The Complexity of Binding in English and ASL

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The Talk in a Nutshell

- Computational considerations lead us to posit a new, descriptive universal of syntactic binding:

Limited Obviation (Simplified Version)

For every binding domain, its syntactically bound pronouns need at most a total of n antecedents to yield a grammatical reading.

- English obeys **Limited Obviation**.
- ASL seems to violate **Limited Obviation**.
- We argue that apparent counterexamples in ASL do not involve syntactic binding but discourse binding. Hence they have no bearing on **Limited Obviation**.

What we do not Talk About

- Reflexives
- Specific binding theories (any approach is fine)

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1. Computational Motivation
   - Technical Assumptions
   - Binding as a Computational Problem
2. Limited Obviation Defined and Explained
   - Definition
   - Empirical Predictions
3. English Data
4. Why ASL is no Counterexample

Technical Assumptions

- **Assumption 1: Syntactic Binding $\neq$ Discourse Binding**
  if not indicated otherwise, we mean syntactic binding
  $\Rightarrow$ every pronoun supposedly needs a syntactic antecedent
- **Assumption 2: (Strongly) Index-Free Binding**
  there are no indices in syntax (cf. Chomsky 1995)
  $\Rightarrow$ syntax tests for availability of some grammatical reading, does not evaluate grammaticality of specific readings

Example

(1) a. * Every patient said that he should sedate him.

b. Every patient told some doctor that he should sedate him.

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Computing the Satisfiability of Principle B

Satisfiability of Principle B is equivalent to the following:

The Checkbook Version of Principle B

- There are **obviation domains** and **possible antecedents**.
- Obviation domains incur one point of **debt** for each syntactically bound pronoun satisfying certain conditions.
- The entire **debt** must be "paid off" by **antecedents**.

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(2) a. * **Every patient** said that **he** should sedate **him**.

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The Computational Difficulty of the Checkbook Problem

Determining whether the debt has been fully paid off requires unlimited counting capabilities.

An Important Note on the Computational Difficulty

The difficulty of the task is an inherent property of the distribution of bound pronouns. It is independent of the algorithm we use to compute it and cannot be lowered without changing the task itself.

A Physics Analogy

Bringing an object in motion to a full stop means reducing its kinetic energy to (almost) 0.
This can be accomplished in various ways, but in every case the same amount of kinetic energy needs to be converted.

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The Computational Limits of Minimalist Syntax

- The computational requirements of Minimalist syntax (in the sense of Stabler 1997) without syntactic binding conditions are very well understood (Michaelis 2001; Kobele et al. 2007; Kobele 2011; Graf 2011a,b).
- In particular, unlimited counting is not required.
- Conceptually, then, it would be neat if syntactic binding did not need unlimited counting, either.
- Minimalist syntax does need bounded counting, though.
- So what if we restrict the Checkbook task to make it computable with bounded counting? Is that empirically feasible?
  - if yes: we have an upper bound on what binding is capable of
  - if no: even the restricted binding problem considered here is significantly harder than the majority of syntax

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Defining Limited Obviation

Limited Obviation (Simplified Version)

For every binding domain, its syntactically bound pronouns need at most a total of n antecedents to yield a grammatical reading.

Limited Obviation (Checkbook Version)

No obviation domain's debt exceeds some fixed value n.

So, what does that mean?

If an obviation domain contains more than n bound pronouns, those additional pronouns can be coreferent with pronouns in the same obviation domain.

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How would one Falsify Limited Obviation?

- All binding proposals agree that there is some domain within which pronouns may not be syntactically bound ≈ obviation domain
- All proposals agree that the size of the obviation domain is no larger than a single CP, and possibly smaller than that.
- Within a single CP, there are three ways of introducing an unbounded number of pronominal DPs:
  - adjuncts
  - nested TPs/*v*Ps, VPs, and DPs
  - coordination
- **Limited Obviation** is violated only if the pronouns in these configurations all obviate each other (because each pronoun would add another point of debt).

How Limited Obviation Could be Rescued

- **Limited Obviation** won't be violated if pronouns show special behavior in these constructions.
- There are three ways of preserving **Limited Obviation**:
  - allowing pronouns to be non-obviative
    (since **Limited Obviation** is specific to obviation)
  - establishing a new obviation domain
    (since obviation is relativized to obviation domains)
  - blocking pronouns in these constructions
    (since **Limited Obviation** only cares about pronouns)

Adjuncts

Pronouns contained by adjuncts usually lack obviation.

(3) Every/No/Some woman put the box down in front of her.

But even when obviation can be observed, pronouns contained by distinct adjuncts do not obviate each other.

(4) a. * Every/No/Some priest sacrificed a goat for him.

b. Every/No/Some Egyptian god asked of some priest that he sacrifice a goat for him in honor of him.

Hence adjuncts increase the debt of an obviation domain only by a limited amount.

Nested TPs/VPs

- *Nested TPs/vPs*
  In English, TPs establish new obviation domains
  (although overlap is possible for Spec,TP).

  (5) a. * Every/No/Some patient said that he wants him to sedate him.

  b. Every/No/Some patient told some doctor that he wants him to convince to him to sedate him.

- *Nested VPs*
  Nested VPs, if they exist at all in English, behave like nested TPs.

  (6) a. * Every/No/Some patient said that he made him operate on him.

  b. Every/No/Some doctor told some patient that he made him watch him operate on him.

Nested DPs with Possessors

Depending on your choice of binding theory,
one of the two holds:

- possessed DPs establish a new obviation domain
- pronouns inside possessed DPs are not obviative

Either way **Limited Obviation** is satisfied.

(7) a. Every/No/Some politician liked the photographer's picture of him.

b. Every/No/Some politician complained about [the reporter's article on him and [the photographer's picture of him]].

Nested DPs without Possessors

There is no obviation effect with non-possessed DPs.

(8) a. Every/No/Some post-modern artist must paint at least one [picture of [him and a picture of him]].

b. Every/No/Some client wanted to see a [presentation of [a presentation to him] to him].

Coordination

Coordination involving bound pronouns is ungrammatical if the two pronouns are identical.

(9) a. Every/No/Some football player told every/no/some cheerleader that the coach wants to see him and her in the office.

b. * Every/No/Some football player told every/no/some masseur that the coach wants to see him and him in the office.

Since every language has only a finite number of distinct pronouns, coordination can only introduce a bounded number of pronouns that obviate each other.

Interim Summary

- Limited Obviation predicts that if an obviation domain contains more than a fixed number of pronouns, those additional pronouns can be coreferent with other pronouns in the same domain.
- This claim can be falsified only by constructions that may introduce an unbounded number of pronouns:
  - Adjuncts
  - Nested TPs/*v*Ps/VPs/DPs
  - Coordination
- We saw that
  - a new obviation domain is established, or
  - pronouns do not show (mutual) obviation effects, or
  - introducing an unbounded number of pronouns is blocked.
- Consequently, English provides no counterexample to **Limited Obviation**.

A Counterexample in ASL?

Coordination of bound pronouns is grammatical in ASL.

(10) ALL_i WRESTLER_i INFORM_j SOMEONE_j SWIMMER_j THAT $\text{IX}_{i/j}$ $\text{IX}_{j/i}$ WILL RIDE-IN-VEHICLE LIMO GO-TO DANCE
Every wrestler$_i$ told some swimmer$_j$ that him$_{i/j}$ and him$_{j/i}$ would ride in a limo to the dance.

(11) EACH_i WRESTLER_i TELL_j SOMEONE_j SWIMMER_j THAT SOMEONE_k FOOTBALL_k PLAYER_k ASK CAN IX_i IX_j IX_k THREE-HUMANS-GO-TO DANCE (TOGETHER)
Each wrestler$_i$ told some swimmer$_j$ that some football player$_k$ asked if him$_i$ and him$_j$ and him$_k$ could go to the dance together.

Binding in ASL

- Every DP can be assigned a locus in space.
- Pronominal binding is realized by pointing at the locus which a DP has been assigned to (transcribed as IX).

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The Role of Deixis

Pointing at referents in space resembles deictic pronouns in English. And deictic pronouns can easily be coordinated.

(12) Every/No/Some football player told every/some/no masseur that the coach wants to see him$_{deictic}$ and him$_{deictic}$ in his office.

Since **Limited Obviation** only applies to syntactic binding, (12) does not constitute a counterexample.

The Big Question

Are the coordinated pronouns in ASL syntactically bound?

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Lack of Structural Sensitivity

Syntactic binding is subject to structural constraints (c-command/sub-command) which do not seem to hold for (coordinated) pronouns in ASL.

(13) EACH $_{\text{i}}$BOY POSS$_{\text{i,pl-dist}}$ MOTHER LOVE IX$_{\text{i,(pl-dist)}}$
Each boy$_i$'s mother loves him$_i$.

(14) ALL$_{\text{i}}$ WRESTLER$_{\text{i}}$ WITH SOMEONE$_{\text{j}}$ SWIMMER$_{\text{j}}$ GO-TO$_{\text{i/j}}$ POSS$_{\text{i/j}}$ HOUSE
Every wrestler$_i$ and some swimmer$_j$ went to his$_{i/j}$ house.

(15) EACH $_{\text{i}}$BOY IX$_1$ $_1$GIFT$_{\text{i,pl-dist}}$ PRESENT THEN IX$_{\text{i,pl-dist}}$ HAPPY
I gave a present to each boy$_i$ and then he$_i$ was happy.

Non-empty Domain Restrictions

While pronouns can be discourse-bound by quantifiers in English, the extension of the quantified DP must be non-empty.

(16) a. Every player is handed a card. He then has to role a dice.

b. # No player is handed a card. He then has to role a dice.

A similar pattern emerges for pronouns in ASL.

(17) EACH POLITICS $_{i}$PERSON TELL-STORY (IX$_{i}$) WANT WIN
Each politician$_i$ said he$_i$ wants to win.

(18) NO POLITICS $_{i}$PERSON TELL-STORY (?*IX$_{i}$) WANT WIN
No politician$_i$ said he$_i$ wants to win.

Converging Evidence from the Literature

Several recent findings in the literature indicate that the modality difference between spoken and signed languages affects binding.

1. Pronominals bound by non-indefinite quantifiers in French Sign Language (and ASL) behave like donkey anaphora (Schlenker 2011).

(19) EACH-TIME $_{a}$LINGUIST $_{b}$PSYCHOLOGIST ALL-THREE$_{b,a,1}$ TOGETHER WORK, IX$_{a}$ HAPPY BUT IX$_{b}$ HAPPY NOT
Whenever I work with a linguist and a psychologist, the linguist is happy but the psychologist is not happy.

Converging Evidence from the Literature [cont.]

2. Pronouns in ASL allow complement set anaphora interpretations with negative quantifiers (Schlenker 2012).

(20) POSS_1 STUDENT $\text{IX}_{\text{arc-ab}}$ FEW $\text{IX}_{\text{arc-ab}}$ $\text{IX}_{\text{arc-a}}$ $_{\text{a}}$CAME. $\text{IX}_{\text{arc-b}}$ $_{\text{b}}$STAY HOME
Few of my students came to class. They [= the students who didn't come] stayed home.

3. In Russian Sign Language, pronouns with non-quantified antecedents show no obviation effects (Rudnev and Kimmelman 2011).

(21) a. BOY IX_{a} PAINT IX_{a}
The boy paints himself.

b. BOY IX_{a} PAINT SEBA
The boy paints himself.

Conclusion

- Motivated by computational considerations, we conjecture that pronominal binding is restricted by **Limited Obviation**.
- This condition makes a testable empirical prediction:
  if the number of syntactically bound pronouns of an obviation domain exceeds some threshold n, some of them lose their obviation requirement.
- This behavior is observed in English.
- Counterexamples in ASL do not look like syntactic binding.
- If our evaluation is on the right track, then syntactic binding in English and ASL is equally complex in so far as neither increases the computational requirements of Minimalist syntax.
  However, they do differ with respect to non-syntactic binding.

Thanks!

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References I

Chomsky, Noam. 1995. *The minimalist program*. Cambridge, Mass.: MIT Press.

Graf, Thomas. 2011a. Closure properties of minimalist derivation tree languages. In *LACL 2011*, ed. Sylvain Pogodalla and Jean-Philippe Prost, volume 6736 of *Lecture Notes in Artificial Intelligence*, 96–111.

Graf, Thomas. 2011b. Locality and the complexity of minimalist derivation tree languages. In *Proceedings of the 16th Conference on Formal Grammar*. To appear.

Kobele, Gregory M. 2011. Minimalist tree languages are closed under intersection with recognizable tree languages. In *LACL 2011*, ed. Sylvain Pogodalla and Jean-Philippe Prost, volume 6736 of *Lecture Notes in Artificial Intelligence*, 129–144.

Kobele, Gregory M., Christian Retoré, and Sylvain Salvati. 2007. An automata-theoretic approach to minimalism. In *Model Theoretic Syntax at 10*, ed. James Rogers and Stephan Kepser, 71–80.

Michaelis, Jens. 2001. Transforming linear context-free rewriting systems into minimalist grammars. *Lecture Notes in Artificial Intelligence* 2099:228–244.

References II

Rudnev, Pavel, and Vadim Kimmelman. 2011. Breaking the coreference rule: Reflexivity in Russian Sign Language. Submitted to Semantics & Pragmatics.

Schlenker, Philippe. 2011. Donkey anaphora: The view from sign language (ASL and LSF). To appear in Linguistics & Philosophy.

Schlenker, Philippe. 2012. Complement set anaphora and structural iconicity in asl. To appear in Snippets.

Stabler, Edward P. 1997. Derivational minimalism. In *Logical aspects of computational linguistics*, ed. Christian Retoré, volume 1328 of *Lecture Notes in Computer Science*, 68–95. Berlin: Springer.

FAQ

But are all these pronouns in English actually syntactically bound?

Maybe not. But this has no bearing on the validity of **Limited Obviation**, which only applies to syntactically bound pronouns.

But what about locally bound pronouns?

They show no obviation, so they are exempt from **Limited Obviation**.

What about pronouns that can only be locally bound?

Computationally they behave like reflexives, which can be handled by finite-state constraints.

FAQ [cont.]

What about long distance reflexives?

If they cannot be locally bound, they pose the same computational challenge as syntactically bound pronouns. If they can be locally bound, they fall into the same computational class as reflexives.

What about first/second person pronominals?

In the cases where they seem to be bound in syntax (e.g. *Only I did my homework*) they must be subject to **Limited Obviation**, too.

What about plural pronominals?

While they are a little bit more difficult to keep track of computationally, they can be handled as long as **Limited Obviation** holds.

FAQ [cont.]

I think many of your examples are ungrammatical for reasons independent of **Limited Obviation.**

This is very likely. Keep in mind that **Limited Obviation** isn't supposed to derive the specific patterns we see. It is a descriptive universal (an abstract one, but with clear empirical implications); why things are the way they are is a different question (the one most work on binding theory seeks to answer).

My theory of syntactic binding has no distinguished principle for bound pronouns/derives pronouns from reflexives.

This does not change anything about the computational complexity of the problem, which is what motivates **Limited Obviation**. Any theory that seeks to account for the distribution of bound pronouns runs into the counting problem, irrespective of what this theory's mechanics are (recall the physics analogy).

FAQ [cont.]

What about other obviation domains in ASL?

Coordination and nested VP/TP domains provide the only true ASL parallel to their English counterparts, the latter of which also introduce new binding domains in ASL. Nested DP structures are not well-attested in the language and comparable adjunct structures are expressed in ASL through the use of complex locative and classifier morphology.

Could spatial reference just be an elaborate case or gender system?

Then the grammatical coordination examples parallel the coordination of *him* and *her* in English and are not a problem for Limited Obviation. However, there is no sense in which spatial loci are inherently associated with (pro)nominals in ASL, as is typical of gender systems, nor are spatial loci reliably assigned in specific syntactic environments, as is typical of case systems.

More on Coordination in English

Some speakers accept (22) as grammatical.

(22) ?? Every/No/Some football player told every/no/some masseur that the coach wants him to run six laps and him to prepare the massage room.

If this pattern is a productive instance of coordinating syntactically bound pronouns, it would falsify **Limited Obviation**.
But just like in ASL, the binding mechanism at play here arguably isn't (purely) syntactic in nature.

More on Coordination in English [cont.]

- Most speakers need to put (contrastive) stress on the respective pronouns.
- There is no c-command requirement (even in configurations where QR is bounded).

(23) a. A coach of every/some football player told a receptionist of every/some masseur that the team's president wants him to get a massage and him to give it.

b. An agent of every/some actress told a bodyguard of every/some first lady that he wants her to do a movie about Jackie Kennedy and her to be on the set as a consultant.