

**Logic in Grammar:**

**an experimental investigation**

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Based on joint work with Vincent Homer and Daniel Rothschild
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**Linguistic Generalizations**

$S$ is well-formed $\iff$ $S$ satisfies property $P$

**Examples**

- **Polarity items (syntax/semantics)**
  $S$($NPI$) is felicitous only if $S(\ldots)$ 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 $S(some)$

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**Purely formal version**

$S$ is well-formed $\iff$ $S$ subjectively satisfies $P$

**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

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**From a psychological point of view**

**Grammar**

- subjective
- graded
- intuitive
- « easy »

**Logic**

- objective
- binary
- artificial, unconscious
- « hard »

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**Goals for today: three studies**

**Result 1 – NPI**

Correlations individual level

**Result 2 – NPI**

Illusory inferences

**Result 3 – Definiteness**

Correlations individual level + assess competing views

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**Study 1: Negative Polarity Items**

Correlations between well-formedness and inferences

With Vincent Homer and Daniel Rothschild, L&P 2012

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**Negative Polarity Items**

**Distribution of any**

<table>
<thead>
<tr>
<th>John has any talent.</th>
<th>John doesn’t have any talent.</th>
</tr>
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<td><img src="https://via.placeholder.com/15" alt="✓" /> John did not see doves.</td>
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**Intuition**

Hard, logical property (e.g., van der Slik & Geurts, 2005)

$S(NPI)$ is well-formed to the extent that $S(\ldots)$ subjectively is Down-Entailing

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- **Task 1:** Collect judgments about NPI grammaticality
  - The top sentence is always a control without the NPI

- **Task 2:** Collect judgments about monotonicity inferences
  - **Downward monotonicity:** same sentences in the reverse order

- **Upward monotonicity:** same sentences in the reverse order
Subjective monotonicity at the individual level

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

<table>
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<tr>
<th>NPI</th>
<th>Monotonicity</th>
</tr>
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<tr>
<td>S1</td>
<td>B</td>
</tr>
<tr>
<td>S2</td>
<td>B</td>
</tr>
<tr>
<td>S3</td>
<td>B</td>
</tr>
<tr>
<td>S4</td>
<td>B</td>
</tr>
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**Measure**
- For each line/participant S, \( F(S) = \#(B : W > B)/\#B \)

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

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

### 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:***

- **Study 1:** Comparing Scopes and Restrictors systematically
- **Study 2:** 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.) \( \times 6 \) (judgments) \( \times 6 \) (repetitions)

### Bare results: NPI (acceptability)

**Results**
- Good correlation between NPI and DEness
- Good correlation between NPI and non-UEness just as well
- Best correlation with both UEness and non-UEness

\( (M_p = 28\%) \) \( (M_p = 23\%, \text{ difference: } p = .24) \) \( (M_p = 45\%, \text{ differences: } p < .001) \)

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

### NPI and monotonicity

**Results**
- Good correlation between NPI and non-UEness

**Controls:** no NPI

### Interim summary

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

**Progovac:** 1994, Postal 2000, Rothschild 2006

**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\alil) birds."
  \[\rightarrow\] The red alien did not see doves.

- Possible environments and PPIs:
  - (7) Non-monotonic environments:
    - Accept both PPIs and NPIs
    - Intermediate PI judgments though

- (6) "Exactly 12 aliens saw (some/any\alil) doves."
  \[\rightarrow\] Exactly 12 aliens saw doves.

- (5) "The red alien did not see (any\alil) doves."
  \[\rightarrow\] The red alien did not see doves.

- (4) "The red alien did not see (any\alil) doves."
  \[\rightarrow\] The red alien did not see doves.

- Positive environments and PPIs:
  - (3) Opposite direction (testing UEness instead of DEness):
    - 12 pairs of (set, subset) VPs: (see \(\text{PI}\), birds, see \(\text{PI}\) doves)
    - (PI): nothing, some (PPI), any (NPI).

- "The red alien did not see doves.

- "Exactly 12 aliens saw (some\alil) doves."

- "The red alien did not see (any\alil) doves."

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 \(\text{PI}\), birds, see \(\text{PI}\) 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 \(\text{PI}\) condition.

Exp 2b (replication) PIs in premise and consequent

(7) The red alien did not see any\alil birds.
\[\rightarrow\] The red alien did not see any\alil doves.

\(N=72-1\)

\[\chi^2(2) = 17.6, p = .0015\]

Overall PI effect:

\[\chi^2(2) = 17.6, p < .0001\]

Exp 3a: double negations

(9) No alien died without seeing (any\alil) birds.
\[\rightarrow\] No alien died.

\(N=112-7\)

\[\chi^2(2) = 6.69, p = .035\]

Overall PI effect:

\[\chi^2(2) = 24, p < .001\]

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) = \(\rightarrow\) DE?!
  - In these complex UE environments, NPIs are licensed globally
    These UE environments can be perceived as DE and not-UE

Exp 2a: Illusory inferences in difficult cases

75 participants, 74 native speakers of English

\[\chi^2(2) = 13, p = .0015\]

Overall PI effect:

\[\chi^2(2) = 6.9, p = .031\]

Exp 3b: double negations (replication)

Different arrangement of the items: a given participant does not see a given environment with items of different polarity.

\(N=80-4\)

\[\chi^2(2) = 1.62, p = .40\]

\[\chi^2(2) = .43, p < .0001\]

Overall PI effect:

\[\chi^2(2) = 1.62, p < .0001\]

Summary for Polarity Items

- Good-old rule
  \(\varphi(\text{NPI})\) 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?
  - Validity 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: \([Q]\ [adj]1\) alien went to the [loc].
Test: There is \([Q]\ [adj]1\) alien in the [loc].

Symmetry
\([Q]\ [adj]1\) alien is \([adj]2\].
\(\Rightarrow\) \([Q]\ [adj]2\) alien is \([adj]1\).

Presupposition:
Natural: I don’t know whether there are \([adj]1\) aliens at all.
But if [Name] finds \([Q]\ [adj]1\) alien, I would go to the [loc].
Infer1: If [Name] finds \([Q]\ [adj]1\) alien, I would go to the [loc].
\(\Rightarrow\) There is no question that \([adj]1\) aliens exist.
Infer2: [Name] wonders whether \([Q]\ [adj]1\) alien is \([adj]2\].
\(\Rightarrow\) There is no question that \([adj]1\) aliens exist.

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!

General summary of the results

Result 1 – NPI
Correlations individual level

Result 2 – NPI
Illusory inferences

Result 3 – Definiteness
Correlations individual level + competing accounts

Linguistic generalizations

- Objective’ version
Sentence \(S\) is felicitous iff \(S\) satisfies property \(P\).
  – An intuitive, subjective property of \(S\)
  – An abstract, objective property of \(S\)
- 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 \(S\)

Psychological perspective on formal generalizations
- Finer predictions (e.g., at the individual level)
- New directions to refine generalizations
  - Polarity items: both UEleness and DEleness matter
  - Definiteness: relative value of symmetry and presupposition

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

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