The Semantics and Processing of Distributivity

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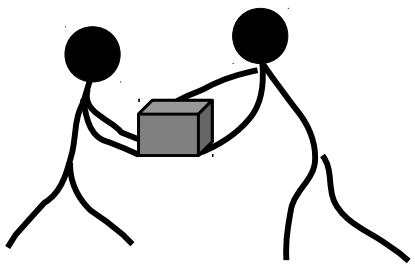
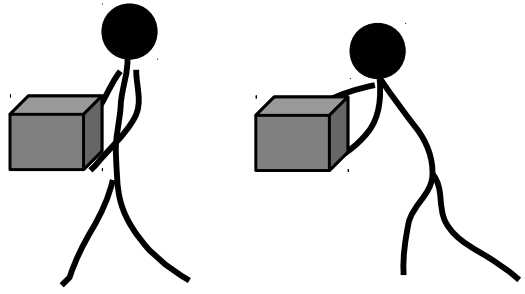
1. The boys lifted a box.



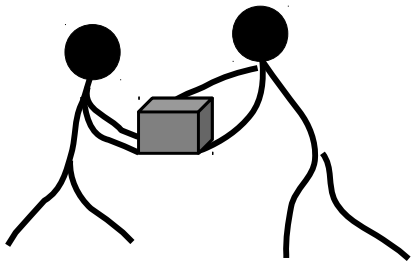
Collective



Distributive

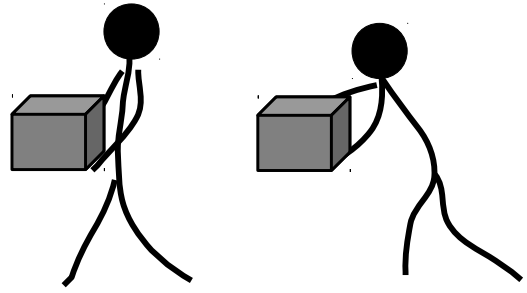
- The boys drank an espresso. (dist)

1. The boys lifted a box together.



Collective

2. Each of the boys lifted a box.



Distributive

Questions

- Distributive/collective: vagueness or ambiguity (Lasersohn 1995, Schwarzschild 1996, Nouwen, to app.)
- Are both interpretations entertained during sentence processing?
- If not, which one is preferred?
- Which factors influence the choice?

Plan

- Eye tracking to study reading comprehension
- Building on Frazier et al. (1999)

Plan

- Frazier et al. (1999)
- Problems
- Three new experiments testing processing of distributive and collective interpretations

Distributive and collective reading

Lynne and Patrick saved $1000

1. each. (Distributive)
2. together. (Collective)

- Locally ambiguous:
  1. Lynne and Patrick saved \$1000 **each** to pay for their honeymoon.
     (Ambiguous, Dist)
  2. Lynne and Patrick saved \$1000 **together** to pay for their honeymoon.
     (Ambiguous, Coll)
- Unambiguous:
  1. Lynne and Patrick **each** saved \$1000 to pay for their honeymoon.
     (Unambiguous, Dist)
  2. Lynne and Patrick **together** saved \$1000 to pay for their honeymoon.
     (Unambiguous, Coll)

Predictions

- Locally ambiguous, Dist reading → processing difficulties
- Coll reading has been chosen until then
- Locally ambiguous, Coll reading → processing difficulties
- Dist reading has been chosen until then

Rating study

Locally ambiguous sentences:

Lynne and Patrick/They saved $1000 **each/together** to pay for their honeymoon.

Distributive	3.6
Collective	3.4

ANOVA by subject and item: Difference not significant, $p > .1$

First-pass:

Predicate:	Ambiguous<Unambiguous
Next 3 words:	Ambiguous, Coll<Ambiguous, Dist
	Unambiguous, Coll≈Unambiguous, Dist

1. Lynne and Patrick (each/together) weighed 220 pounds(each/together) weighed 220 pounds after their low-proteinafter their low-protein diet.
2. Lynne and Patrick weighed 220 pounds (each/together)weighed 220 pounds (each/together) after their low-proteinafter their low-protein diet.

Total reading times:

Predicate:	Collective<Distributive
Next 3 words:	Ambiguous, Coll<Ambiguous, Dist
	Unambiguous, Coll>Unambiguous, Dist

1. Lynne and Patrick (each/together) weighed 220 pounds(each/together) weighed 220 pounds after their low-proteinafter their low-protein diet.
2. Lynne and Patrick weighed 220 pounds (each/together)weighed 220 pounds (each/together) after their low-proteinafter their low-protein diet.

Regression:

Next 3 words: Ambiguous, Coll$<$Ambiguous, Dist
Unambiguous, Coll$\approx$Unambiguous, Dist

1. Lynne and Patrick (each/together) weighed 220 pounds after their low-proteinafter their low-protein diet.
2. Lynne and Patrick weighed 220 pounds (each/together) after their low-proteinafter their low-protein diet.

Frazier et al., 1999

Disambiguating towards distributivity leads to processing costs (first-pass, total times, regression)

Frazier et al., 1990

1. An ambiguous expression: *Pitcher*
2. . . .
3. Only one (dispreferred) reading possible
4. → Difficulties

Frazier and Rayner, 1990

1. A vague expression: *Library*
2. . . .
3. Only one (dispreferred) reading possible
4. → No difficulties

Conclusion:

1. The processor chooses the collective interpretation
2. Coll/Dist is a matter of ambiguity

Problems with Frazier et al., 1999

1. Specific
2. General

Specific problems

- Comparison of *each* and *together*
- Two types of *each*, which are considered identical

1. Lynne and Patrick (each/together) weighed 220 pounds after their low-protein diet.
2. Lynne and Patrick weighed 220 pounds (each/together) after their low-protein diet.

Specific problems

1. Lynne and Patrick each saved $1000. ($each_1$)
2. Lynne and Patrick saved $1000 each. ($each_2$)

The two types of *each* differ syntactically and semantically (Doetjes, 1997, Zimmermann 2002, Dotlacil, to app)

Differences between *each*$_1$ and *each*$_2$

Each$_1$ is an adverb (Doetjes, 1997), a floating quantifier (Kayne, 1975; Sportiche, 1988)
Each$_2$ is a part of an NP (Burzio 1986, Safir and Stowell 1988).

1. The men have each left. (*each*$_1$)
2. *The men have left each. (*each*$_2$)
3. The men have read one book each. (*each*$_2$)

Differences between $each_1$ and $each_2$

$Each_2$ requires a cardinality specification on its NP

1. The men each saw every movie. ($each_1$)
2. *The men saw every movie each. ($each_2$)

Differences between each$_1$ and each$_2$

Each$_2$ is in many languages expressed differently than *each*$_1$ (Zimmermann, 2002)

English: *apiece*=*each*$_2$

Specific problems

- Differences between $each_1$ and $each_2$ might cause the observed effect

General questions

- The effect of pragmatic preferences

1. The boys saved $1000.
2. The boys drank a coffee.
3. The girls ate an apple.
4. The students lifted a piano.

Plan

- Improving on Frazier et al. (1999)
- Testing how other issues (pragmatics, lexical restrictions) influence preferences

Experiment 1

- Locally ambiguous:
  1. Last year, the students saved several thousand dollars **individually** to pay for their holiday.
     (Ambiguous, Dist)
  2. Last year, the students saved several thousand dollars **together** to pay for their holiday.
     (Ambiguous, Coll)
- Unambiguous:
  1. Last year, the students **individually** saved several thousand dollars to pay for their holiday.
     (Unambiguous, Dist)
  2. Last year, the students **together** saved several thousand dollars to pay for their holiday.
     (Unambiguous, Coll)

Predictions

1. Coll preferred → Slowdown and more regressions if **individually** follows the object
2. Dist preferred → Slowdown and more regressions if **together** follows the object

Procedure

- 24 subjects, 18 undergraduate students from UCSC, 6 volunteers
- 24 test items (+18 test items from Experiment 2), 85 fillers
- Randomized order

Experiment 1: Procedure

- Last year, the students saved several thousand dollars individually to pay for their holiday.QuestionQuestionnaire

Results

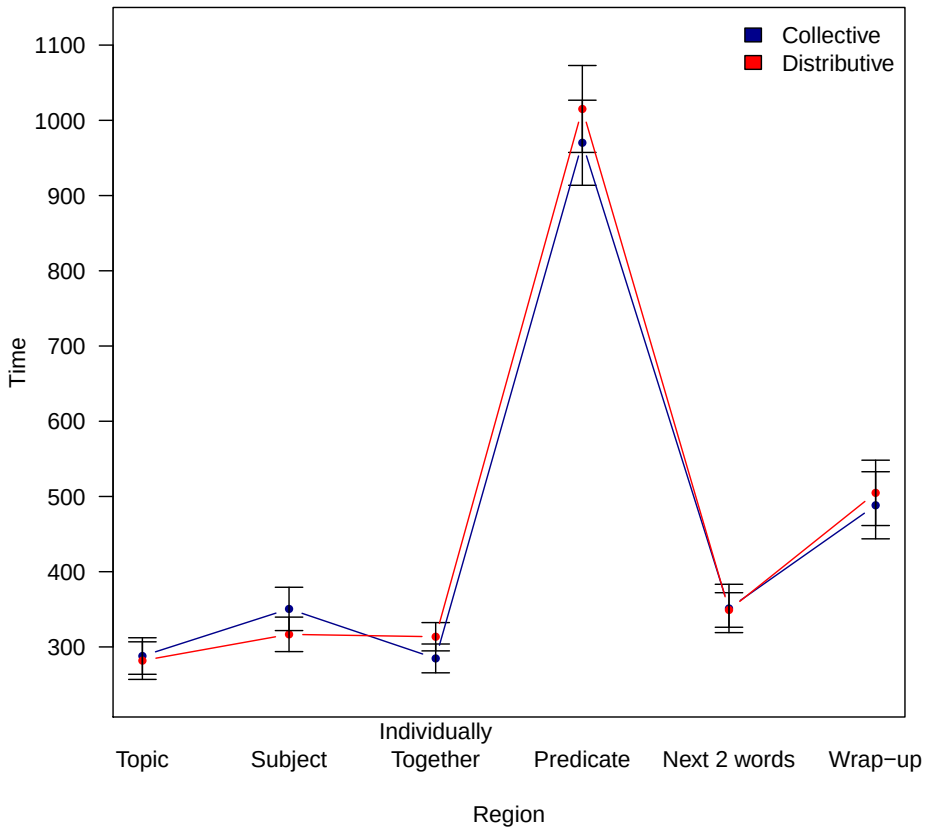
- Answers: 92.5% correct, nobody worse than 80%
- Acceptability:

	Dist	Coll
Ambiguous	4.14	4
Unambiguous	4.16	4.14

No effect of ambiguity or reading
Probit regression, ranef: subject/item; $p > .3$

Results: Right-bounded

Unambiguous



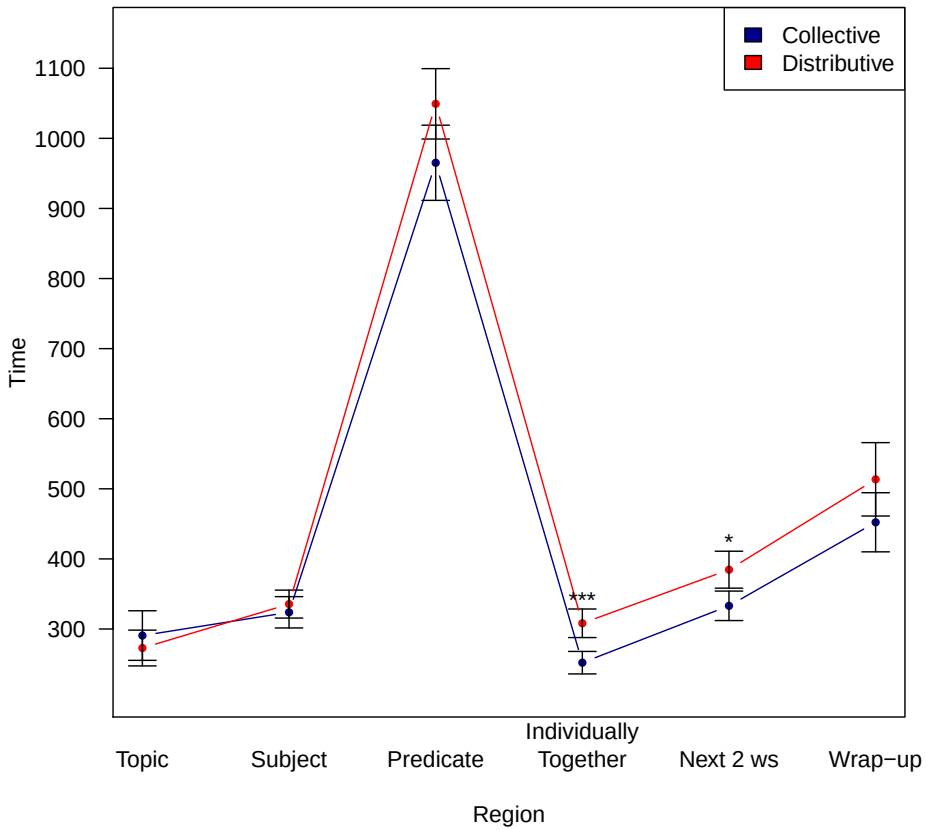
Linear model

Fixef: Interpretation
Ranef: Subjects, Items
$t = 1.86$, $p < .1$ for Adverb

Last year,/the students/(individually—together)/saved several thousand dollars/to pay/for their holiday.

Results: Right-bounded

Ambiguous



Linear model

Fixef:	Interpretation	
Ranef:	Subjects, Items	
$t = 3.32$,	$p = .001$	for Adverb
$t = 2.06$,	$p < .05$	for Next 2 words

Last year,/the students/saved several thousand dollars/(individually—together)/to pay/for their holiday.

Results: Regressions

Adverb

	Dist	Coll
Ambiguous	**14%**	6%
Unambiguous	4%	7%

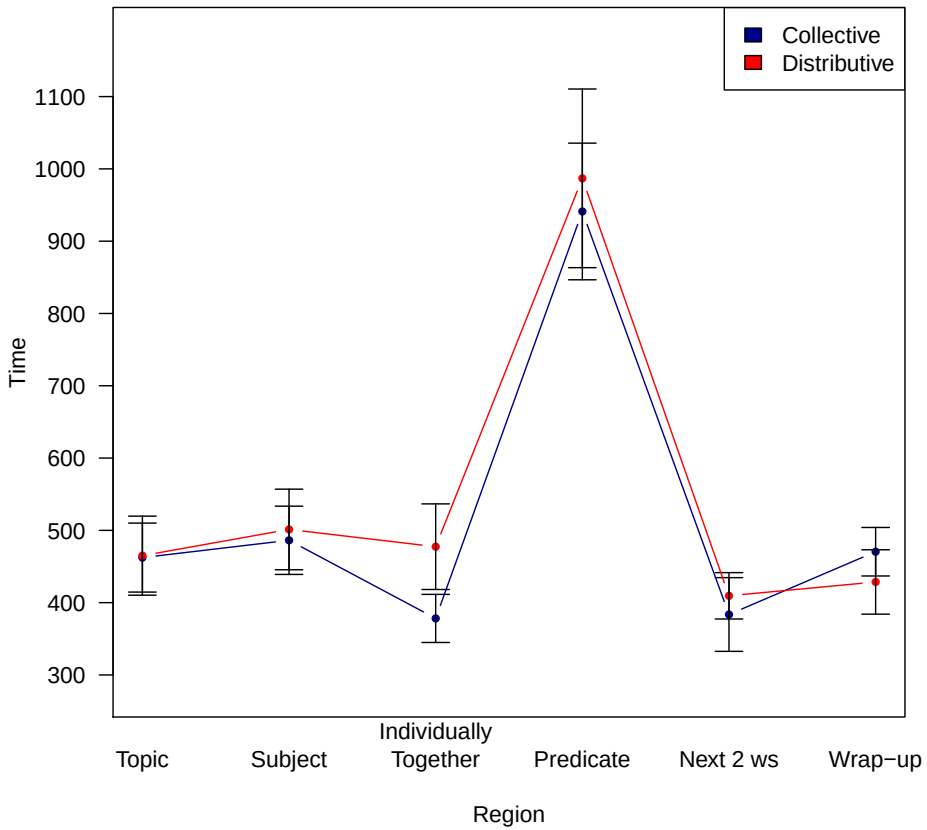
Logistic regression

Fixef: Interpretation, Ambiguity
Ranef: Subjects, Items

$z = 1.9$, $p = .06$ for Ambiguity:Interpretation

Results: Re-reading time

Unambiguous



Linear model

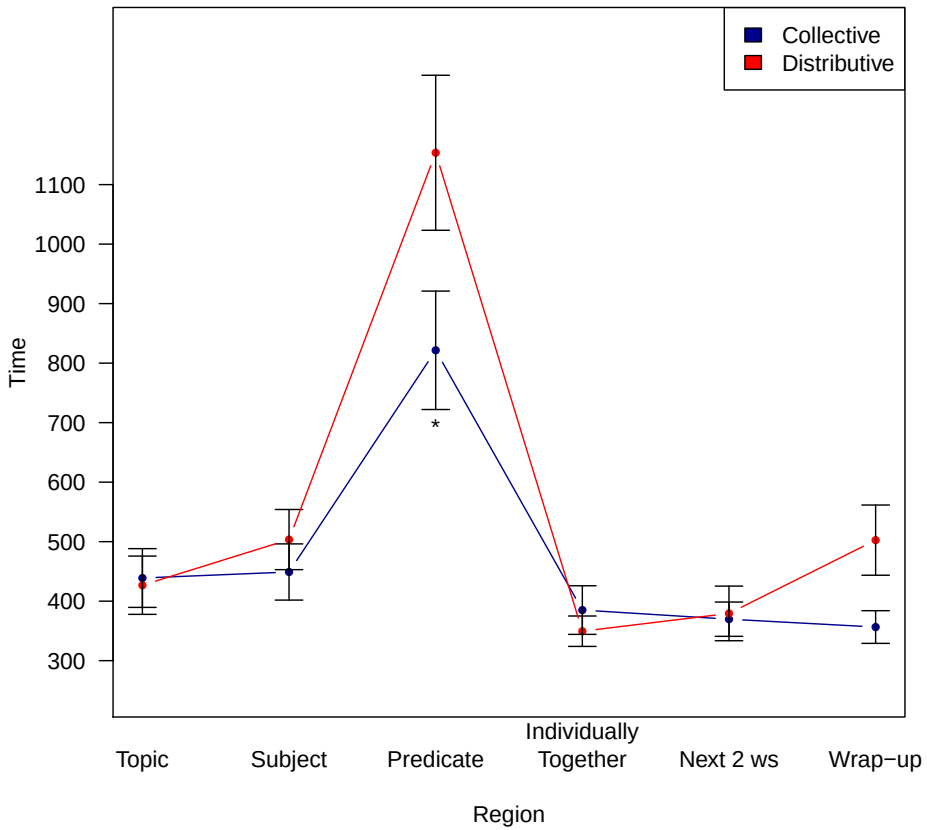
Fixef: Interpretation, Ambiguity
Ranef: Subjects, Items

No significant effect

Last year,/the students/(individually—together)/saved several thousand dollars/to pay/for their holiday.

Results: Re-reading time

Ambiguous



Linear model

Fixef: Interpretation, Ambiguity
Ranef: Subjects, Items

$t = 2.1$, $p < .05$ for Ambiguity:Interpretation on Predicate

Last year,/the students/saved several thousand dollars/(individually—together)/to pay/for their holiday.

Summary

Distributive adverb in the late position causes problems for the processor

1. Slower right-bounded pass of the adverb and its spillover
2. More regressions
3. Higher re-reading time of the predicate

Consequences

1. Potentially ambiguous sentences show a preference for the collective reading
2. The collective/distributive distinction is an instance of ambiguity, not vagueness

The role of pragmatics?

- The boys sat in an uncomfortable chair.
- The girls ate an apple.

Experiment 2

The pragmatically forced distributive interpretation:

1. During the lunch break, the managers drank **an espresso** in the newly opened coffee shop.
2. During the lunch break, the managers **each** drank **an espresso** in the newly opened coffee shop. (each)
3. During the lunch break, the managers **all** drank **an espresso** in the newly opened coffee shop. (all)

Predictions

1. Subj V an NP...
2. Subj **all** V an NP...
3. Subj **each** V an NP...

- The preference solely driven by pragmatics:
  No difference
- The preference not only driven by pragmatics:
  Difference between **1&2** vs. **3**
  (following Brooks and Braine 1996 we expect **2** vs. **3**)

Procedure

- 18 undergraduates from Santa Cruz+6 volunteers
- 18 test items (+24 test items from Experiment 1), 85 fillers
- Randomized order

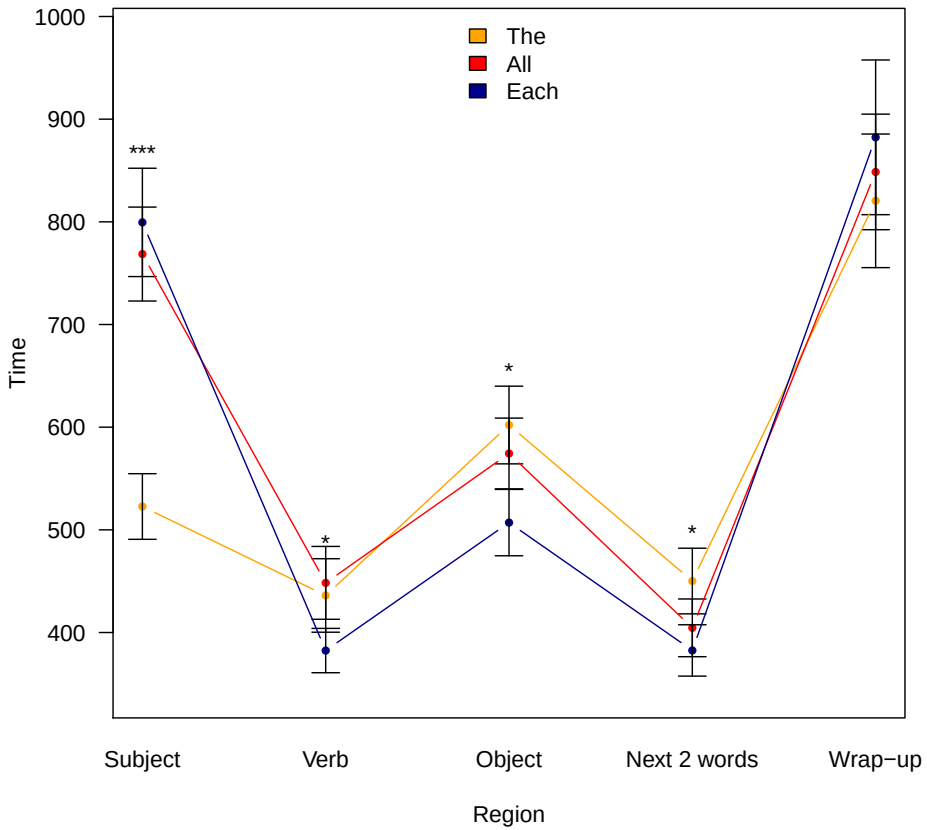
Results

- Answers: 92.5% correct, nobody worse than 80%
- Acceptability:

The	**All**	**Each**
3.76	3.8	4.22

Probit regression, ranef: subject/item; $z = 1.85, p < .1$

Results: Total time



Linear model

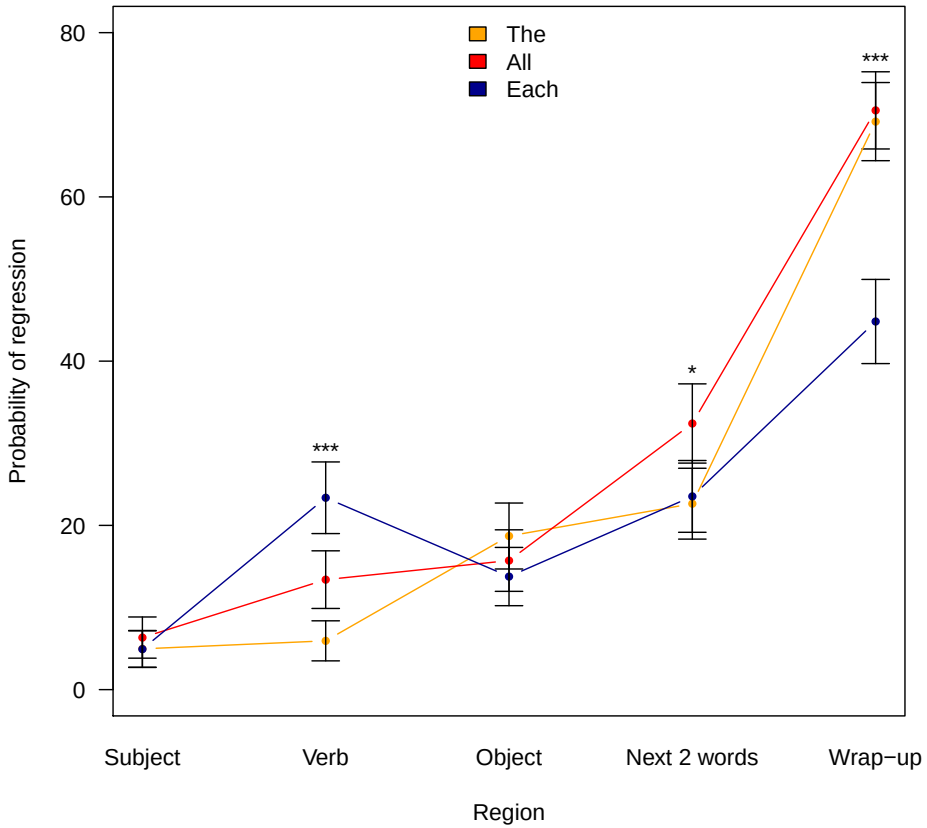
Fixef: Quantifier
Ranef: Subjects, Items

$t = -1.7,$	$p < .1$	for **the** vs. **each** at V
$t = -2.4,$	$p < .05$	for **all** vs. **each** at V
$t = -2.7,$	$p < .01$	for **the** vs. **each** at Obj
$t = -1.98,$	$p < .05$	for **all** vs. **each** at Obj
$t = -2.3,$	$p < .05$	for **the** vs. **each** at Next 2 ws

(the effect on V also at re-reading times)

During the lunch break,/the managers (-/all/each)/drank/an espresso/in the/newly opened coffee shop.

Results: Regressions



Logistic regression

Fixef:	Quantifier	
Ranef:	Subjects, Items	
$z = 1.8$,	$p < .1$	for **all** vs. **the** at V
$z = 3.4$,	$p < .001$	for **each** vs. **the** at V
$z = 2.3$,	$p < .05$	for **all** vs. **the** at Next 2 ws
$z > 4$,	$p < .001$	for **all**,**the** vs **each** at Wrap-up

During the lunch break,/the managers (-/all/each)/drank/an espresso/in the/newly opened coffee shop.

Summary

Pragmatically forced distributive readings cause problems if *each* is not present

1. More regressions on Wrap-up
2. Higher total reading time on the predicate
3. Higher re-reading time on the predicate

Consequences

1. Preference for collective readings for definites and definites with *all*
2. This preference manifests itself even when it is pragmatically implausible
3. The fact that we saw the effect only in late measures is compatible with other observations on higher discourse effects (Filik, 2004)

Experiment 3

1. The boxes are large.
   (Schwarzschild, 2009 - stubbornly distributive predicates)

Experiment 3

- Distributive predicate:
  1. Liz wanted the plates for the potluck party to be **round** because they can be cleaned easily. (the)
  2. Liz wanted **each** of the plates for the potluck party to be **round** because they can be cleaned easily. (each)
  3. Liz wanted **all** the plates for the potluck party to be **round** because they can be cleaned easily. (all)
- Ambiguous predicate:
  1. Liz wanted the plates for the potluck party to be **cheap** because they can be thrown away afterwards.(the)
  2. Liz wanted **each** of the plates for the potluck party to be **cheap** because they can be thrown away afterwards. (each)
  3. Liz wanted **all** the plates for the potluck party to be **cheap** because they can be thrown away afterwards. (all)

Predictions

1. . . . the plates to be round. . .
2. . . . **all** the plates to be round. . .
3. . . . **each** of the plates to be round. . .

- General preference for collective readings:
  Difference between **1&2** vs. **3**
- Preference for collective readings of syntactic predicates only:
  No difference

Procedure

- 26 subjects from Santa Cruz
- 36 test items, 67 fillers
- Pseudo-randomized order

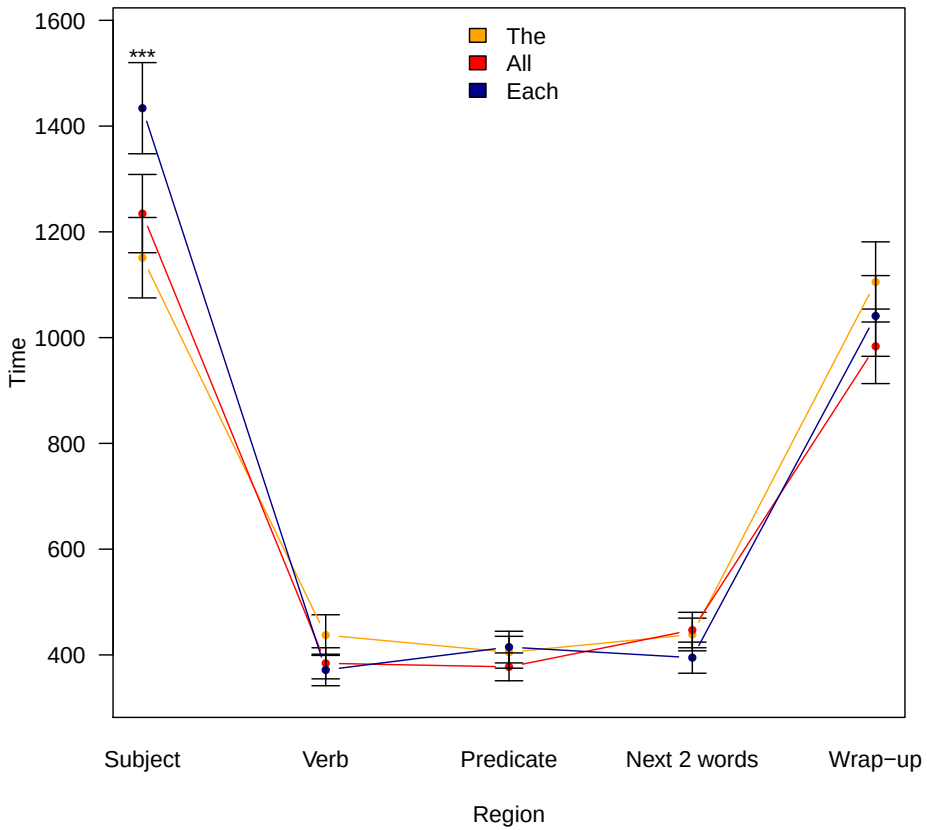
- Answers: 90% correct, 3 people between 75-80%
- Acceptability:

	the	**All**	**Each**
Dist	3.93 (1.16)	3.9 (1.17)	3.87 (1.19)
Non-dist	4.02 (1.14)	4.04 (1.16)	4.04 1.13)

Probit regression, ranef: subject/item; $p > .5$

Results: Total time

Ambiguous



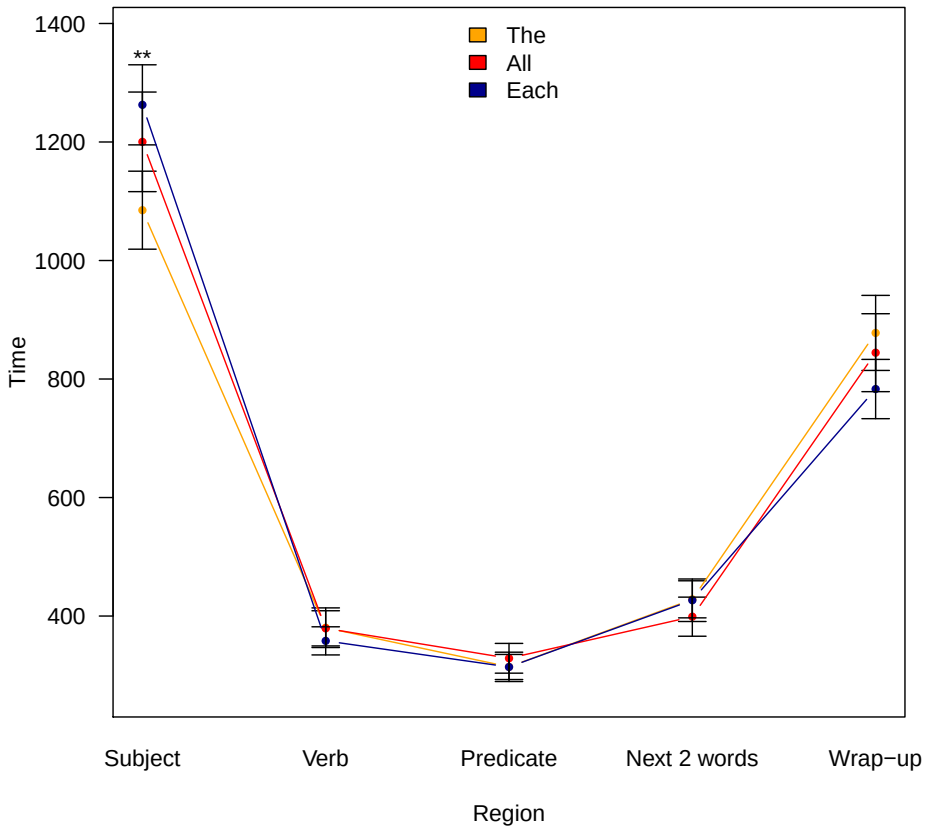
Linear model

Fixef:	Quantifier		
Ranef:	Subjects, Items		
$t = 4.2$,	$p < .001$	for **the** vs. **each** at Subj	
$t = 1.7$,	$p < .1$	for **the** vs. **all** at V	
$t = -1.8$,	$p < .1$	for **the** vs. **all** at Wrap-up	

Liz wanted/ (each of/all) the plates for the potluck party/ to be/ cheap/ because they/ can be thrown away afterwards.

Results: Total time

Distributive



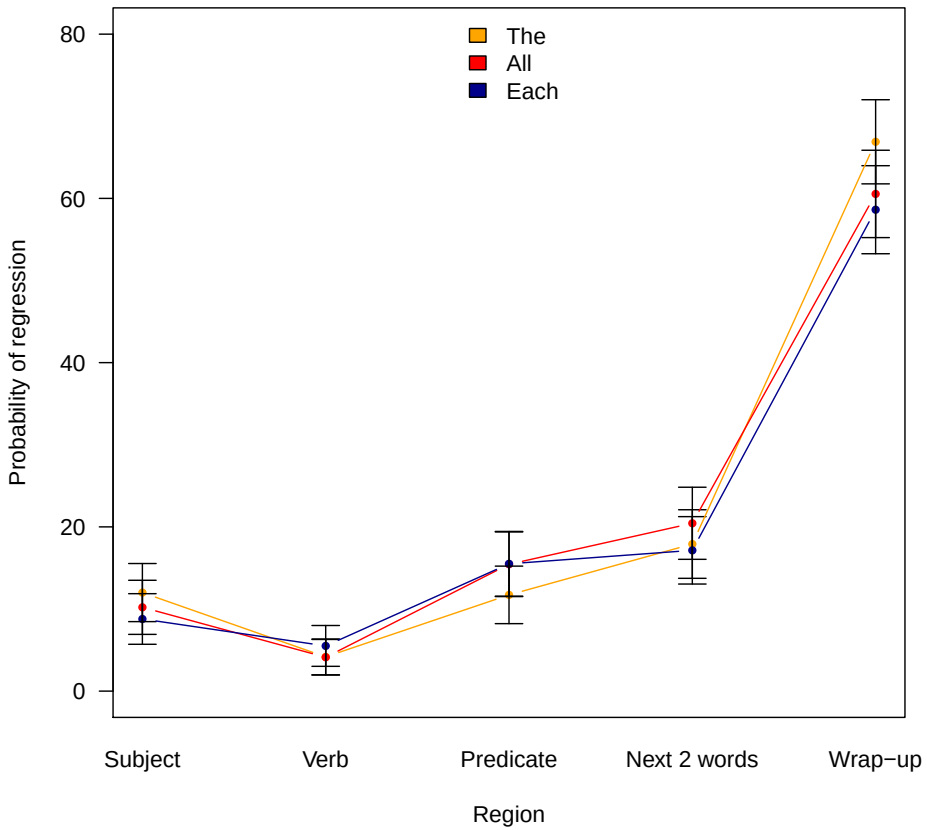
Linear model

Fixef:	Quantifier	
Ranef:	Subjects, Items	
$t = 1.7$,	$p < .1$	for **the** vs. **all** at Subj
$t = 2.8$,	$p < .01$	for **the** vs. **each** at Subj

Liz wanted/ (each of/all) the plates for the potluck party/ to be/ round/ because they/ can be cleaned easily.

Results: Regressions

Ambiguous



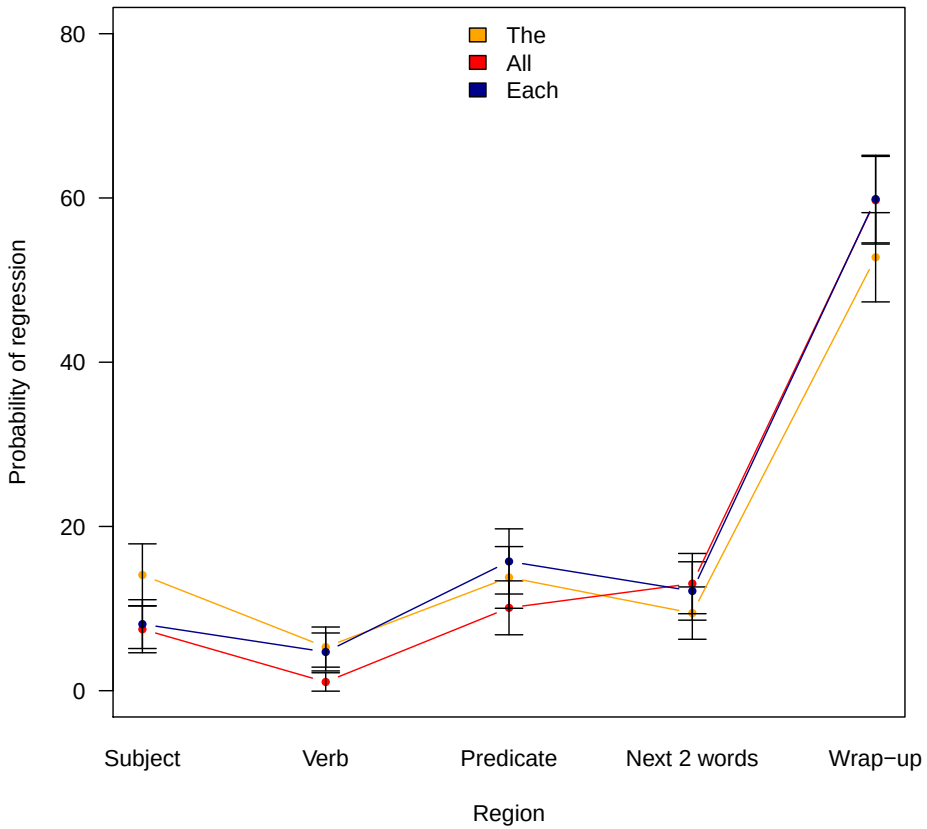
Logistic regression

Fixef: Quantifier
Ranef: Subjects, Items
No effects

Liz wanted/ (each of/all) the plates for the potluck party/ to be/ cheap/ because they/ can be thrown away afterwards.

Results: Regressions

Distributive



Logistic regression

Fixef: Quantifier
Ranef: Subjects, Items

No effects

Liz wanted/ (each of/all) the plates for the potluck party/ to be/ round/ because they/ can be cleaned easily.

Summary

No difference between **each**, **all**, **the**

- When the predicate was ambiguous
- When the predicate was distributive

Comparison: Experiment 2 a 3

1. The managers drank an espresso in the newly opened coffee shop.
2. The managers **each** drank an espresso in the newly opened coffee shop.
3. Liz wanted the plates for the potluck party to be round because they can be cleaned easily.
4. Liz wanted **each** of the plates for the potluck party to be round because they can be cleaned easily.

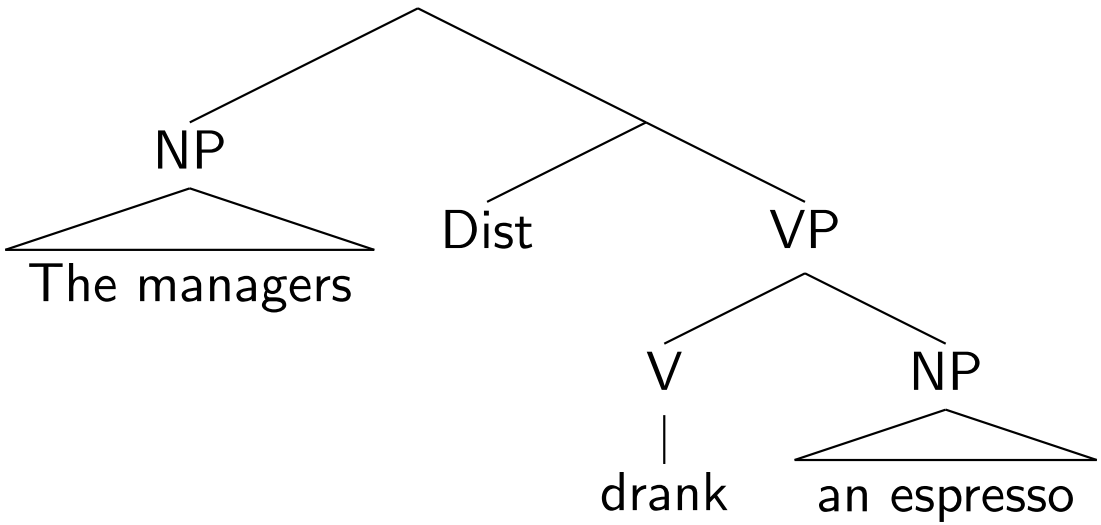
1 slowdown as compared to **2**
3 no slowdown as compared to **4**

Comparison: Experiment 2 a 3

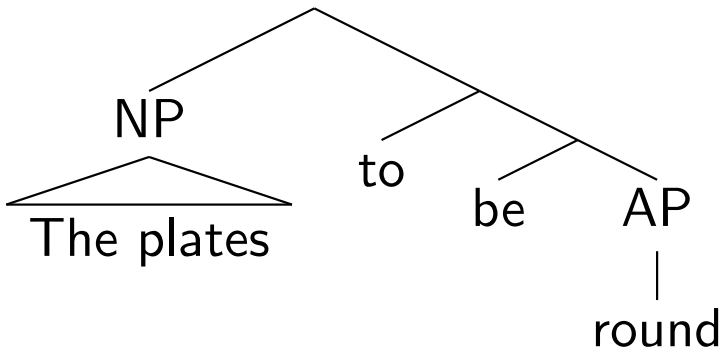
1. The managers drank an espresso in the newly opened coffee shop.
2. The managers **each** drank an espresso in the newly opened coffee shop.
3. Liz wanted the plates for the potluck party to be round because they can be cleaned easily.
4. Liz wanted **each** of the plates for the potluck party to be round because they can be cleaned easily.

1 and 2: Distributivity syntactically encoded
3 and 4: Distributivity lexically encoded

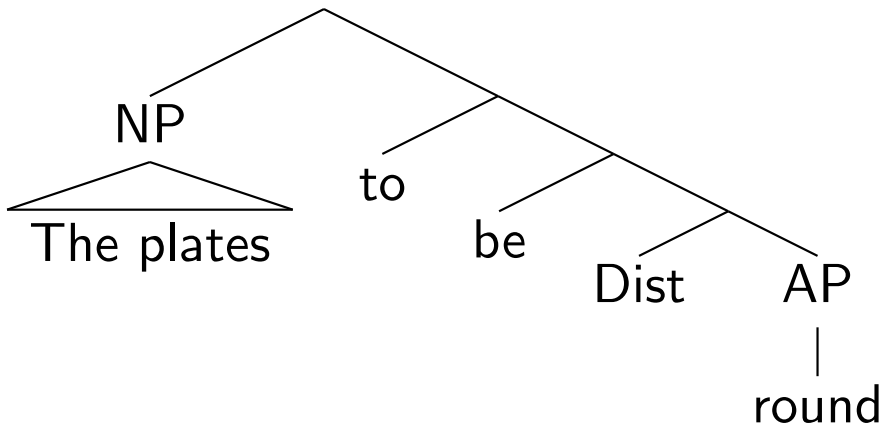
1. The managers drank an espresso...



1. The plates . . . to be round. . .



1. The plates . . . to be round. . .



No observable effect because the reanalysis is local

But see Dotlacil (2011) why this option should not be possible

Summary

- The processor interprets plural definites preferably collectively
- This forced choice signals that Dist/Coll is a matter of ambiguity (contra Schwarzschild 1996)
- The choice cannot be fully explained by pragmatic reasoning

Summary

- Observable distinction between lexical and syntactic distributivity
- Preference for syntactic collectivity
- No such preference regarding lexical Dist/Coll

Thanks!

Donka, Joseph, Megan, Milica, Nate

References

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