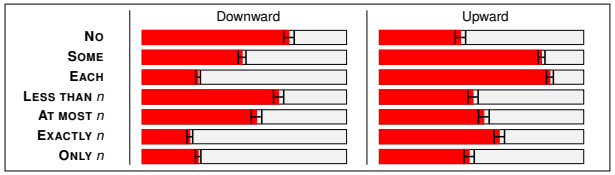


- Controls are good
- Intuitively reasonable judgments
- Subtle differences arise

→ Useful methodology

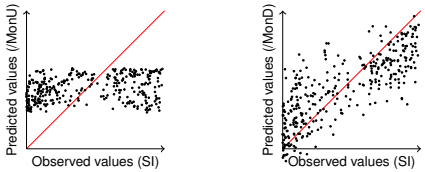
Bare results: Monotonicity





Not clear cut (as one may expect):
→ participants do not have direct access to monotonicity judgments

Implicatures and monotonicity



Mean r^2s: 16.1%, 38.7%

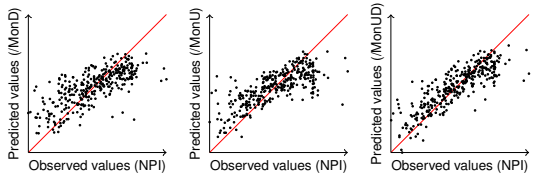
- Interpretation

Generalization [dSI] *(purely Gricean version)*
φ(*some*) implicates not-φ(*all*)
when φ(...) is **upward-entailing**

Generalization [dSI] (Update) *(post-Gricean version)*
φ(*some*) implicates not-φ(*all*)
when φ(...) is **not downward-entailing**

Specter, van Rooij & Schulz, Fox, Chemla, less explicit in Sauerland

NPI and monotonicity



- Results
  - Good correlation between NPI and **DEness** (M_{r^2} = 28%)
  - Good correlation between NPI and **non-UEness** just as well

    (M_{r^2} = 23%, difference: p = .24)
  - Best correlation with **both UEness** and **non-UEness**

    (M_{r^2} = 45%, differences: $p < .001$)

NB: This last point is not a mathematical necessity because (a) we used adjusted r^2s. (b) it does not hold for SIs.

Subjective monotonicity at the individual level

- **Within** vs. **Between** correlation values

		Monotonicity				
		S_1	S_2	S_3	S_4	...
NPI	S_1	W	B	B	B	...
	S_2	B	W	B	B	
	S_3	B	B	W	B	
	S_4	B	B	B	W	
	...					

- Measure

  For each line/participant S, $F(S) = \#\{\mathbf{B} : \mathbf{W} > \mathbf{B}\}/\#\mathbf{B}s$
- Result

  Within-subject subjective monotonicity is a better predictor than **Between**-subject subjective monotonicity of NPI judgments.

  (means of $F(S) > 59\%$ for MonU, MonD and MonD*MonU; $p_s < .021$)

Interim summary

- Subjective rule

φ(NPI) is felicitous to the extent that φ(...) is
1. **perceived** as **downward**-entailing **and**
2. **perceived** as not-**upward**-entailing

(Progovac 1994, Postal 2000, Rothschild 2006)

- Result: correlation found, at the individual level
  - Confirms that the underlying licensing condition is inferential
  - Subjective notions on both sides of the generalization
  - Opens the possibility to combine DEness and UEness

Role of **logical** capacity in **linguistic** faculty

Study 2:

Negative and Positive Polarity Items

Illusory inferences

With Vincent Homer and Daniel Rothschild, in progress

Material (from examples)

"The red alien did not see {any/∅} birds."
→ The red alien did not see doves.

- Opposite direction (testing UEness instead of DEness):

(4) "The red alien did not see {any/∅} doves."
→ The red alien saw birds.

- Positive environments and PPIs:

(5) "The red alien saw {some/∅} doves."
→ The red alien saw birds.

- Non-monotonic environments:
  - Hard monotonicity inferences
  - Accept both PPIs and NPIs
  - Intermediate PI judgments though

(6) "Exactly 12 aliens saw {some/any/∅} doves."
→ Exactly 12 aliens saw birds

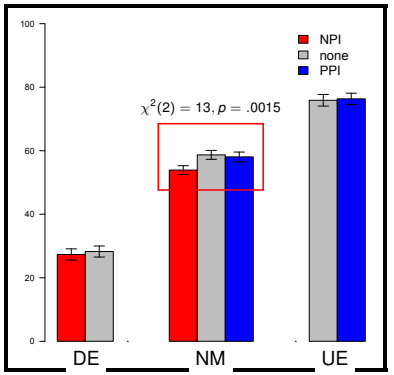
Material (description)

- Three types of environments
  - 3 UE environments: positive *(The red alien)*, *Every*, *Many*
  - 3 DE environments: negative *(The red alien did not)*, *No*, *Few*
  - 2 NM environments: *Exactly 12*, *Only 12*
- Polarity items and Content
  - 12 pairs of (set, subset) VPs: (*see* ⟨*PI*⟩ *birds*, *see* ⟨*PI*⟩ *doves*)
  - ⟨PI⟩: nothing, *some* (PPI), *any* (NPI).
- All 'grammatical' combinations
  - NPI in DE or NM contexts
  - PPI in UE or NM contexts
- Direction: testing UE and DE inferences (simply reversing the order)
- Groups of items

  Each participant would see a given 'content' in a single ⟨PI⟩ condition.

Exp 2a: Illusory inferences **in difficult cases**

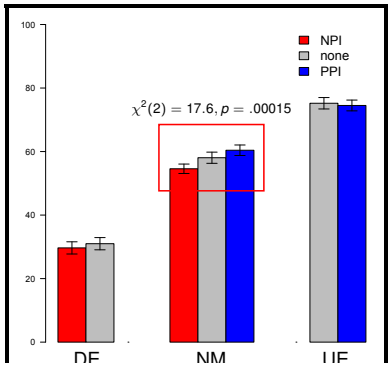
75 participants, 74 native speakers of English



Overall PI effect:
$\chi^2(2) = 6.9, p = .031$

Exp 2b (replication) PIs in premise **and** consequent

(7) The red alien did not see **any** birds.
→ The red alien did not see **any** doves. N=72-1



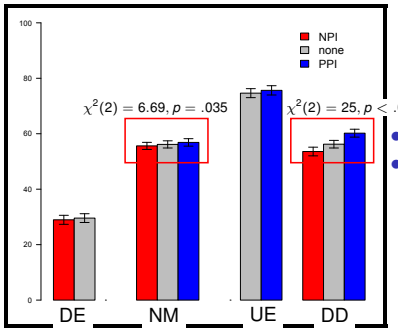
Overall PI effect:

Discussion

- Polarity items influence monotonicity inferences
  - The effect is visible only when monotonicity inferences are tough
    cf. Szabolcsi et al. 2008, Chemla 2008
  - Even under adverse conditions, the effect is found
- Consequences
  - This result further confirms the inferential nature of PIs
  - This effect could be used for further tests...

Exp 3a: double negations

(9) **No** alien died **without** seeing {**any**/**some**/∅} birds.
(10) **Every** alien who did **not** see {**any**/**some**/∅} birds is hairy. N=112-7

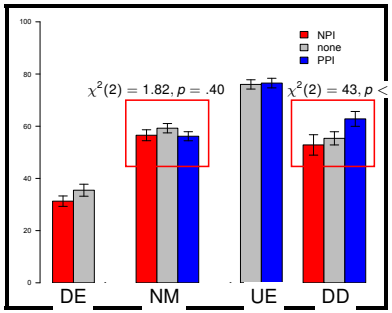


- PPIs: UE inferences
- NPIs: **DE illusions**

Overall PI effect:
$\chi^2(2) = 24, p < .0001$

Exp 3b: double negations (replication)

Different arrangement of the items: a given participant does not see a given environment with items of different polarity. N=80-4



Overall PI effect:
$\chi^2(2) = 18, p < .0001$

Study 2: summary

- Results
  - Polarity items influence monotonicity inferences
  - Effect observed when monotonicity inferences are tough
  - The direction of the effect goes against local licensing:
    NPIs create illusory DE inferences in otherwise UE contexts
- Possible interpretation: DE + **DE(NPI)** = ... DE?!

  In these complex UE environments, NPIs are licensed **globally**

  These UE environments can be **perceived** as **DE** and **not-UE**

Summary for Polarity Items

Good-old rule
$\psi(\varphi(\text{NPI}))$ is felicitous when $\varphi(...)$ is **downward**-entailing

Subjective version of the rule
$\varphi(\text{NPI})$ is felicitous to the extent that $\varphi(...)$ is
1. **perceived** as **downward**-entailing **and**
2. **perceived** as not-**upward**-entailing

- Observed:
  - PIs acceptability **correlates** with subjective judgments of monotonicity, at the individual level
  - Presence of a PI interferes with **global** monotonicity judgments
- Questions about polarity items

  Raison d'être: they can help with/influence inferences?

  PI variability: weak/strong correspond to different thresholds?

  Variation with content, correlate with content effect in logical tasks?

Study 3:

Definiteness effect

Correlations between well-formedness and several abstract properties

With Daniel Rothschild, very fresh

Definiteness effect

There is a student. **There is the student.*
There are many students. **There are all students.*

Two questions: - Proper generalization
- Why?

Definiteness effect:

*There are **Q** students* is felicitous
iff **Q** is symmetrical (e.g., Higginbotham 1987)
iff **Q** is not presuppositional (e.g., Zucchi 1995)

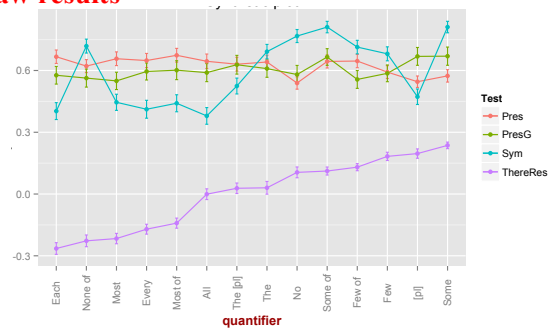
Tests

There-constructions
Baseline: [Q] [adj1] alien went to the [loc].
Test: There is [Q] [adj1] alien in the [loc].

Symmetry
[Q] [adj1] alien is [adj2].
=> [Q] [adj2] alien is [adj1].

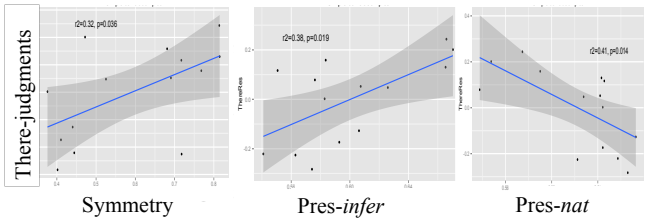
Presupposition:
Natural: I don't know whether there are [adj1] aliens at all.
But if [Name] finds [Q] [adj1] alien, I would go to the [loc].
Infer1: If [Name] finds [Q] [adj1] alien, I would go to the [loc].
=> There is no question that [adj1] aliens exist.
Infer2: [Name] wonders whether [Q] [adj1] alien is [adj2].
=> There is no question that [adj1] aliens exist.

Raw results



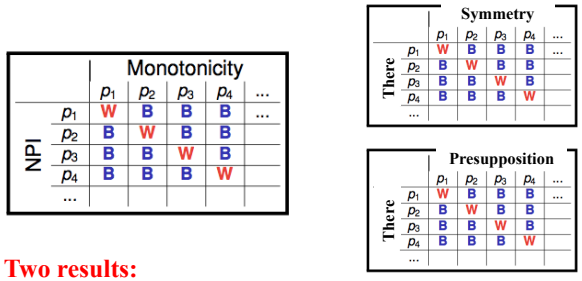
Three main results:
1. Graded target judgments
2. Variable symmetry judgments
3. Rather flat presuppositional judgments (both *infer* and *nat*)

Correlations (across quantifiers)



Two main results:
1. Good correlations everywhere:
no wonder, that's why the generalizations were proposed
2. Best correlation:
when **both** generalizations are taken into account together

Correlations at the individual level



Two results:
1. One-to-one correlations: **not better at the individual level**

2. Correlation using both predictors: **better at the individual level**

If both generalizations are motivated (why question): makes sense!

Linguistic generalizations

- **'Objective' version**
Sentence *S* is felicitous iff *S* satisfies property *P*.
  - An intuitive, **subjective** property of *S*
  - An abstract, **objective** property of *S*

  Predictive

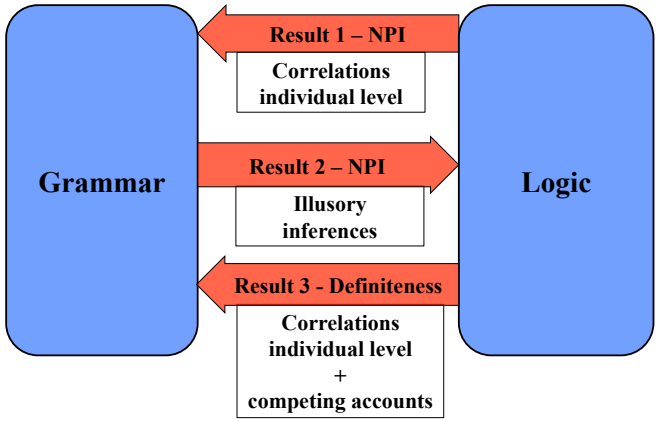
- **'Subjective' version**
Sentence *S* is felicitous **to the extent that** *S* **subjectively** satisfies property *P*.
  - An intuitive, **subjective** property of *S*
  - An abstract, **subjective** property of *S*

  Finer Predictions

- Psychological perspective on formal generalizations
  - Finer predictions (e.g., at the individual level)
  - New directions to refine generalizations

- Polarity items: both UEness and DEness matter
- Definiteness: relative value of symmetry and presupposition

General summary of the results



General conclusion

Two types of studies:
- Individual level correlations
- Linguistic influence on Logic

Two phenomena:
- Polarity items
- Definiteness effect

Psychological perspective: new insights to
- study good-old generalizations
- evaluate the relative value of competing options

Thanks: Vincent Homer and Daniel Rothschild
Gennaro Chierchia, Danny Fox, Yossi Grodzinsky, Martin Hackl, Michael Israel, Salvador Mascarenhas, Philippe Schlenker, Benjamin Spector, Michael Wagner

erc