

Coherence and the (Psycho-) Linguistics of Pronoun Interpretation

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1

What's the Problem?

Subject Assignment (Crawley et al, 1990)

- a. George narrowly defeated John, and special interests promptly began lobbying him. [him = George]
- b. John was narrowly defeated by George, and special interests promptly began lobbying him. [him = John]
- c. George narrowly defeated John, and Mitt absolutely trounced him. [him = John]
- d. George narrowly defeated John, and he quickly demanded a recount. [he = John]

Grammatical Role Parallelism
(Kamayama, 1986; Smyth, 1994)

Reasoning/World Knowledge
(Hobbs, 1979)

2

The SMASH Approach

- ◆ Search: Collect possible referents (within some contextual window)
- ◆ Match: Filter out those referents that fail 'hard' morphosyntactic constraints (number, gender, person, binding)
- ◆ And Select using Heuristics: Select a referent based on some combination of 'soft' constraints (grammatical role, grammatical parallelism, thematic role, referential form, ...)

3

The Big Question

- ◆ Why would anybody ever use a pronoun?
 - ◆ Speaker elects to use an ambiguous expression in lieu of an unambiguous one, seemingly without hindering interpretation
 - ◆ A theory should tell us why we find evidence for different 'preferences', and why they prevail in different contextual circumstances
 - ◆ We ask: What would the discourse processing architecture have to look like to allow for a simple theory of pronoun interpretation?

4

The Case for Coherence

- ◆ The meaning of a discourse is greater than the sum of the meanings of its parts
- ◆ Hearers will generally not interpret juxtaposed statements independently:

The domestic pharmaceutical industry fears the institution of a Medicare drug benefit. They do not want to reveal the true costs of their proprietary medicines. (Explanation)

5

Hume on the Association of Ideas



“To me there appear to be only three principles of connection among ideas, namely Resemblance, Contiguity in time or place, and Cause or Effect”
(Hume, 1748)

6

Cause-Effect Relations

- ◆ “Infer P from S1 and Q from S2 presupposing that...”:
 - ◆ Result: $P \Rightarrow Q$
George is a politician, and (thus) he's dishonest.
 - ◆ Explanation: $Q \Rightarrow P$
George is dishonest, because he's a politician
 - ◆ Violated Expectation: $P \Rightarrow \sim Q$
George is a politician, but he's honest
 - ◆ Denial of Preventer: $Q \Rightarrow \sim P$
George is honest, even though he's a politician

7

Resemblance Relations

- ◆ Based on similarity and contrast under a ‘common topic’
- ◆ Parallel: Infer $P(a_1, a_2, \dots)$ from S_1 and $P(b_1, b_2, \dots)$ from S_2 for common P and similar a_i and b_i
George warned against ‘mixed messages’, and John tried to look presidential.
- ◆ Other resemblance relations:
 - ◆ Contrast
 - ◆ Generalization, Exemplification
 - ◆ Exception
 - ◆ Elaboration

8

Contiguity Relations

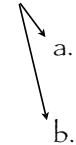
- ◆ Require that states of affairs be identified as points of connection between partial descriptions of a scenario
- ◆ Occasion: Infer a change of state for a system of entities from S2, inferring the initial state for this system from S1.

A flashy-looking campaign bus arrived in Iowa. Soon afterward, Bush gave his first speech of the primary season.
(Hobbs, 1990)

9

Our Examples Again

Contiguity



Resemblance

Cause-Effect

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10

Agenda

- ◆ Describe experiments to test the role of coherence establishment in pronoun interpretation
- ◆ These address the following 'preferences' in turn:
 - ☞ ◆ Grammatical role parallelism preference
 - ◆ Thematic role preferences
 - ◆ Implicit causality
 - ◆ Grammatical subject preference
- ◆ Work toward a coherence-based, expectation-driven model of pronoun interpretation

11

Grammatical Parallelism

- ◆ Smyth (1994), arguing against the 'subject assignment strategy of Crawley et al (1990), posits an 'Extended Feature Match Hypothesis' that says that pronouns will corefer with occupants of the same grammatical role (see also Chambers and Smyth, 1998)
- ◆ A sample passage:

Mary helped Julie change the tire and then she helped Peter change the oil

- ◆ 100% subject pronouns to subject antecedent;
- ◆ 88% object pronouns to object antecedent

12

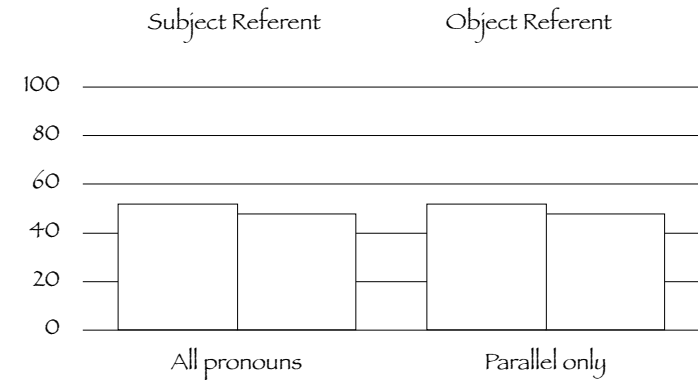
Kertz, Kehler, and Elman (CogSci 2006)

- ◆ Tested relationship between coherence, syntactic parallelism, and pronoun position
 - *John accidentally elbowed Kyle, and Zoe (deliberately) kneed him.*
 - *John accidentally elbowed Kyle, and Zoe (angrily) scolded him.*
 - *John accidentally elbowed Kyle, and he (deliberately) kneed Zoe.*
 - *John accidentally elbowed Kyle, and he (embarrassingly) dropped the cake.*

(Cause-Effect vs. Resemblance)

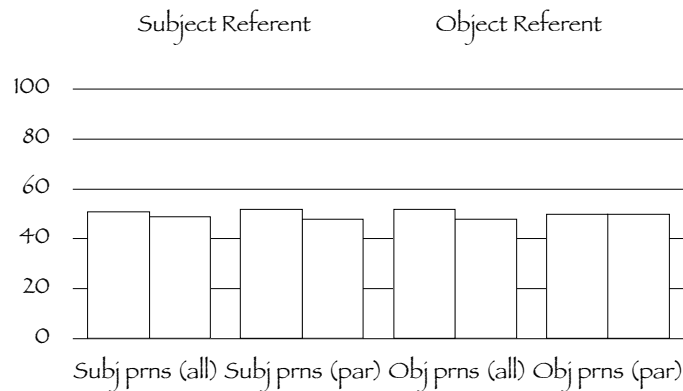
13

Subject Preference Results



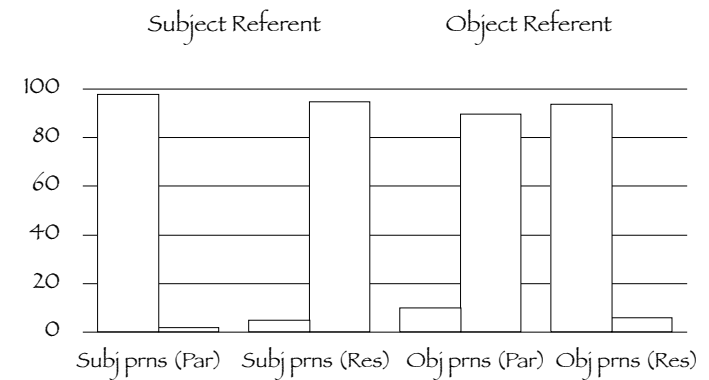
14

Parallel Role Preference Results



15

Coherence Results



16

Summary

- ◆ Results support the coherence analysis
 - ◆ Parallel syntax without Parallel coherence: No parallelism preference
 - ◆ Parallel coherence without parallel syntax: Parallelism preference
- ◆ Leads us to conclude that the contradictory results in the literature stem in part from a failure to control for coherence in stimuli

17

Explaining the Parallelism Bias

- ◆ The parallelism effect is recalcitrantly strong:

Margaret Thatcher admires Hillary Clinton, and Newt Gingrich absolutely worships her.

Margaret Thatcher admires Ronald Reagan, and Newt Gingrich absolutely worships her.

- ◆ Accent needed on the pronoun to refer to Thatcher
- ◆ Accent often regarded as a pronoun-specific strategy for accessing an otherwise nonpreferred (yet activated) referent (Smyth 1994; Kameyama, 1999; Beaver 2004)

18

Pronouns and Accent

- ◆ Problem: Accent is needed for unambiguous pronouns and proper names as well (cf. de Hoop, 2004, inter alia):

Margaret Thatcher admires Ronald Reagan, and Newt Gingrich absolutely worships HER/THATCHER/#her/#Thatcher

- ◆ Pattern: Accent is necessary for any element in a Parallel relation that is not coreferent with its parallel element
- ◆ These facts are therefore independent of any pronoun-specific strategy

19

The Parallelism Preference

- ◆ See Kehler (2005) for a detailed discussion of how different coherence relations partition the focus and background differently
- ◆ Effects are particularly clear when considering coherence-ambiguous cases:

Colin Powell defied Dick Cheney, and George Bush punished him.

- ◆ There is no work left for a grammatical role parallelism preference to do

20

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21

Rohde, Kehler, and Elman (CogSci 2006)

- ◆ Goal/Source preferences (Stevenson et al., 1994):
 - Bush seized the speech from Powell. He... [Bush]*
 - Bush passed the speech to Powell. He... [Powell]*
- ◆ Possible explanations:
 - ◆ Thematic role preferences ('superficial')
 - ◆ Focus on end states of events ('deep')
- ◆ Latter is what one would expect for Occasion relations
Occasion: Infer a change of state for a system of entities from S2, inferring the initial state for this system from S1

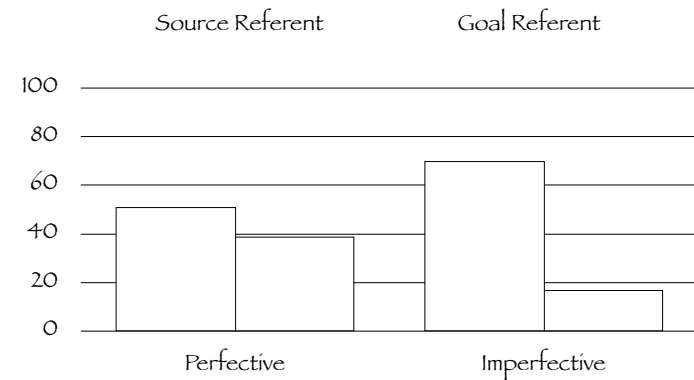
22

Rohde, Kehler, and Elman (CogSci 2006)

- ◆ Ran an experiment to distinguish these, comparing the perfective and imperfective forms for Source/Goal verbs
 - Bush passed the speech to Powell. He...*
 - Bush was passing the speech to Powell. He...*
- ◆ More references to the Source/Subject in the imperfective case would support the event structure/coherence analysis

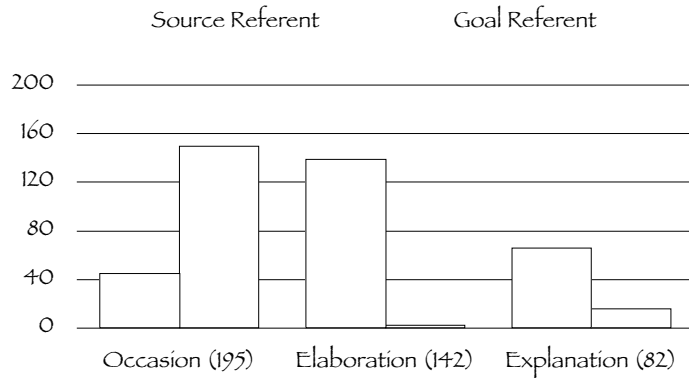
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Results



24

Breakdown by Coherence Type (Perfective Only)



25

Conditioning on Coherence

- ◆ Expectations are conditioned on coherence relations:

$$P(\text{pron}=\text{ref}) = \sum_{CR \in \{\text{Occasion, Explanation, Elaboration, ...}\}} P(CR) * P(\text{pron}=\text{ref} | CR)$$

- ◆ Different factors in the context could influence these probabilities
 - ◆ e.g., connective placement

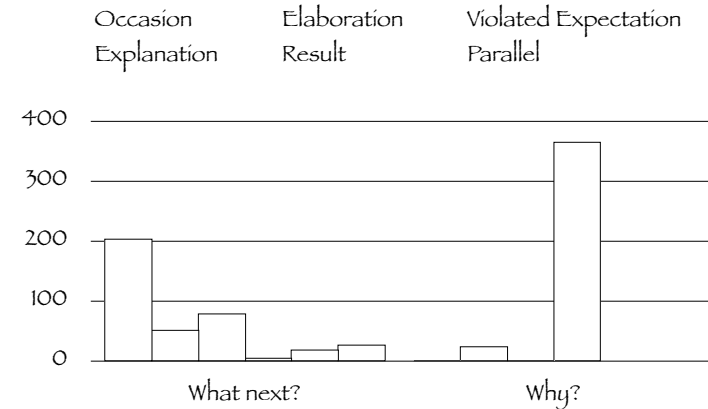
26

Rohde, Kehler, and Elman (CogSci 2007)

- ◆ If coherence matters, a shift in the distribution of coherence relations should induce a shift in the distribution of pronoun interpretations
- ◆ Run the previous experiment again, except with one difference in the instructions for how to continue the passage:
 - ◆ What happened next? (Occasion)
 - ◆ Why? (Explanation)
- ◆ Stimuli kept identical across conditions

27

Results: Coherence Distribution



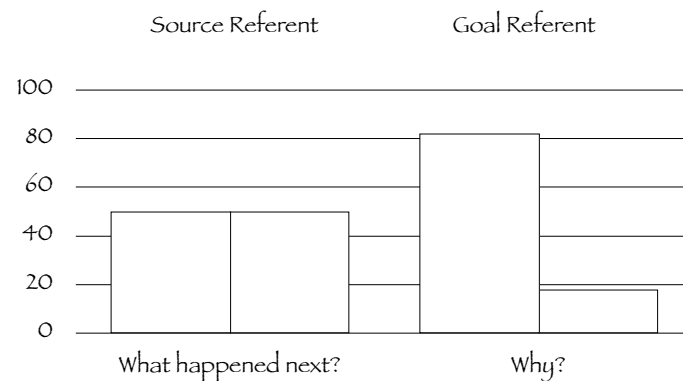
28

Pronoun Biases

<i>Coherence Relation</i>	<i>Prob(Source Coh Reln)</i> <i>1st Exp</i>	<i>Prob(Source Coh Reln)</i> <i>2nd Exp</i>
Elaboration	0.99	1.00
Explanation	0.75	0.81
Violated Exp	0.87	0.81
Occasion	0.20	0.28
Result	0.16	0.10

29

Results



30

Summary

- ◆ Thematic role biases are epiphenomena of event structure biases
- ◆ Event structure biases are epiphenomena of coherence-driven biases
- ◆ The biases that influence pronoun interpretation include:
 - ◆ Expectations about the ensuing coherence relation
 - ◆ Expectations about who will be mentioned next, conditioned on the coherence relation
- ◆ Altering the first of these will also alter pronoun interpretation biases

31

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32

Implicit Causality

- ◆ Garvey et al. (1976), Caramazza et al. (1977), inter alia
hit
Jane angered Mary because she had stolen a tennis racket
- ◆ Bias estimation using sentence completions:
Tom scolded Bill because he _____
- ◆ Reading times:
Tom scolded Bill because he was annoying/annoyed

33

IC and Coherence

- ◆ Is IC simply a microcosm of a larger system of coherence-driven preferences?
- ◆ Most studies of IC use 'because' prompts (cf. Ehrlich, 1980)
- ◆ A prediction: 'because' in these stimuli is doing nothing more than indicating an Explanation relation (contra Stevenson et al, 2000)
- ◆ If so, the effect should essentially be to drive the probability of $P(\text{CR}=\text{Explanation})$ to 1
- ◆ That is, the biases found with 'because' prompts should be the same as those for Explanations in a full-stop condition

34

Implicit Causality

- ◆ Participants completed prompts such as:
Tony disappointed Courtney. _____
Tony disappointed Courtney because _____
- ◆ Three conditions: NP1 biased, NP2 biased, and non-IC
- ◆ First mentioned entities catalogued (note that they chose the referring expressions)
- ◆ Two judges annotated coherence relations

35

Results (IC-NP1 Verbs)

	No Prompt		'Because' Prompt	
	P(CR)	P(Subj CR)	P(CR)	P(Subj CR)
Explanation	58%	0.842	100%	0.851
Result	22%	0.103	Effect of Prompt Type: p<.88 (subjects) p<.86 (items)	
Elaboration	10%	0.609		
Occasion	4%	0.056		
Total	100%	0.604		

36

Results (IC-NP2 Verbs)

	No Prompt		'Because' Prompt	
	P(CR)	P(Subj CR)	P(CR)	P(Subj CR)
Explanation	62%	0.130	100%	0.095
Result	15%	0.029	Effect of Prompt Type: p<.51 (subjects) p<.28 (items)	
Elaboration	14%	0.459		
Total	100%	0.190		

37

Results (Non-IC Verbs)

	No Prompt		'Because' Prompt	
	P(CR)	P(Subj CR)	P(CR)	P(Subj CR)
Explanation	24%	0.573	100%	0.556
Elaboration	29%	0.582	Effect of Prompt Type: p<.98 (subjects) p<.23 (items)	
Result	22%	0.244		
Violated Expectation	13%	0.402		
Occasion	9%	0.534		
Total	100%	0.475		

38

Summary

- ◆ IC effects are just one instance of a general set of coherence-driven biases in pronoun interpretation
- ◆ Study brings to light that there are actually two stronger-than-normal biases at work in IC contexts:
 - ◆ An expectation for an upcoming Explanation
 - ◆ An expectation towards a particular referent given an Explanation
- ◆ The first of these never documented since no one had categorized for coherence in their set of completions

39

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40

The Subject Preference

- Stevenson et al's (1994) study paired their pronoun-prompt condition with a no-prompt condition:

Bush passed the speech to Powell. He _____

Bush passed the speech to Powell. _____

- They found a near 50/50 split in Source vs. Goal interpretations for pronouns in the prompt condition
- But in the no-prompt condition, they found a strong tendency to use a pronoun to refer to the subject and a name to refer to the object

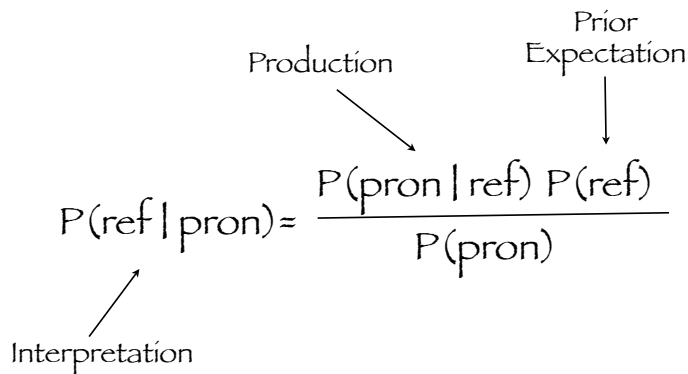
41

The Subject Preference

- The latter result was replicated by Arnold (2001), and by us
- Arnold's numbers in a no-prompt condition for Source-Goal sentences:
 - 76% of Source-subjects pronominalized
 - 20% of Goal-non-subjects pronominalized
- Why would hearers resolve pronouns to the Goal so often when they don't have a similar production bias?

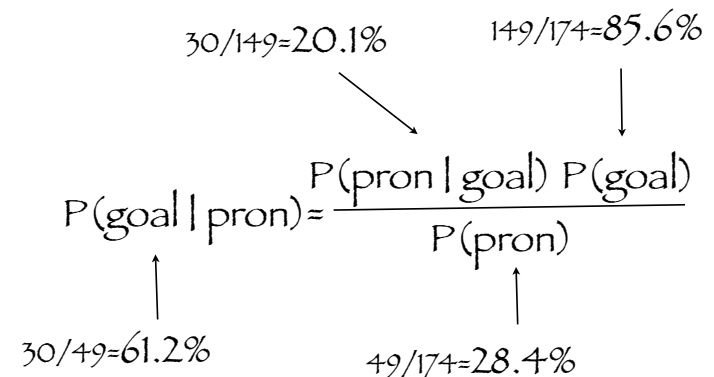
42

Bayesian Pronoun Interpretation



43

Arnold (2001)'s Data



44

The Subject Preference

- There is a subject bias for pronouns: a *production* bias
- Or perhaps a *topichood* bias, which would predict:
 - More subject references for passives than actives
 - More subject references when established as the discourse topic
 - Cross-linguistic differences for languages with stronger ways of marking the topic
- This bias has an indirect effect on interpretation
- But then again, so does referent expectation...

45

Bayesian Pronoun Interpretation

Prior
Expectation
↓

$$P(\text{ref} | \text{pron}) = \frac{P(\text{pron} | \text{ref}) P(\text{ref})}{P(\text{pron})}$$

Question: What is the potential impact of this component with respect to stimulus selection?

46

Next Mentions, Non-IC Condition

Verb Frame	P(NPI)	Verb Frame	P(NPI)
borrowed-a-bike-from	0.857	edited-an-essay-for	0.400
saw	0.722	repaired-a-bike-for	0.350
waited-to-see	0.636	watched	0.261
counted-the-money-from	0.545	went-to-visit	0.200
played-the-piano-for	0.500	read-a-funny-story-to	0.130

47

Bayesian Pronoun Interpretation

Prior
Expectation
↓

$$P(\text{ref} | \text{pron}) = \frac{P(\text{pron} | \text{ref}) P(\text{ref})}{P(\text{pron})}$$

Lesson: Next mention biases need to be controlled for before conclusions about pronoun interpretation biases can be drawn

48

Conclusion

- ◆ The coherence-driven theory of pronoun interpretation offers an explanation of why we see evidence for so-called 'preferences', and why they appear to prevail in different contextual circumstances
- ◆ The expectation-driven aspect parallels recent work at the sentence processing level (e.g., Hale 2001, Levy 2007)
- ◆ The behavior of pronouns is an important source of evidence for larger questions concerning the discourse processing architecture

49

Conclusion

- ◆ If the top-down, expectation-driven influences of coherence establishment affect pronoun interpretation, how about:
 - ◆ VP-ellipsis
 - ◆ Gapping
 - ◆ Extraction from coordinate clauses
 - ◆ Tense interpretation
 - ◆ Focus marking and accent placement
- ◆ Child language acquisition; language impairments

50

Eliminating Myths

- ◆ There are basic preferences for pronoun antecedents that occupy
 - ◆ a parallel grammatical role
 - ◆ certain thematic roles
 - ◆ implicit causality positions
 - ◆ subject/topic position (but there is a production bias)
- ◆ Accented pronouns are special
- ◆ Psycholinguistic studies need not control for the operative coherence relations nor next mention biases in their stimuli

51

Thank you!

52