

Experimental evidence for the status of the Right-Frontier Constraint

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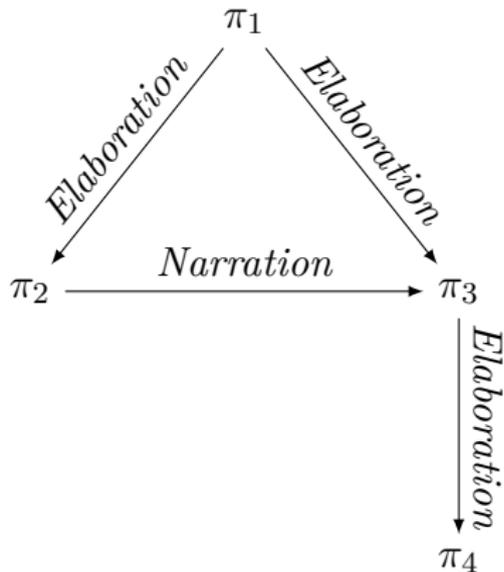
DETEC
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- How do speech participants track discourse?

(a) Linear updates

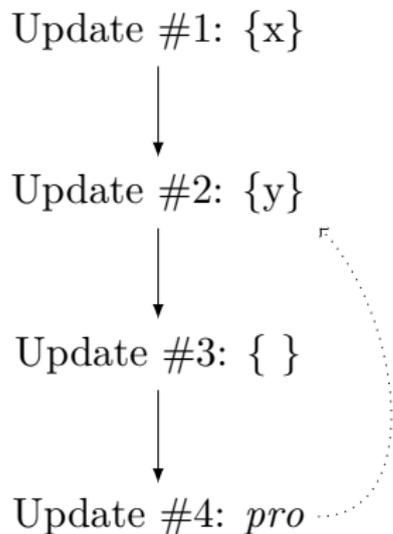


(b) Hierarchy of discourse relations

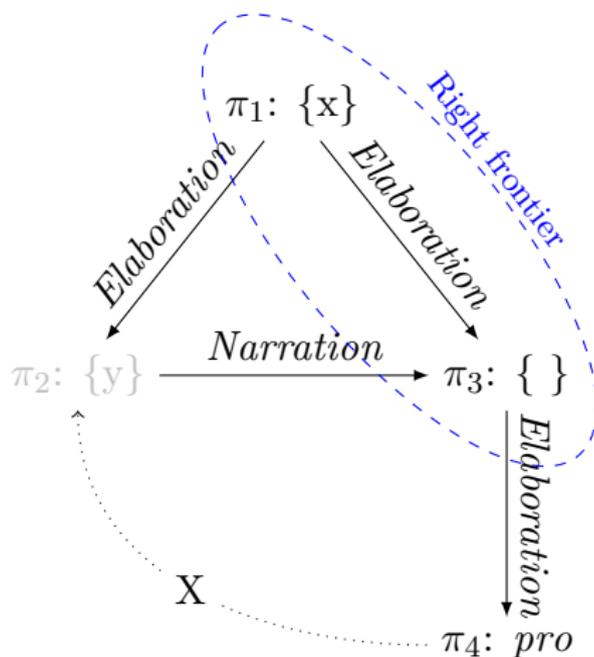


- What is the set of potentially accessible referents in a discourse?

(a) Linear closeness



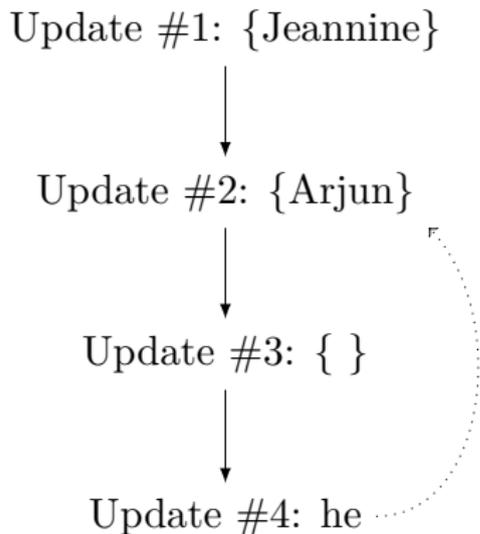
(b) Right-Frontier Constraint



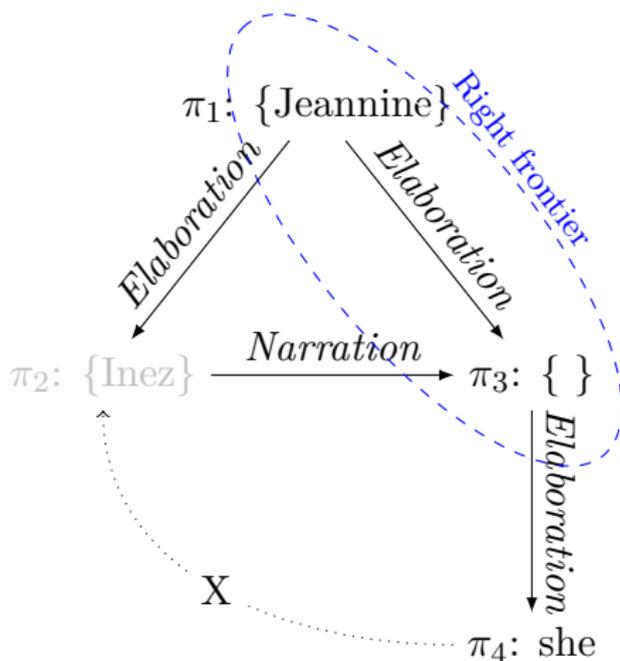
- This paper finds that English pronouns have two search algorithms, determined by the presence or absence of competition between possible antecedents
 - No antecedent competition: Linear closeness
 - Antecedent competition: Right-Frontier Constraint
- This adds to existing evidence that the RFC is connected to the presence of antecedent competition (Holler & Irmen 2007)

Figure: English pronoun search algorithms and antecedent competition

(a) Linear closeness



(b) Right-Frontier Constraint



Outline

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- The status of the RFC
- How to test the RFC

2 Experiment 1: Pronoun vs. Full NP

- Methodology
- Results

3 Experiment 2: Antecedent choice

- Methodology
- Results

4 Conclusion

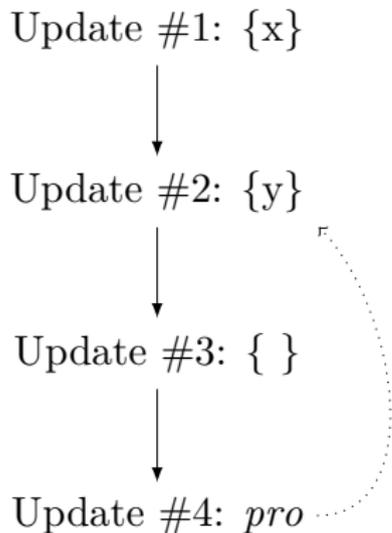
- The coexistence of Linear Closeness and the RFC

Right-Frontier Constraint (RFC)

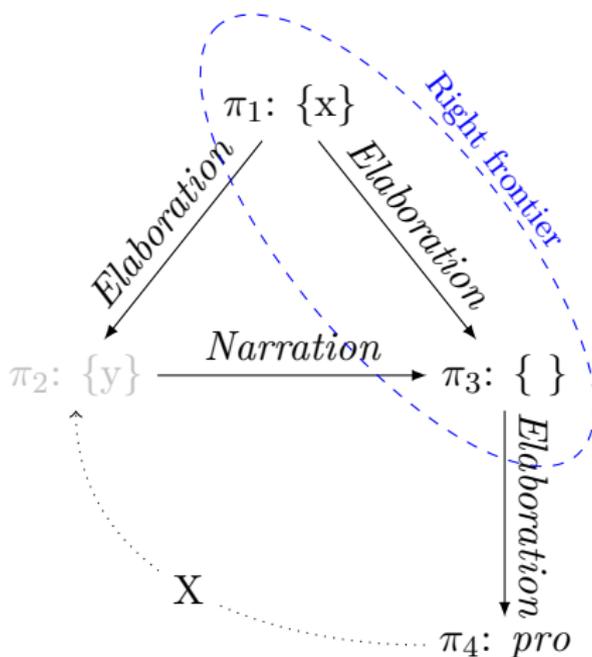
- The RFC holds that antecedents are accessible if they are along the right edge of a discourse tree, relative to the anaphor's attachment point
(cf. Polanyi 1985, 1988; Webber 1988)
- Also, the set of possible attachment points on a discourse tree
- Assuming that discourse is represented as a directed graph of discourse relations, with subordinating relations denoted by top-down arrows, and coordinating relations as left-right
(e.g. Grosz & Sidner 1986; Asher & Lascarides 2003; Asher & Vieu 2005)
 - Similar to the “left-and-up rule” (Kamp & Reyle 1993), superficially similar to c-command (Zeldes 2018: 167),
cf. also Veins Theory in Rhetorical Structure Theory
(Cristea, Ide & Romary 1998)

- What is the set of potentially accessible referents in a discourse?

(a) Linear closeness



(b) Right-Frontier Constraint



The status of the RFC

- The RFC has been argued to be a built-in constraint on anaphora (e.g. Webber 1988 on demonstratives; Zeldes 2017 on bridging)
- It has been supported by some corpus analyses (Cristea, Ide & Romary 1998 on Veins Theory; Afantenos & Asher 2010 on the RFC)
- Propositional anaphora in particular obey the RFC (Webber 1988, Asher 1993: 256)

The status of the RFC: Propositional anaphora

- (1) a. *After thirty-eight months, America is back in space.* The shuttle Discovery roared off the pad from Cape Kennedy at 10:38 this morning. The craft and crew performed flawlessly. *Later in the day the TDRS shuttle communications satellite was successfully deployed.* **This** has given a much needed boost in NASA morale.
- b. The shuttle Discovery roared off the pad from Cape Kennedy at 10:38 this morning. The craft and crew performed flawlessly. Later in the day the TDRS shuttle communications satellite was successfully deployed. *After thirty-eight months, America is back in space.* **This** has given a much needed boost in NASA morale. (Asher 1993: 259)

The status of the RFC

- Other corpus studies have suggested it is violable or even detrimental to real-world anaphora resolution in many genres (Tetreault & Allen 2003; Chiarcos & Krasavina 2008)
- Corpus and experimental evidence suggest the RFC may be conditional or one of multiple factors, especially in discourse (Sassen & Kühnlein 2005; Zeldes 2018; Hunter et al. 2017)
- Holler & Irmen (2007) specifically argue that the RFC only applies under antecedent competition in German
 - In contexts like (2a), there is no antecedent competition, and participants judged *she* to refer to *student(F)*, regardless of the RFC
 - In contexts like (2b), there is competition, and participants judged the reference of *she* largely according to the RFC

The status of the RFC

- (2) a. In the morning **the student(F)** went to the university because it was time to attend the lecture on advantages and disadvantages of Kant's categorical imperative. The lecture hall was busy. **The fellow student(M)** however was in the library because it was quiet there. In the afternoon **she** still had many things to do.
- b. In the morning **the student(F)** went to the university because it was time to attend the lecture on advantages and disadvantages of Kant's categorical imperative. The lecture hall was busy. **The fellow student(F)** however was in the library because it was quiet there. In the afternoon **she** still had many things to do. (Holler & Irmen 2007: 21)

How to test the RFC

- In this paper, we test the interaction of antecedent competition, Linear Closeness, and the RFC
- However, there are difficulties in testing this interaction through interpretation questions and fill-in-the-blank tasks
 - The pronoun in (3c) might be trivially interpreted as referring to *Jeannine* in an experimental context
 - Similarly, a sentence starting with the pronoun (3c') might be filled in with reference to *Jeannine* depending on the participants' understanding of the limitations of the task

- (3)
- a. ...Jeannine ...
 - b. ...Arjun ...
 - c. ...she ...
 - c'. She _____.

How to test the RFC

- To circumvent these possible issues, we performed two experiments
 - In Experiment 1, participants were asked to make a binary choice between a pronoun and a coreferential full NP in a context where their reference was made clear
- A crucial assumption being that full NPs are more capable of violating the RFC than pronouns (Asher 2008)
- In Experiment 2, participants were asked to fill in blanks as a sanity check to test the contexts in question

- (4)
- a. ... Jeannine ...
 - b. ... Arjun ...
 - c. Experiment #1: ... she/Jeannine ...
 - c'. Experiment #2: She _____.

Experiment 1: Pronoun vs. Full NP

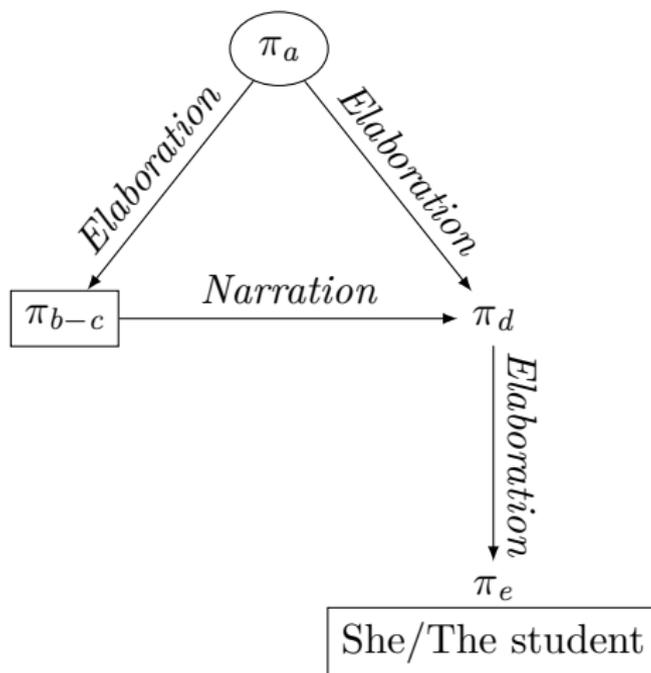
Methodology: Components of discourse context

- Five sentence structure with two human referents (*Jeannine*, circled throughout, *student*, boxed throughout)
- Target referents all grammatical subjects
- Intended grammatical gender indicated by coreferential pronoun (*her old high school, she needed help...*)
- Context intended to disambiguate referents in (e)
- Cue phrases used to enforce Narration relation between (b) and (c)

- (5)
- Jeannine* likes tutoring at her old high school.
 - Last week, *a student* was really struggling in history class.
 - She needed help memorizing dates.
 - This week, there was a big exam.
 - She/The student* got into Harvard!

Methodology: Components of discourse context

Figure: Intended discourse structure for (5)



Methodology: Predictions

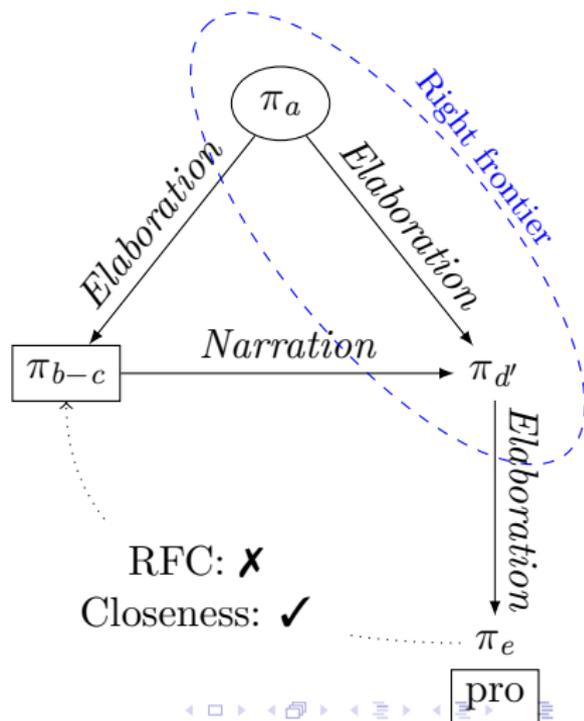
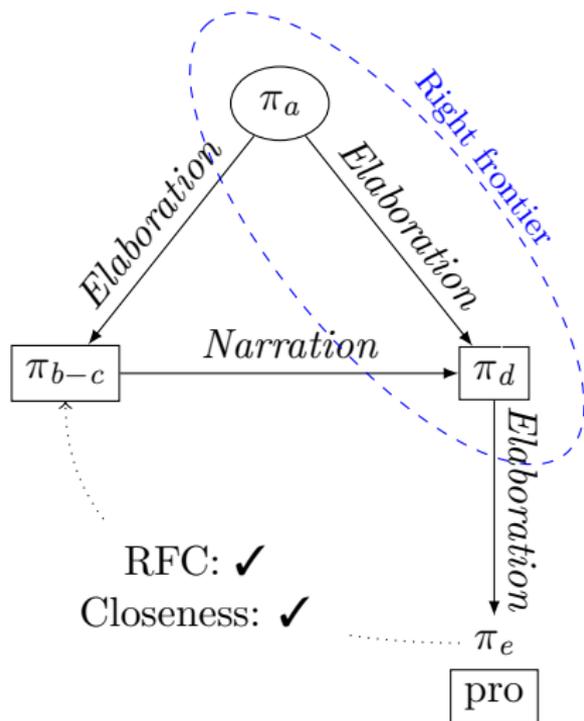
- (6)
- a. Jeannine likes tutoring at her old high school.
 - b. Last week, a student was really struggling in history class.
 - c. She needed help memorizing dates.
 - d. This week, the student had a big exam.
 - d'. This week, there was a big exam.
 - e. She/The student got into Harvard!
- Linear closeness:
 - Pronoun can refer to *student*, regardless of (d) or (d')
 - Right-frontier constraint:
 - Pronoun can only refer to *student*, given (d), not (d')
 - Both predict that a pronoun can refer to Jeannine

Methodology: Predictions

Figure: Predictions for (6)

(a) student mentioned in (b) and (d)

(b) student mentioned only in (b)



Methodology: Factors

- Previous mention: Was the referent mentioned in (b) or (b)+(d)?
(only in (b) = ✗RFC; in (b)+(d) = ✓RFC)
- Competition: Do the two human referents **match** or **mismatch** in terms of intended grammatical gender?
- Prompts varied intended referent (*Jeannine* , *student*)

Methodology: Experimental design

- Using Amazon Mechanical Turk, 50 participants from the US/Canada were trained to read stories and perform a binary choice task to fill in blanks
- Each participant performed 6 tasks + 2 fillers
 - During beta testing, participants reported fatigue after 20–30 minutes of the task
 - mTurkers self-reported high levels of satisfaction with shorter design
- Participants were vetted on English fluency and were eliminated if they failed to complete gatekeeping tasks
- Fillers were put in place to as a distractor to avoid participant detection of experiment focus

Methodology: Experimental design

- If participants chose the pronoun she, a comprehension question asked which referent they intended the pronoun to refer to (Success rate: >95%)

- (7)
- a. Jeannine likes tutoring at her old high school.
 - b. Last week, a student was really struggling in history class.
 - c. She needed help memorizing dates.
 - d. This week, there was a big exam.
 - e. _____ was proud to have helped.
(Forced choice: She / Jeannine)

Who does “She” refer to?

Jeannine/The student/Someone else/I don't know

Results for *student*

- When the blank referred to *student* (the linearly closer antecedent), the results were split based on competition
- In **the mismatch condition (no competition)**, pronouns were chosen about 60% of the time regardless of the RFC
 - This is predicted by Linear Closeness, but explicitly not by the RFC
- In the **match condition**, pronouns were chosen largely only if *student* is introduced in (1d) (77% vs 20%)
 - This is predicted by the RFC, but not by Linear Closeness

Figure: Anaphor choice and *student*

	Match,(b)	Match,(b)+(d)	Mismatch, (b)+(d)	Mismatch, (b)
Pronoun	4	20	16	14
Full NP	16	6	10	9

Results for *Jeannine*

- When the blank referred to Jeannine (the linearly further antecedent), participants almost never chose pronouns (3%)
- The existence of antecedent competition and whether the other antecedent was on the right frontier had no effect
- We leave this issue open for further research

Figure: Anaphor choice and *Jeannine*

	Match,(b)	Match,(b)+(d)	Mismatch, (b)	Mismatch, (b)+(d)
Pronoun	0	0	3	0
Full NP	27	25	18	22

Experiment 2: Antecedent choice

Methodology: Factors

- Identical discourse contexts from Experiment 1
- Participants instructed to fill in sentence, starting with *She*
- Intended referent: Which referent is the pronoun intended to refer to? (*Jeannine*, *student*)
- Previous mention: Was the referent mentioned in (b) or (b)+(d)? (i.e. is it on the right-frontier)
- Only contexts with competition included

- (8)
- a. Jeannine likes tutoring at her old high school.
 - b. Last week, a student was really struggling in history class.
 - c. She needed help memorizing dates.
 - d. This week, there was a big exam.
 - e. She _____.

Methodology: Experimental design

- Using Amazon Mechanical Turk, 20 vetted participants from the US/Canada were trained to read stories and undergo a production task to interpret a pronoun with competition
- Each participant performed 8 tasks + 2 fillers
- Participants were vetted on English fluency and were eliminated if they failed to complete gatekeeping tasks
- The resulting sentences were annotated by two independent annotators for the reference of the pronoun
 - Inter-annotator agreement: 99% (118/120)
 - In many cases, the sentences had explicit cues to the pronoun's reference (e.g. *She thanked Jeannine*)

Results

- In the mismatch condition, *she* referred to the linearly closest referent, student, 88% of the time
- In the match condition, this bias was significantly reduced, albeit not flipped as in Experiment #1

Figure: Referent choice and RFC accessibility

	Match,(b)	Match,(b)+(d)
Jeannine	36%	12%
student	64%	88%

Figure: t-Test output in R

	Match (1b)	Match (1d)
Jeaninne	36%	12%
The Student	64%	88%

t-Test: Two-Sample Assuming Unequal Variances

	<i>Variable 1</i>	<i>Variable 2</i>
Mean	0.358730159	0.12467532
Variance	0.076449148	0.01875246
Observations	7	7
Hypothesized Mean I	0	
df	9	
t Stat	2.006986703	
P(T<=t) one-tail	0.037847561	
t Critical one-tail	1.833112933	
P(T<=t) two-tail	0.075695123	
t Critical two-tail	2.262157163	

Conclusion

- Corroborating evidence that the RFC arises in instances of antecedent competition (Holler & Irmen 2007)
 - Different target referent (i.e. the second antecedent)
 - Different methodology (binary choice)
- Why would this interaction exist?
 - Linear Closeness \sim Economy
 - RFC \sim Avoid Ambiguity/Maximize Discourse Coherence
 - Antecedent competition creates ambiguity
(cf. Rohde & Kehler 2014 on pronouns and antecedent competition)

- This could help explain why propositional anaphora and the RFC
 - Multi-sentence discourses introduce competing propositions

(9) After thirty-eight months, America is back in space.

The shuttle Discovery roared off the pad from Cape Kennedy at 10:30

The craft and crew performed flawlessly.

Later in the day the TDRS shuttle communications satellite was successfully

This has given a much needed boost in NASA morale.

Further research

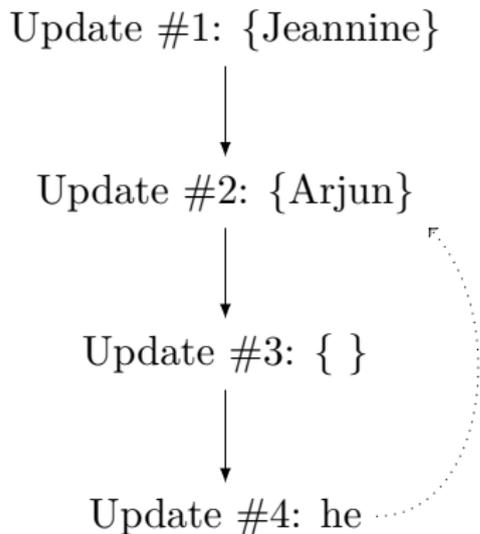
- Similar experiments with a larger sample size and greater range of example contexts
- Experiments isolating the interactions between the RFC, different factors, and other search algorithms (e.g. Linear Closeness)
- Complementary corpus work with naturalistic examples
- Theoretical work on how these factors and algorithms can coexist

The RFC and Linear Closeness

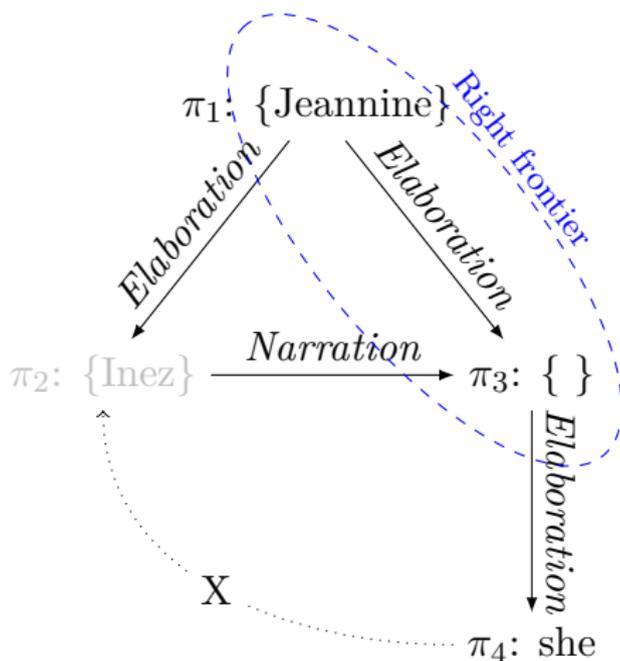
- How can the RFC and Linear Closeness coexist?
- Option 1: They are two competing factors or constraints
 - This would entail that the RFC is not a deep fact about discourse structure that affects discourse expectations
 - Instead, it is a retroactive search algorithm
- Option 2: Speech participants track discourse simultaneously in two ways
 - As a linear string of updates → Linear Closeness
 - As a hierarchy of discourse relations → RFC
 - This permits the RFC to be a deep fact about hierarchical discourse structure and shape discourse expectations

Figure: English pronoun search algorithms and antecedent competition

(a) Linear closeness



(b) Right-Frontier Constraint



The RFC and Linear Closeness

- Perhaps pronouns search one space and/or the other, and this is subject to cross-linguistic variation
- Perhaps there are other purely linear or hierarchical constraints
 - Baclawski Jr (forthcoming) on old information topic as a linear constraint, but *discourse connectedness* as a hierarchical constraint
 - In Eastern Cham (Austronesian: Vietnam), a phrase can be dislocated to the left edge of CP or DP only if it is anaphoric to a referent in a superordinate sentence (cf. also López 2009 on Catalan)

Thank you!

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