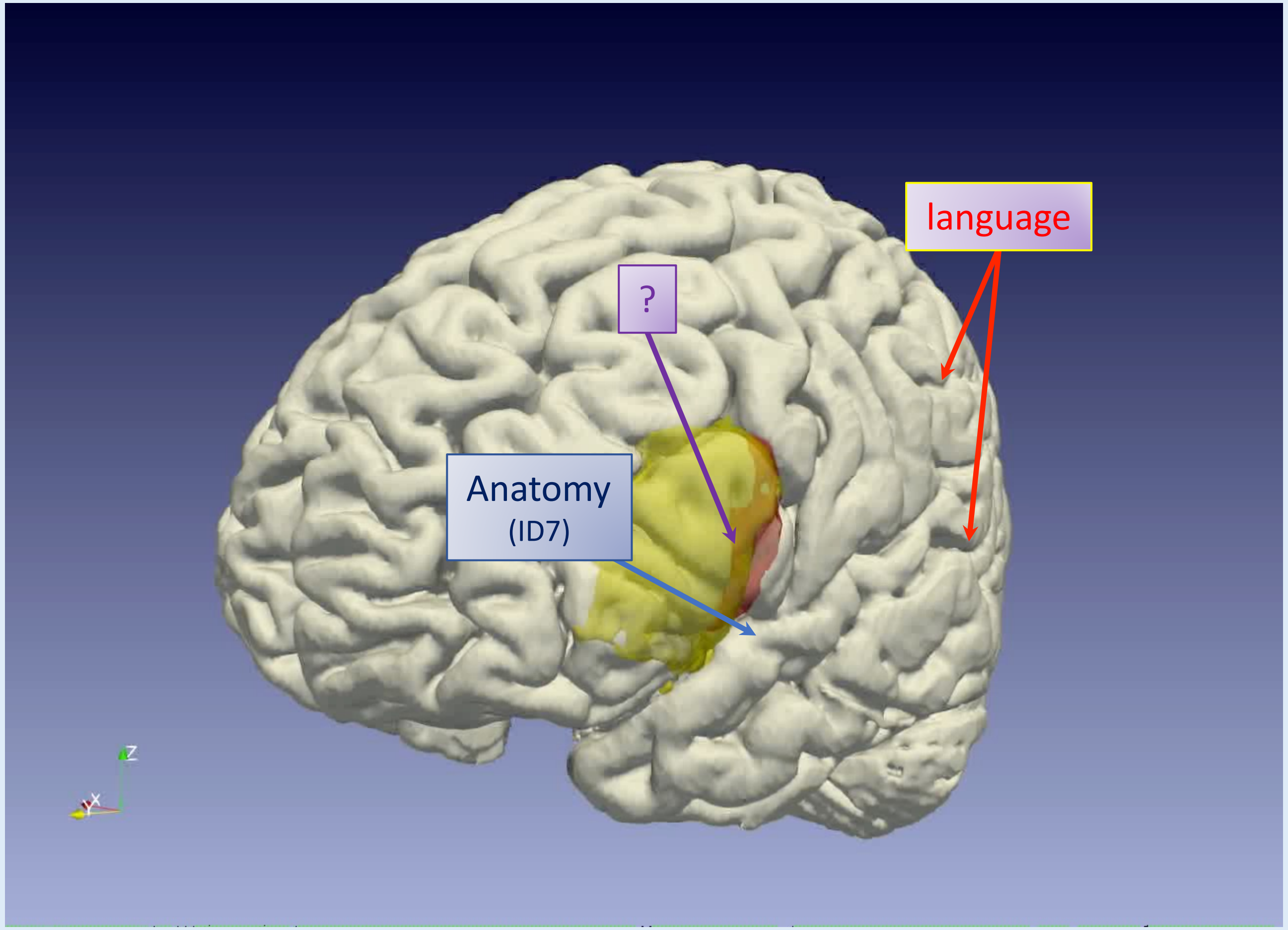
Wednesday

- [x] Appetizer: monotonicity-related experiments with a single Neg operator
  - ✓ Some relevant behavioral results
  - ✓ Some relevant fMRI results
- [ ] Main course: monotonicity-related experiments with more than one Neg operator
- [ ] Dessert: Deciding between two views of NPI licensing
  - Two different views of NPI licensing, and Flip-flop in French and Hebrew
  - A processing experiment with and without flip-flop environments
  - Ruling out alternative interpretations
- [ ] Implications

Mapping the anatomy and comparing to the language regions

A 3-D reconstruction



No overlap with Broca’s region

More than one negation: Processing costs

Cost of DE thus far: A sentence is UE by default; monotonicity reversal is costly.

Question: Do the costs accumulate? Do DE pairs cancel each other?

Contrasting predictions:

Cumulative: cost is incurred by *n* (=number of DE operators) →

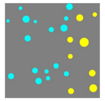
RT grows with *n*

Cancellation: cost is incurred by the monotonicity of a sentence →

RT grows only when the number of negations is odd (=2*n*+1)

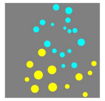
A neg+Q experiment with adult participants

1.1. **More** than half of the circles are yellow
יותר מחצי מהעיגולים הם צהובים



1.2. **Less** than half of the circles are yellow
פחות מחצי מהעיגולים הם צהובים

2.1. **Not more** than half of the circles are blue
לא יותר מחצי מהעיגולים הם כחולים



2.2. **Not less** than half of the circles are blue
לא פחות מחצי מהעיגולים הם כחולים

Comulative neg cost

$RT_{CumNeg} = RT_{base} + n^{neg} * RT_{neg}$

↑ S-cost (baseline) ↑ #neg ↑ Neg-cost

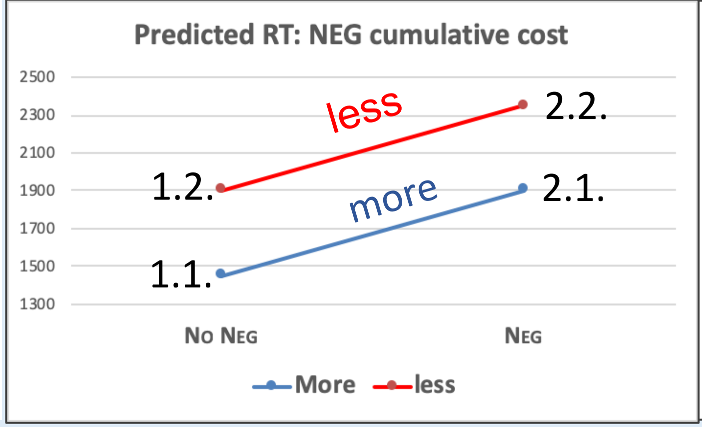
Cancelation neg cost

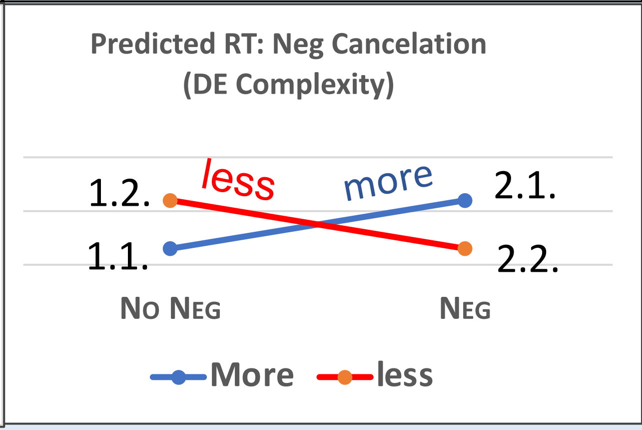
for $n^{neg} = 2n-1$:

$RT_{CanNeg} = RT_{base} + RT_{neg}$

for $n^{neg} = 2n$:

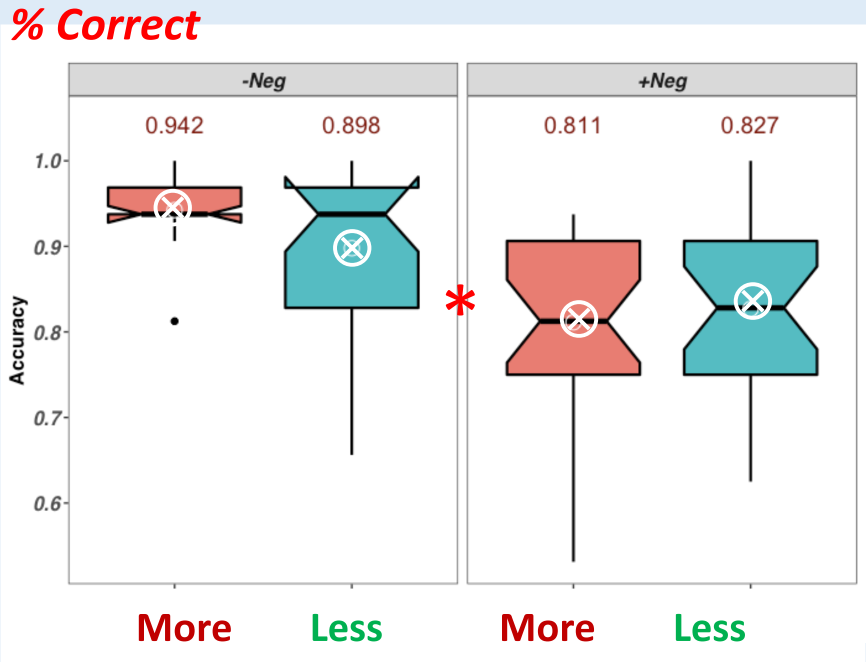
$RT_{CanNeg} = RT_{base}$

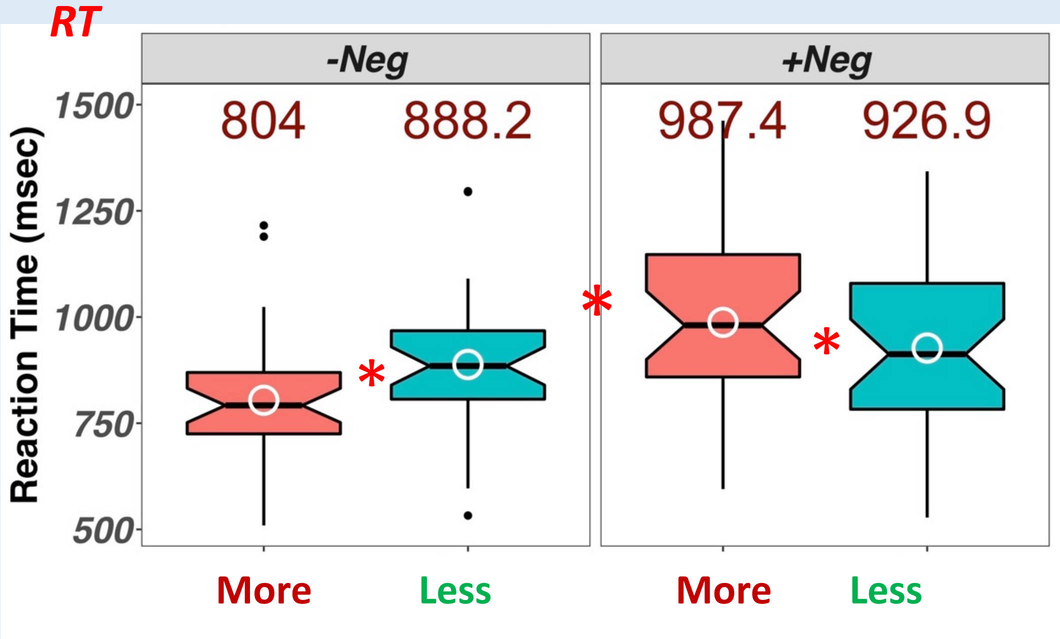




Grodzinsky et al., *J. of Neuroling*., 2021; Tan, Kugler-Ettinger & Grodzinsky, *Lang., Cog. & Neuro.*, 2023.

Results: monotonicity determines $\Delta RT(=RT_{DE} - RT_{UE})$





n=38

Comulative neg cost in ER

$ER_{CumNeg} = ER_{base} + n^{neg} * ER_{neg}$

↑ S-cost (baseline) ↑ #neg ↑ Neg-cost

Cancelation neg cost in RT

for $n^{neg} = 2n-1$:

$RT_{CanNeg} = RT_{base} + RT_{neg}$

for $n^{neg} = 2n$:

$RT_{CanNeg} = RT_{base}$

Workplan

- ☑ Appetizer: monotonicity-related experiments with a single Neg operator
  - ✓ Some relevant behavioral results
  - ✓ Some relevant fMRI results
- ☑ Main course: monotonicity-related experiments with more than one Neg operator
- ❑ Dessert: Deciding between two views of NPI licensing
  - o Two different views of NPI licensing, and Flip-flop in French and Hebrew
  - o A processing experiment with and without flip-flop environments
  - o Ruling out alternative interpretations
- ❑ Implications

Two approaches to NPI licensing

An NPI needs a DE licensor, but where must the NPI be, for it to be licensed?

19. **Operator-Based Approach (OpBA):** An NPI is licensed only if it is in **the scope** of a downward-entailing (DE) expression. (Fauconnier, 1975; Ladusaw, 1980).

20. **Environment-Based Approach (EnvBA):** An NPI α is licensed in sentence *S* only if there is **a constituent** A of *S* containing α such that A is DE w.r.t the position of α. (Gajewski, 2005).

A distinguishing prediction: flip-flop (Chierchia, Homer)

			OpBA	EnvBA
21.	… $[_{A\downarrow}$ **DE** … ***NPI*** ….]	1*DE licensor in A	✓	✓
22.	… $[_{\downarrow}$ **DE** … $[_{A\downarrow}$ **DE** ***NPI*** ….]	1*DE licensor in A	✓	✓
23.	*… $[_{A\uparrow}$ **DE DE** … ***NPI*** ….]	2*DE licensors in A	✓	*

A distinguishing prediction: flip-flop (Chierchia, Homer)

	OpBA	EnvBA
11. … [$_{A\downarrow}$ **DE** … ***NPI*** ….] — 1*DE licensor in A	✓	✓
12. … [$_{\downarrow}$ **DE** … [$_{A\downarrow}$ **DE** ***NPI*** ….] — 1*DE licensor in A	✓	✓
13. *… [$_{A\uparrow}$ **DE DE** … ***NPI*** ….] — 2*DE licensors in A	✓	*

24. Il [$_{A\downarrow}$ **n'** est **pas** possible / est **im**possible que Jean ait fait ***[quoi que ce soit]***$_{NPI}$] pour aider la Mafia.

it is **not** / **im** possible that Jean have.SUBJ done what that this be.SUBJ to help the Mafia

'It is impossible that Jean did anything to help the Mafia.'

25. Il est **im**possible que Jean [$_{A\downarrow}$ **n'**ait **pas** fait ***[quoi que ce soit]***$_{NPI}$] pour aider la Mafia.

'It is **im**possible that Jean did**n't** do anything to help the Mafia.'

A distinguishing prediction: flip-flop (Chierchia, Homer)

26. … [$_{A\downarrow}$ **DE** … ***NPI*** ….] 1*DE licensor in A

27. … [$_{\downarrow}$ **DE** … [$_{A\downarrow}$ **DE** ***NPI*** ….] 1*DE licensor in A

28. *… [$_{A\uparrow}$ **DE DE**… ***NPI*** ….] 2*DE licensors in A

OpBA	EnvBA
✓	✓
✓	✓
✓	*

29. *Il [$_{A\uparrow}$ **n'** est **pas im**possible que Jean ait fait ***[quoi que ce soit]***$_{NPI}$] pour aider la Mafia.

'It is **not im**possible that Jean did anything to help the Mafia.'

Hebrew=French in this respect

30. … [$_{A\downarrow}$ **bilti**-efšari še Dani nirdam *[$_{NPI}$ **'ey-pa'am]*** be-šmira]

Impossible that Dani fell asleep ever while on guard

… [$_{A\downarrow}$ **DE** … ***NPI*** ….]

31. …[**bilti**-efšari še Dani [$_{A\uparrow}$ **lo** nirdam *[$_{NPI}$ **'ey-pa'am]*** be-šmira]

Impossible that Dani did**n't** fall asleep ever while on guard

… [$_{\downarrow}$ **DE** … [$_{A\downarrow}$ **DE**…***NPI*** ….]

2. *… [$_{A\uparrow}$ **lo bilti**-efšari še Dani nirdam *[$_{NPI}$ **'ey-pa'am]*** be-šmira]

Not impossible that Dani fell asleep ever while on guard

*… [$_{A\uparrow}$ **DE DE**… ***NPI*** ….]

Workplan

- ☑ Appetizer: monotonicity-related experiments with a single Neg operator
  - ✓ Some relevant behavioral results
  - ✓ Some relevant fMRI results
- ☑ Main course: monotonicity-related experiments with more than one Neg operator
- ❑ Dessert: Deciding between two views of NPI licensing
  - ✓ Two different views of NPI licensing, and Flip-flop in French and Hebrew
  - o A processing experiment with and without flip-flop environments
  - o Ruling out alternative interpretations
- ❑ Implications

Processing costs of DE-ness

A sentence is UE by default; monotonicity reversal is costly.

We measure the cost through a verification task.

Contrasting predictions:

Operator-dependent cost: DE-processing cost is incurred by the DE-ness of a sentence

Domain-dependent cost: DE-processing cost is incurred by the DE-ness of a domain

23. … [$_{A\downarrow}$ **DE** …*X*] 1*DE licensor in A

24. … [$_{\downarrow}$ **DE** … [$_{A\downarrow}$ **DE** *X* ….] 1*DE licensor in A

25. … [$_{A\uparrow}$ **DE DE**… *X* ….] 2*DE licensors in A

Processing costs

OpBA	*EnvBA*
high	high
High+	High+
High+	low

*Our materials: 2*DE in syntactically different configurations*

26. [$_{A\downarrow}$ **paxot** me-xamiša ratzim higi'u ***[$_{NPI}$ 'ey-pa'am]*** la-gmar].

less than-five runners reached ever to-the-finish-line

'Less than five runners ever reached the-finish-line.'

… [$_{A\downarrow}$ **DE** … ***NPI*** ….]

27. [**paxot** me-xamiša ratzim [$_{A\downarrow}$ **lo** higi'u ***[$_{NPI}$ 'ey-pa'am]*** la-gmar].

less than-five runners **not** reached ever to-the-finish-line

… [$_{\downarrow}$ **DE** … [$_{A\downarrow}$ **DE** ***NPI*** ….]

28. *[$_{A\uparrow}$ **lo** **paxot** me-xamiša ratzim higi'u *ey pa'am* la-gmar].

not less than-five runners reached ***[$_{NPI}$ 'ey-pa'am]*** to-the-finish-line

*… [$_{A\uparrow}$ **DE DE** … ***NPI*** ….]

An experiment with domains (with Nir Segal)

Participants:
n=26 in Hebrew
n>70 in a web-run English equivalent

Constituent negation

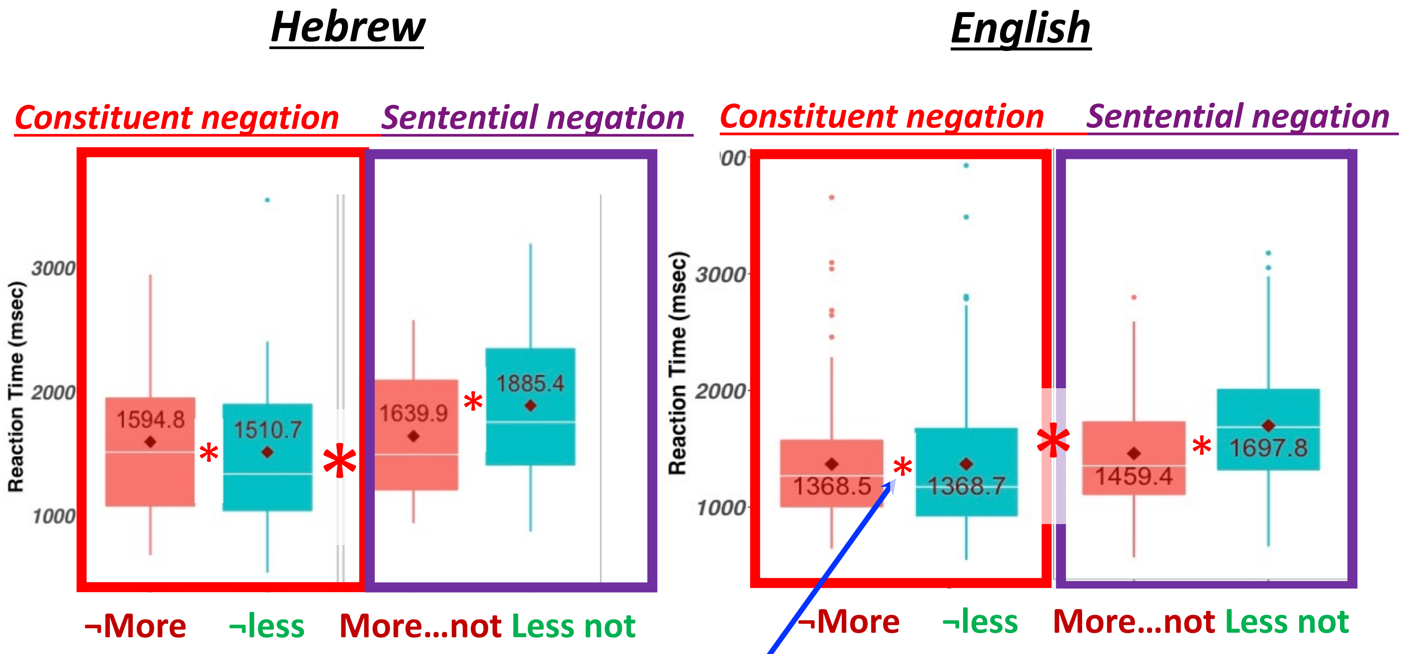
2.1 [Not more than half] of the circles are blue

2.2 [Not less than half] of the circles are blue

Sentential negation

3.1 [More than half] of the circles are not blue

3.2 [Less than half] of the circles are not blue



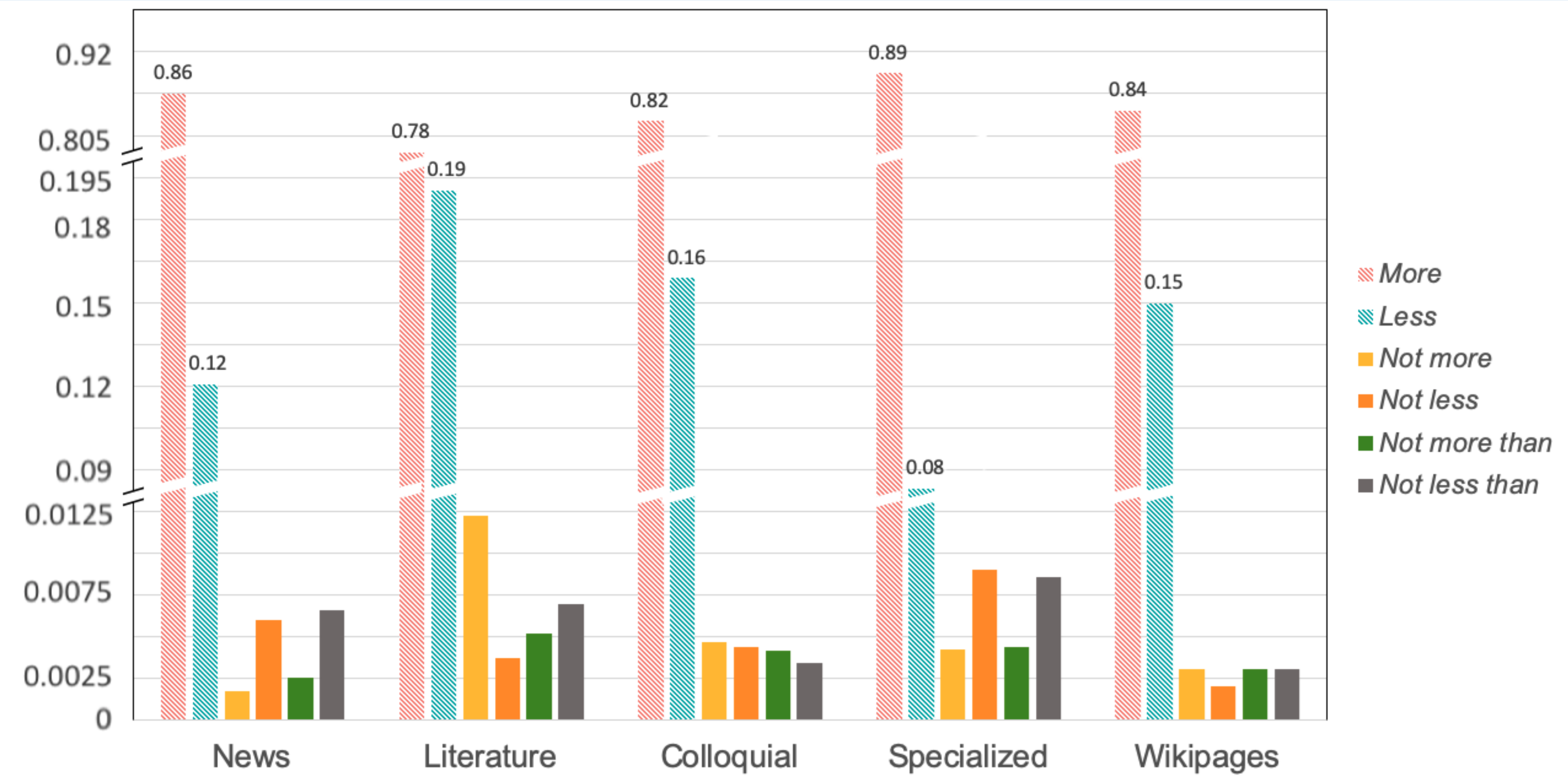
On a mixed model analysis (Δ per subject)

Tan, Segal & Grodzinsky, *J. Sem.*, submitted

Workplan

- ☑ Appetizer: monotonicity-related experiments with a single Neg operator
  - ✓ Some relevant behavioral results
  - ✓ Some relevant fMRI results
- ☑ Main course: monotonicity-related experiments with more than one Neg operator
- ❑ Dessert: Deciding between two views of NPI licensing
  - ✓ Two different views of NPI licensing, and Flip-flop in French and Hebrew
  - ✓ A processing experiment with and without flip-flop environments
  - o Ruling out alternative interpretations
- ❑ Implications

Frequency? A Hebrew study



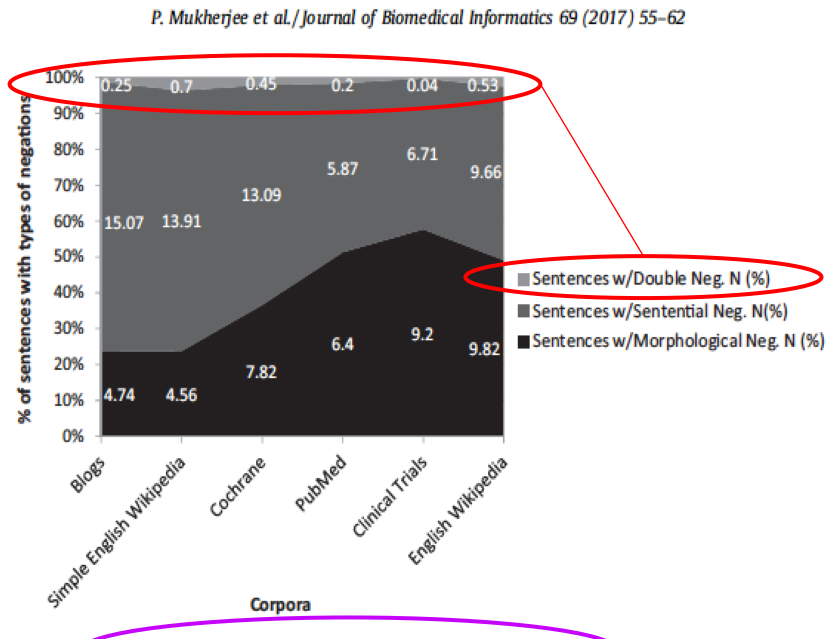


Fig. 3. Distribution of negation types for different corpuses.

The relative frequency of the occurrence of each phrase in each genre.
The sum of the bins in each genre was normalized to 1

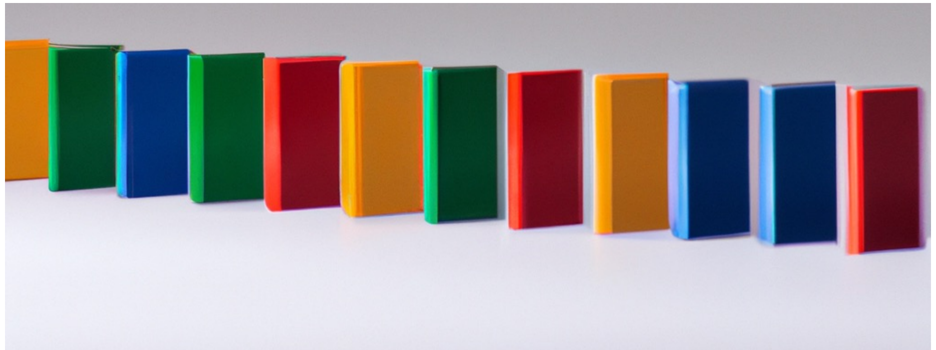
Tan, Kugler-Ettinger & Grodzinsky, *Lang., Cog. & Neuro.*, 2023.

Learning: reorganizing the sequence of stimuli

- Learning hypothesis: participants learn over the testing session
- Learning enhances (speeds up) performance selectively: *not less* is enhanced more than the other conditions

Experimental sequence (random order across all stimuli)

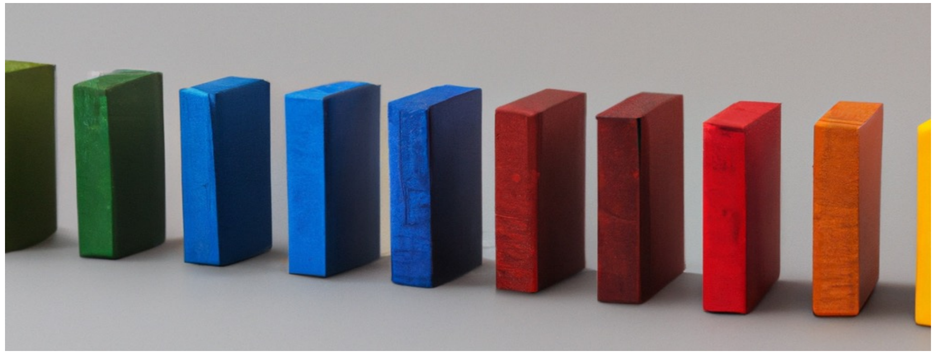
$C_{1,1}$ $C_{3,1}$ $C_{1,2}$ $C_{2,1}$ $C_{4,1}$ …



⇒

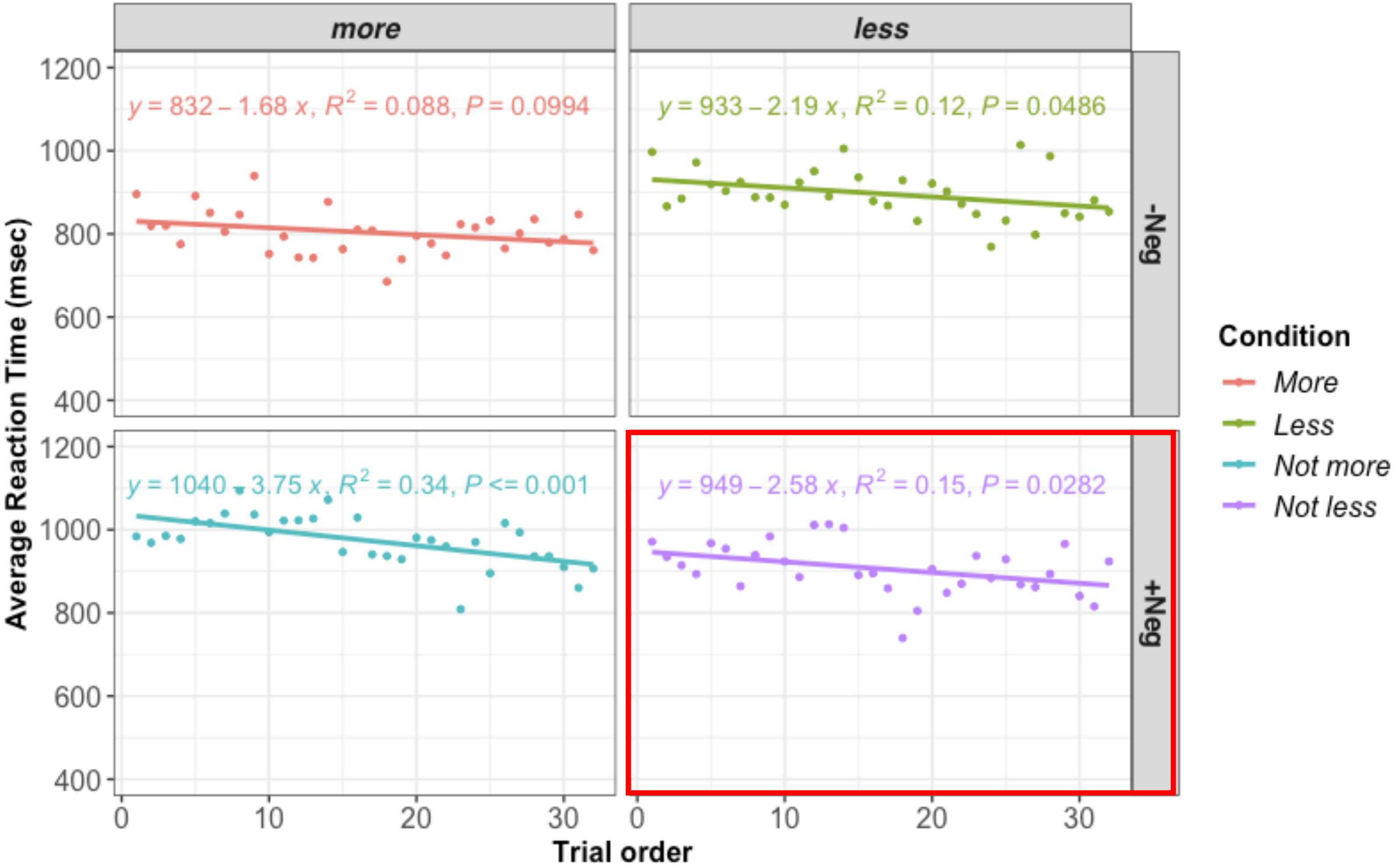
Learning sequence (by condition)

$C_{1,1}$ $C_{1,2}$ $C_{3,1}$ $C_{3,2}$ $C_{3,2}$ $C_{4,1}$ $C_{4,2}$ …



- Prediction: if we plot RT against place in the sequence $C_{\bullet,1\ldots n}$ the slope of the not less condition would be steeper than that of the other conditions

Selective learning?



Slope of Regression line of sequential intra-session RT remains fixed across conditions, indicating that no *selective* learning occurs

Tan, Kugler-Ettinger & Grodzinsky, *Lang., Cog. & Neuro.*, 2023.

Workplan

- ☑ Appetizer: monotonicity-related experiments with a single Neg operator
  - ✓ Some relevant behavioral results
  - ✓ Some relevant fMRI results
- ☑ Main course: monotonicity-related experiments with more than one Neg operator
- ☑ Dessert: Deciding between two views of NPI licensing
  - ✓ Two different views of NPI licensing, and Flip-flop in French and Hebrew
  - ✓ A processing experiment with and without flip-flop environments
  - ✓ Ruling out alternative interpretations
- ☐ Implications

What can we conclude?

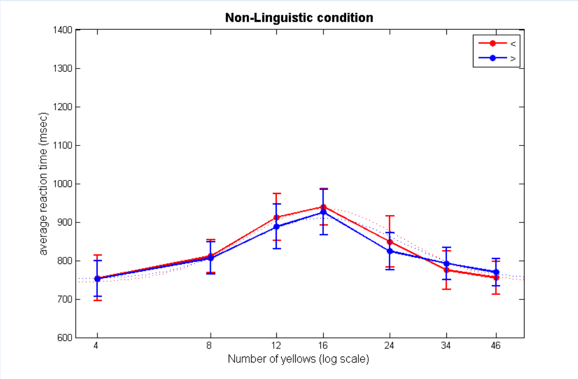
<u>Domain-based Processing Hypothesis (DPH):</u>

- ➢ *parsing is bottom up*
- ➢ *A minimal domain is UE by default*
- ➢ *The Monotonicity Reversal of a Domain of an NPI (MRD) incurs a processing cost*

- *Processing complexity is not just about individual words, but also, about syntactic and semantic properties of linguistic representations*
- *DE-ness (as evinced by RT in verification tasks) is one such complexity determinant*
- *Monotonicity is a property of syntactic domains (whose nature remains to be characterized)*

Tan, Segal & Grodzinsky, *J. Sem*., submitted

CODA: A view from comparatives

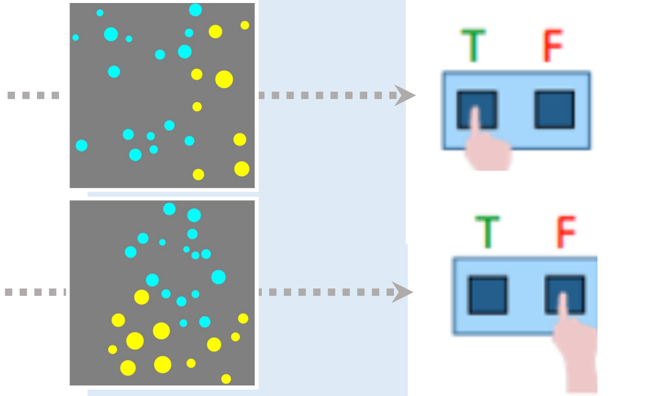


UE:

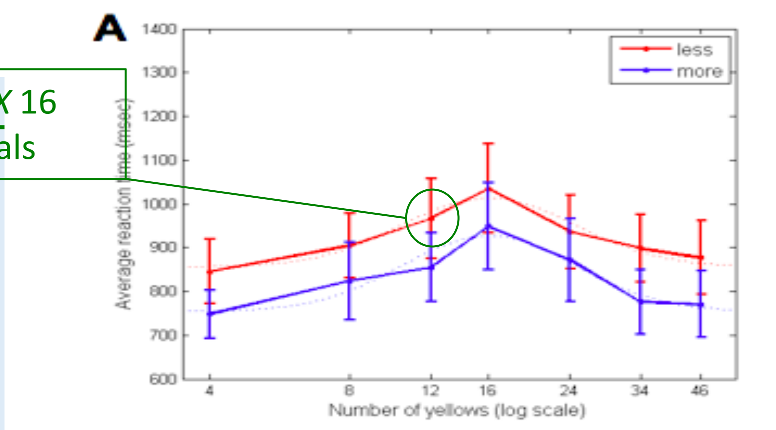
There are more blue circles than Yellow circles

DE:

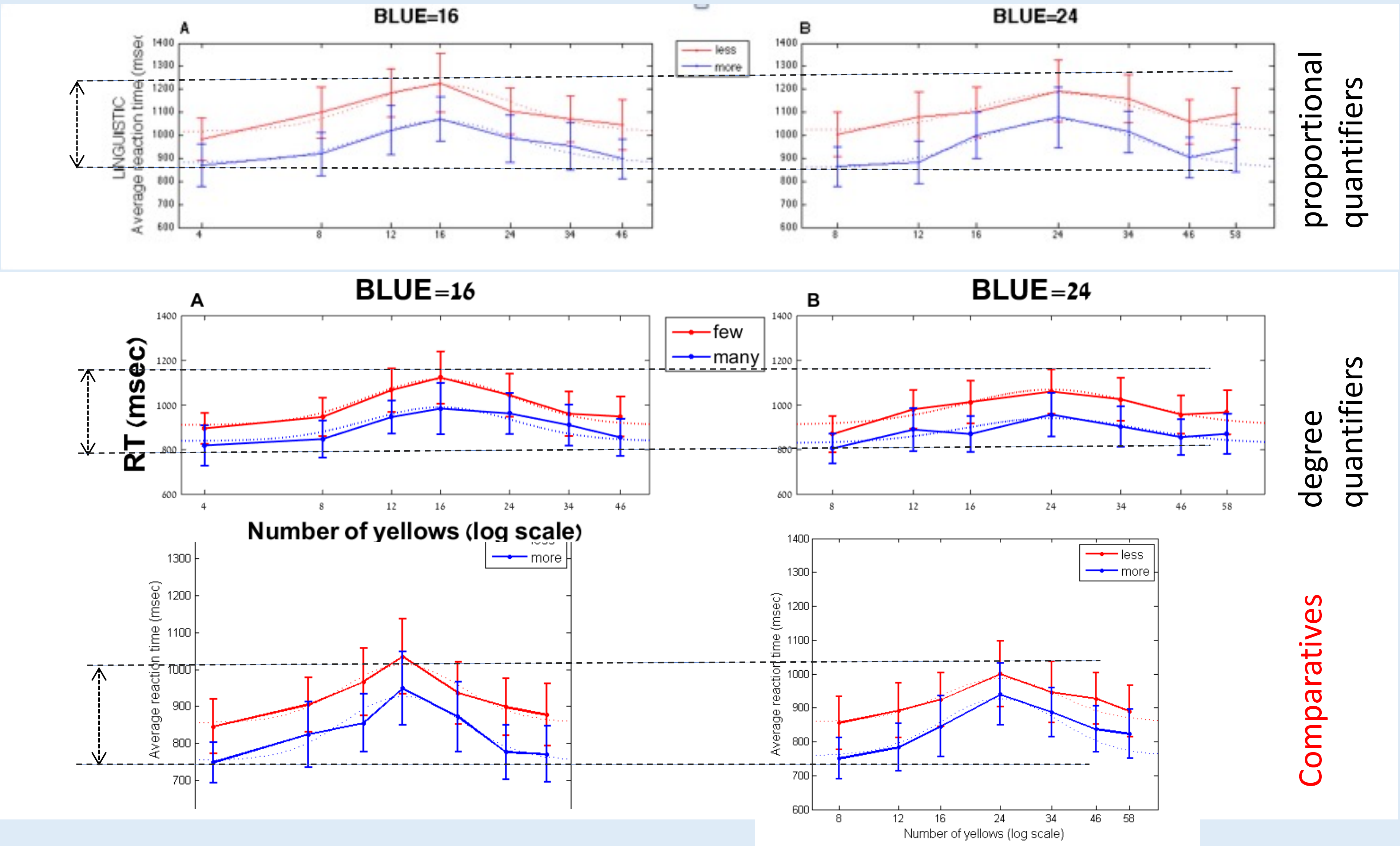
There are fewer blue circles than Yellow circles



22 subjects *X* 16 T/F = 352 trials



The DE cost effect across numerosities and quantifier pairs



But wait:
do we really expect a DE cost in comparatives?

The monotonicity of (phrasal) comparatives

{cats}⊂{mammals}, {snakes}⊂{reptiles}

(1) a. **UE**: More cats than snakes died ⇒ More mammals than snakes died

b. **DE**: More cats than reptiles died ⇒ More cats than snakes died

(2) a. **DE**: Fewer mammals than snakes live in deserts
⇒ Fewer cats than snakes live in deserts

b. **UE**: Fewer cats than snakes live in big cities
⇒ Fewer cats than reptiles live in big cities

Comparatives appear to have mixed monotonicity

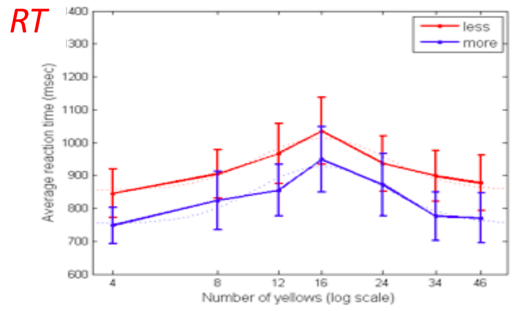
(3) a. [There are more blue circles]^{UE} [than yellow circles]^{DE}

b. [There are fewer blue circles]^{DE} [than yellow circles]^{UE}

Predicted DEC effect (assuming additivity of UE, DE):

$$\Delta RT = RT_{(3b)} - RT_{(3a)} = RT_{DE+UE} - RT_{UE+DE} \approx 0.$$

Observed effect: $\Delta RT > 0$.



Paths toward a solution

I. Experimental path: if sentence is not read to the end, the result follows:

(4) a. UE half: [There are more blue circles]^{UE} [than | yellow circles]^{DE}

b. DE half: [There are fewer blue circles]^{DE} [than | yellow circles]^{UE}

If so, then the predicted effect is

(5) $\Delta RT = RT_{(4b)} - RT_{(4a)} > 0$

Needed: an experiment that would get around this problem.

II. Theory path: the representation of monotonicity above is incorrect.

The ingredients of the equation

(6) $\Delta RT = RT_{(3b)} - RT_{(3a)} = RT_{DE+UE} - RT_{UE+DE} \approx 0.$

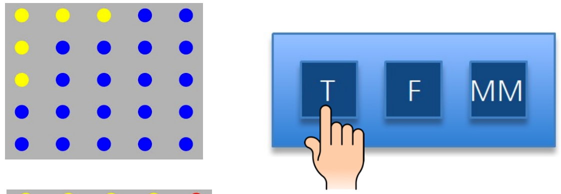
need to be reconsidered.

Down the experimental path

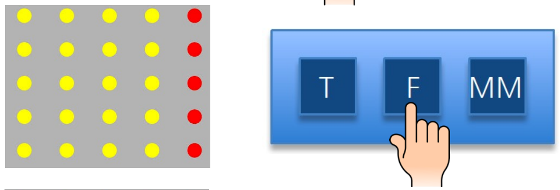
Goal: force participants to read instruction sentence to the end.
Trick: add a color. Inform participants that there may be a sentence-image color mismatch. Add a 3rd response button (MM), to force them to attend to the end:

(7)

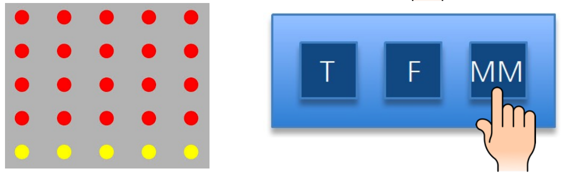
a. There are more blue circles than yellow circles.

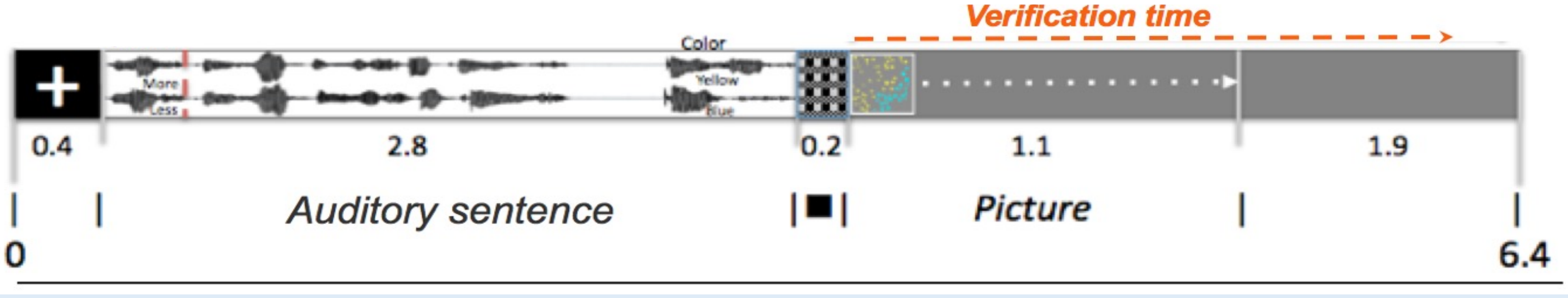


b. There are fewer yellow circles than red circles.



c. There are more red circles than blue circles.

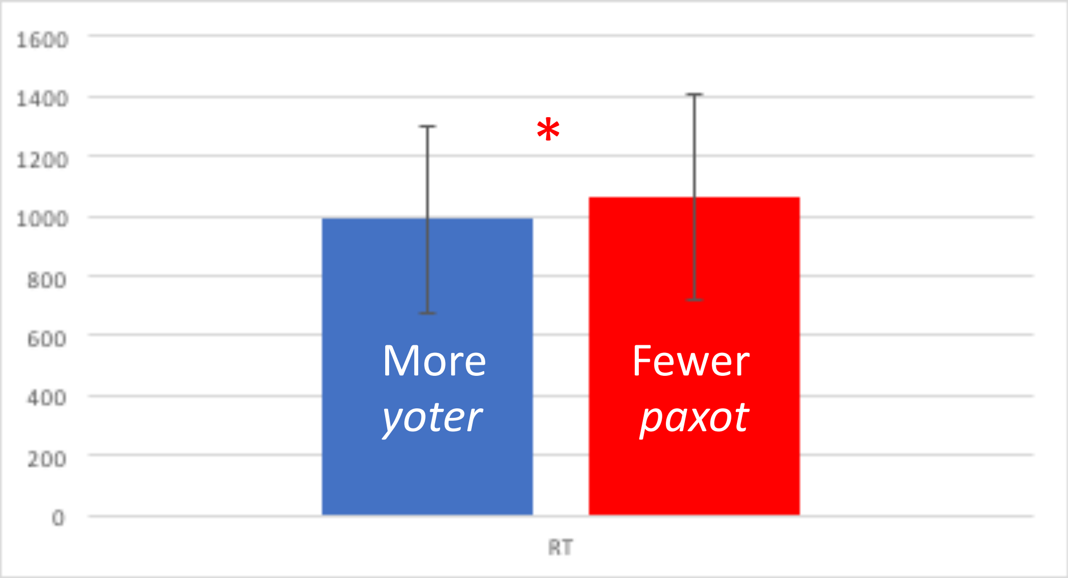




Grodzinsky et al., *SuB 22*, 2018

Results and Status

RT



Notes:

The experiment was done in Hebrew.

Results only include correct T/F responses (MM excluded); error rates are low.

Conclusion: The experimental path is not the way out of the puzzle.

Grodzinsky et al., *SuB 22*, 2018

The Seuren/Rullman puzzle: NPIs in comparatives

Expected: NPIs are licensed only in the "M↓ part" of the more-comparative

(8) a. there are more [students]$^{M\uparrow}$ than [(there are) profs I've ever$_{NPI}$ met]$^{M\downarrow}$

b. *there are more [students I've ever$_{NPI}$ met]$^{M\downarrow}$ than [(there are) profs]$^{M\uparrow}$

Expected: NPI licensing in the "M↓ part" of less-comparatives:

(9) there are fewer [students I've ever$_{NPI}$ met]$^{M\downarrow}$ than [(there are) profs]$^{M\uparrow}$

Unexpected: NPI licensing in the "M↑" of less-comparatives:

(10) there are fewer [students]$^{M\downarrow}$ than [(there are) profs I've ever$_{NPI}$ met]$^{M\uparrow}$

Seuren, 1973; Büring, 2007; Rullman, 1995; Heim, 2006

The Seuren/Rullman puzzle and the DEC effect

This pattern would follow if the DE operator count were:

(11) a. More [(there are) blue circles]^{UE} [than yellow circles]^{DE}

b. Fewer [(there are) blue circles]^{DE} [than yellow circles]^{DE*DE}

Counting DE operators for processing

(12)

a. More:

–er$^{M\downarrow}$ [than ∃d’/d’-many yellow circles][∃d/d-many blue circles]] =1*DE

b. Fewer:

[–er $^{M\downarrow}$ [than little $^{M\downarrow}$ ∃d’/d’-many [yellow circles][little $^{M\downarrow}$ ∃d/d-many [blue circles]]

=3*DE

Seuren, 1973; Büring, 2007; Rullman, 1995; Heim, 2006

DE operator count explains the DEC effect in comparatives

1. Assume that each M↓ operator contributes equally to processing cost.

   DEC is determined by the number of M↓ (DE)-operators, n_{DE}, in a given LF:

DE cost :

$$n_{DE}(LF_2) > n_{DE}(LF_1) \Rightarrow RT(LF_2) >^{s} RT(LF_1).$$

2. The DEC effect can now be used to compare the number of DE operators (all else equal).

3. The DEC effect might help us uncover hidden DE operators through RT patterns (e.g., where 2n*DE =nUE).

4. In such cases, NPIs would be licensed in environments that appear UE due to an even number of DE operators.

Seuren, 1973; Büring, 2007; Rullman, 1995; Heim, 2006