

Selective Statistical Learning

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The learning problem

A child exposed to sentences acquires a grammar

my goldfish convinced me that linguists drive more expensive cars than banjo players

what did your goldfish convince you that linguists drive ___ ?

** who did your goldfish convince you that linguists drive more expensive cars than ___ ?*

What determines the nature of projection of a system from a corpus?

Constraints on projection

Rich, innate hypothesis space makes limited kinds of structures possible

Chomsky, Fodor, Pinker, Crain, deVilliers, Roeper...

Domain general learning mechanisms shape language structure

Saffran, Elman, Christiansen, Seidenberg, Gomez, Goldberg...

For both, constraints on projection determine the shape of the acquired grammatical representation

How does input work?

Restricted hypothesis space restricts interpretation of input data

learning = comparing data against class of models

Statistical regularities in data detected by domain general learner

learning = compiling accurately predictive statistics, abstracting out certain features

False dichotomy

Nativist needs abstract structures to leave detectable signature on input

Statistical learner needs a representation of the input in order to track relevant statistics

statistical learning can feed selective acquisition theory

False dichotomy

Components of a learning theory (Chomsky 1965, Gallistel 1990, Pearl & Lidz 2009)

Format of representations

specifies range of possible acquired grammars

Technique for identifying representations in input

specifies mapping from strings to representations

Mechanism for updating representations based on experience

Syntactic explanation

Syntax is abstract

Pieces of explanation have consequences for:

Interpretation

Word order

Interpretive relations

Morphological form

The Problem

Syntax is abstract

Same structural representations show different surface properties across languages

Preschoolers are aware of abstract structural representations

Learning problem: how to infer abstract structures from surface properties

Learning solution: statistics for inference, not for representation

An extended example

Prepositional Dative

Carmen sent the book to her professor

Chris baked a cake for the students

Double Object Construction

Carmen sent her professor the book

Chris baked the students a cake

Some Differences

Double Object Construction

Carmen sent **her professor** **the book**

Chris baked **the students** **a cake**

Goal before **Theme**

Some Differences

Prepositional Dative Construction

Carmen sent **the book** **to her professor**

Chris baked **a cake** **for the students**

Theme before **Goal**

Some Differences

Possession effects

Carmen sent **the book to NY**

?? Carmen sent **NY the book**

Goal of DOC must be possible possessor

Oehrle 1976, inter alia

Some Differences

Possession effects

Carmen bought **some toys for her grandchildren** (in case she ever has any)

Carmen bought **her grandchildren some toys** (??
in case she ever has any)

Goal of DOC must be possible possessor

Kayne 1975

Some Differences

Binding Asymmetries: Prepositional Dative

Carmen sent **every book** to its author

Carmen sent **his book** to every author

Theme can bind into **Goal**

but **Goal** cannot bind into **Theme**

Barss & Lasnik 1986, Larson 1988

Some Differences

Binding Asymmetries: Double Object

Carmen sent **its author** **every book**

Carmen sent **every author** **his book**

Theme cannot bind into **Goal**

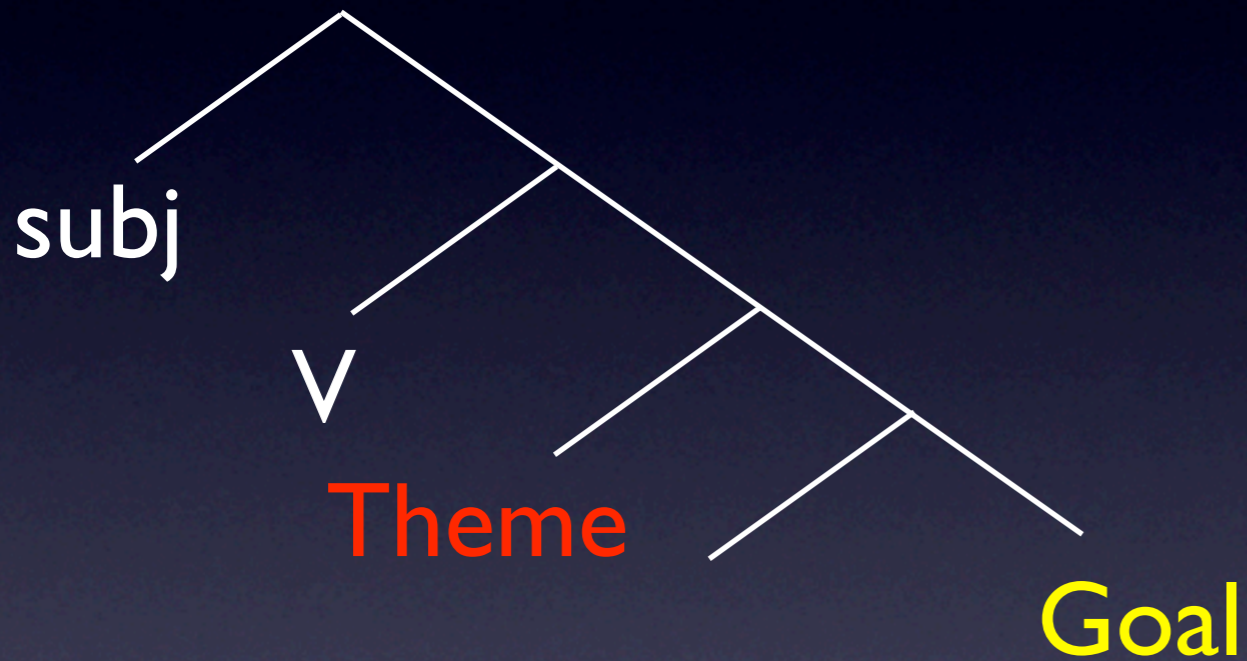
but **Goal** can bind into **Theme**

Barss & Lasnik 1986, Larson 1988

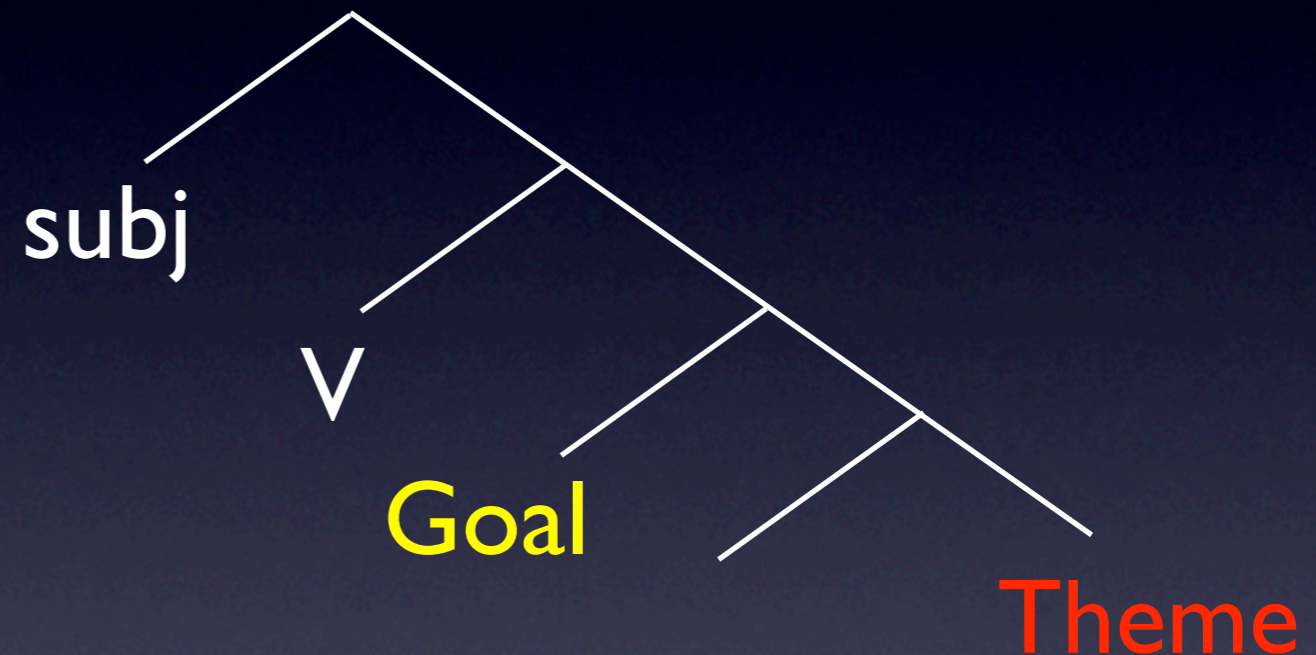
Summary of Pattern

| | Prep Dative | DOC |
|------------|--------------|--------------|
| Possession | No | Yes |
| Order | Theme - Goal | Goal - Theme |
| Binding | Theme > Goal | Goal > Theme |

Syntactic Configurations



Prepositional Dative



Double Object

Harley 1996, Pesetsky 1995...
but cf. Baker 1997

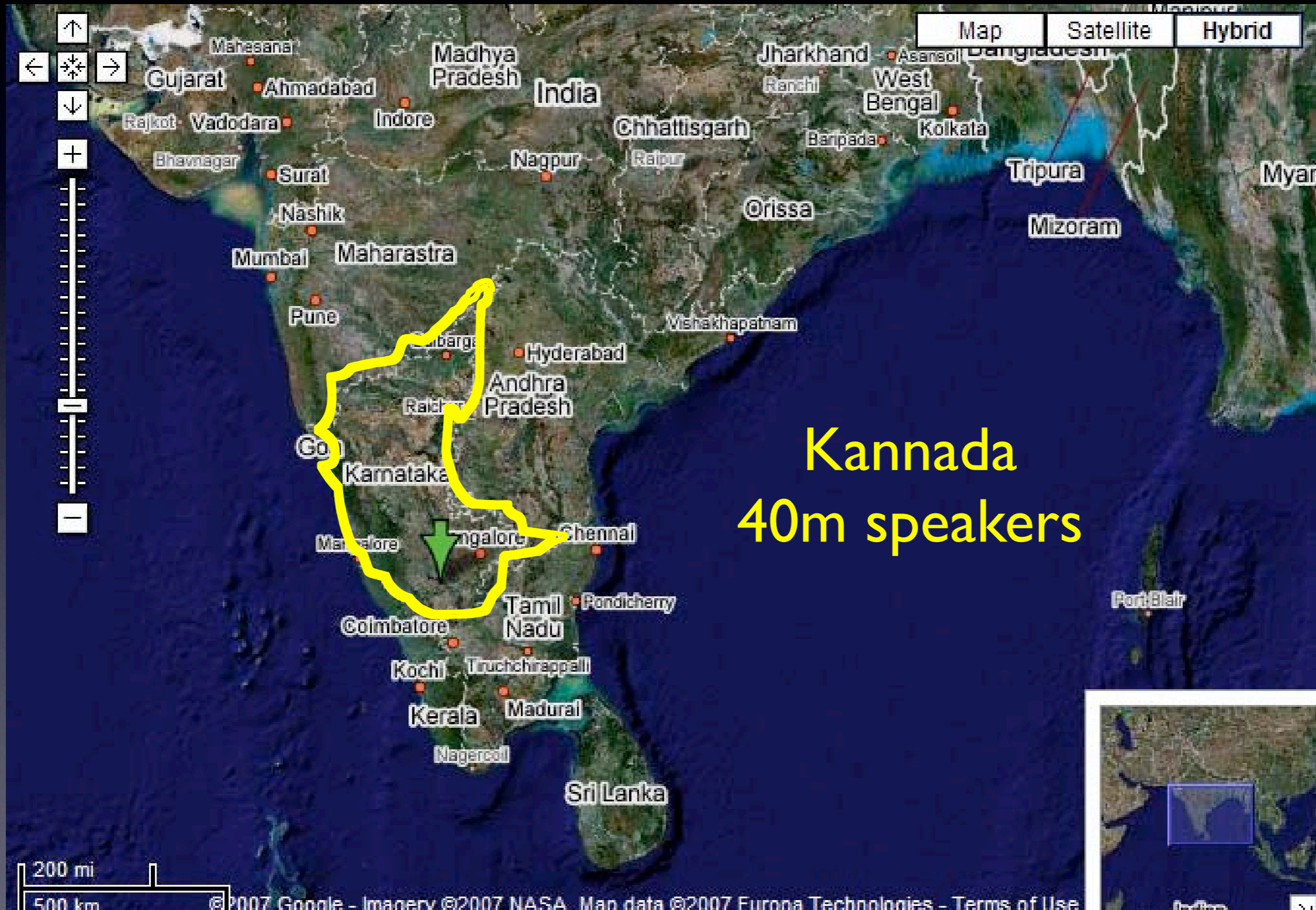
Summary of Pattern

| | Prep Dative | DOC |
|------------|-------------|------|
| Possession | No | Yes |
| Prominence | Theme | Goal |

Are these properties related?

Consequences for learning?

How to find out



Kannada Ditransitives

Hari Rashmi-ge pustaka-vannu kalis-id-a

Hari Rashmi-dat book-acc send-pst-3sm

Hari Rashmi-ge pustaka-vannu kalisi-koTT-a

Hari Rashmi-dat book-acc send-BEN-3sm

‘Hari sent the book to Rashmi’

Kannada Ditransitives

Hari **pustaka-vannu** **Rashmi-ge** kalis-id-a

Hari **book-acc** **Rashmi-dat** send-pst-3sm

Hari **pustaka-vannu** **Rashmi-ge** kalisi-koTT-a

Hari **book-acc** **Rashmi-dat** send-BEN-3sm

‘Hari sent **the book** to **Rashmi**’

Dimensions of variation

| | +Ben | -Ben |
|--------------|------|------|
| Theme - Goal | YES | YES |
| Goal - Theme | YES | YES |

Benefactive = DOC

Possession

Hari **bangaloor-ige** **pustakavannu** kalisida

Hari **pustakavannu** **bangaloor-ige** kalisida

* Hari **bangaloor-ige** **pustakavannu** kalisikoTTa

* Hari **pustakavannu** **bangaloor-ige** kalisikoTTa

Hari sent(***BEN**) **the book** to **Bangalore**

Possession?

| | -Ben | +Ben |
|--------------|------|------|
| Theme - Goal | NO | YES |
| Goal - Theme | NO | YES |

Remember English

| | Prep Dative | DOC |
|------------|-------------|------|
| Possession | No | Yes |
| Prominence | Theme | Goal |

Are these properties related?

What about Kannada

| | -Ben | +Ben |
|------------|------|------|
| Possession | No | Yes |
| Prominence | ?? | ?? |

Does the word-order freedom indicate that there is no asymmetry in prominence in Kannada?

Binding Asymmetries

When can goal bind into theme?

Hari **pratiyobba** lekhanige **avaLa** lekhanavannu
kalisida

* Hari **avaLa** lekhanavannu **pratiyobba** lekhanige
kalisida

Hari sent **every** author **her** article

-Ben: only when **goal** precedes **theme**

Binding Asymmetries

When can **goal** bind into **theme**?

Hari **pratiyobba** lekhanige **avaLa** lekhanavannu
kalisikoTTa

Hari **avaLa** lekhanavannu **pratiyobba** lekhanige
kalisikoTTa

Hari sent(**BEN**) **every** author **her** article

+Ben: **always** - word order is irrelevant

What about Kannada

| | -Ben | +Ben |
|------------|------|-------------|
| Possession | No | Yes |
| Prominence | ?? | GOAL |

Does the word-order freedom indicate that there is no asymmetry in prominence in Kannada? NO

Binding Asymmetries

When can **theme** bind into **goal**?

Hari **adara lekhanige** **pratiyondu lekhanavannu**
kalisida

Hari **pratiyondu lekhanavannu** **adara lekhanige**
kalisida

Hari sent **every article** **to its author**

-Ben: **always** - word order is irrelevant

Binding Asymmetries

When can **theme** bind into **goal**?

Hari **adara lekhanige** **pratiyondu lekhanavannu**
kalisikoTTa

Hari **pratiyondu lekhanavannu** **adara lekhanige**
kalisikoTTa

Hari sent(**BEN**) **every article** to its author

+Ben: only when **theme** precedes **goal**

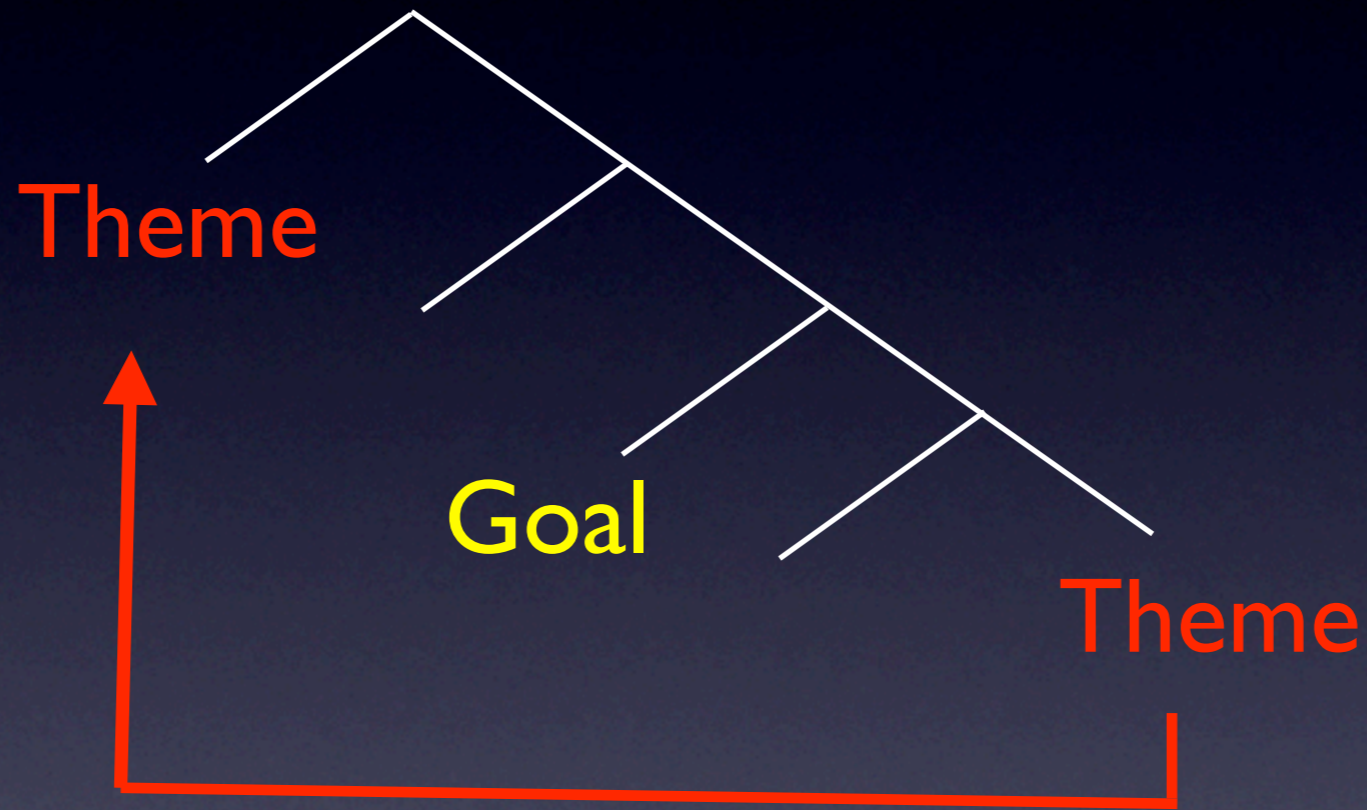
What about Kannada

| | -Ben | +Ben |
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| Possession | No | Yes |
| Prominence | Theme | Goal |

Does the word-order freedom indicate that there is no asymmetry in prominence in Kannada?

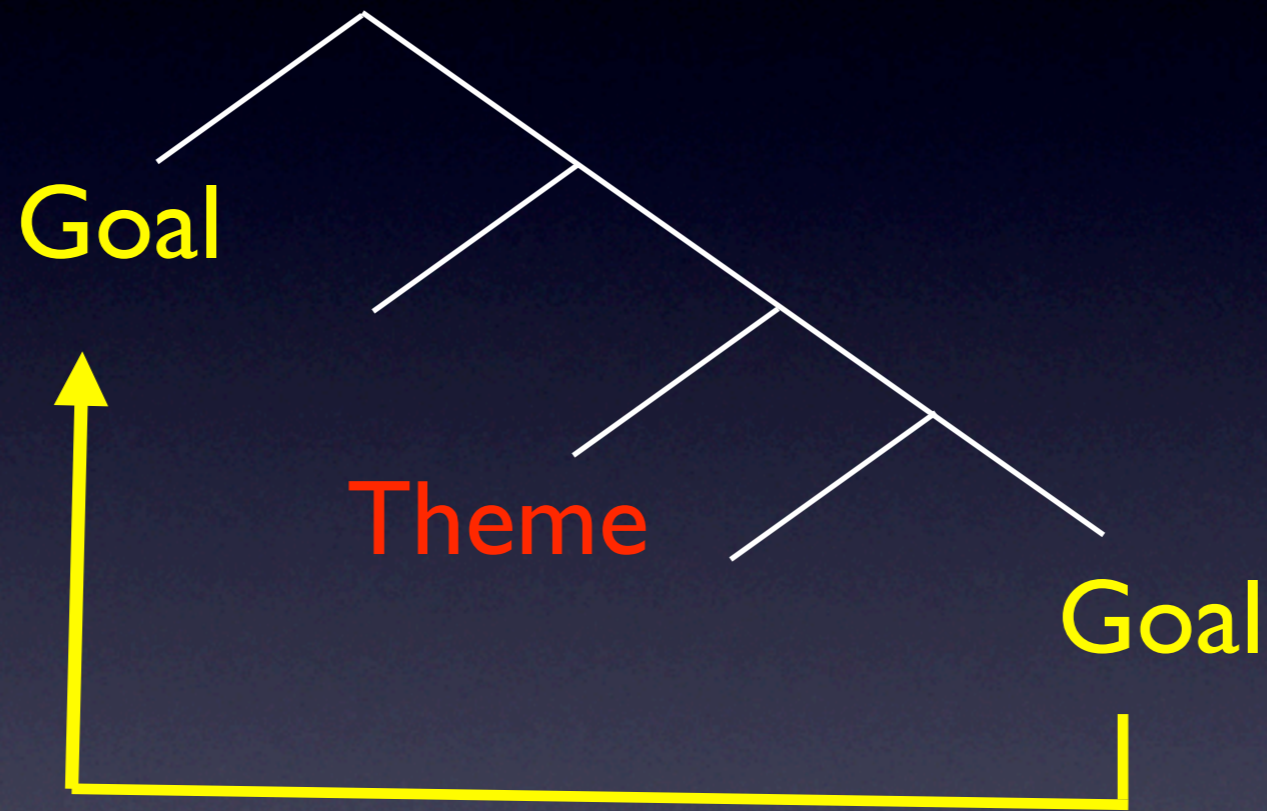
NO - but different signature in Kannada

+Ben Syntax



A-movement of Theme over Goal
Licenses new binding
Doesn't destroy old binding

-Ben Syntax



A-movement of Goal over Theme
Licenses new binding
Doesn't destroy old binding

The point so far

English and Kannada are alike:

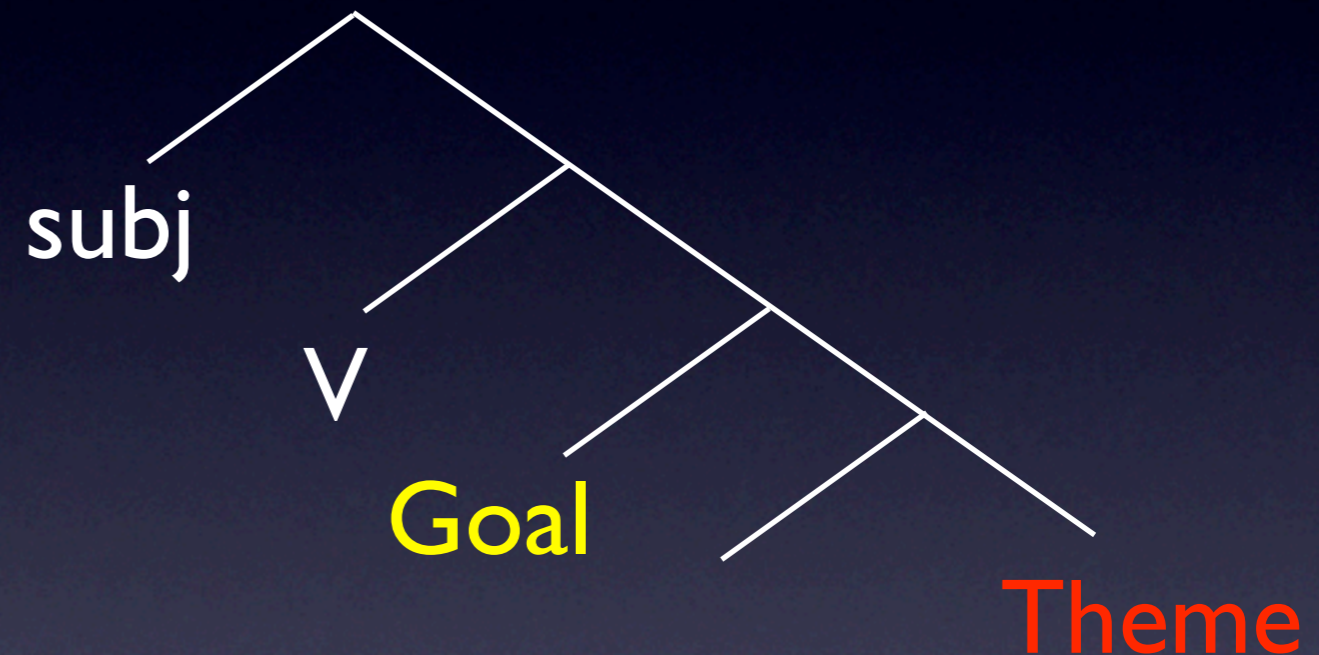
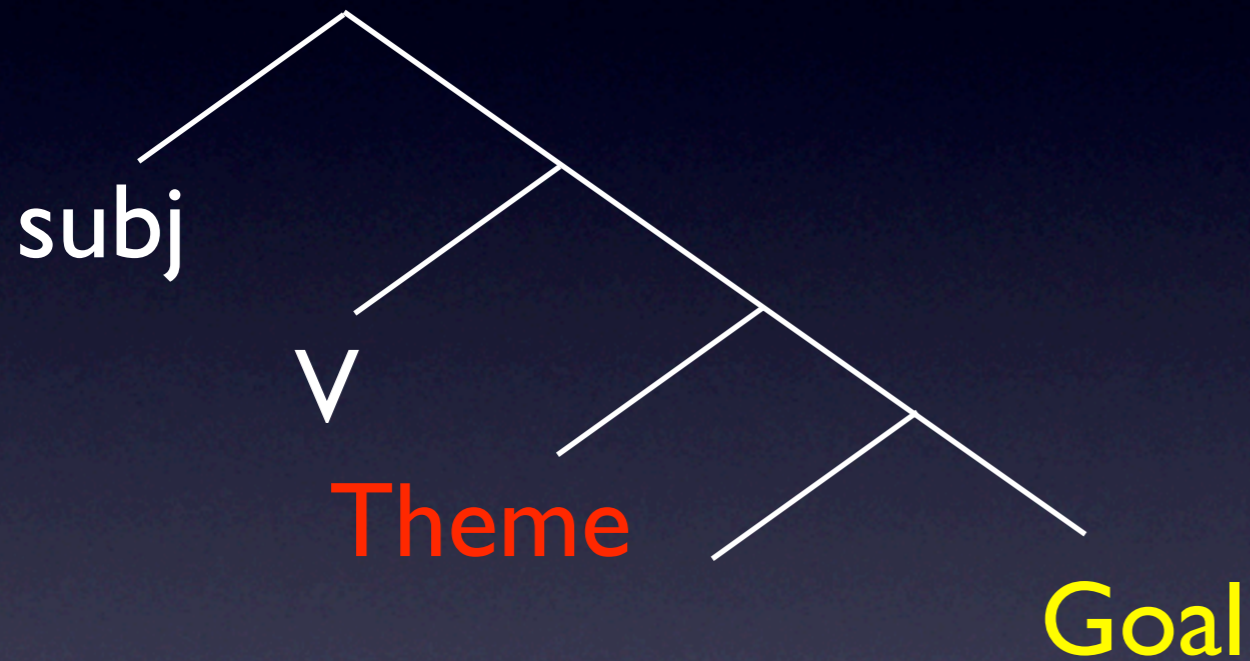
Two kinds of ditransitives

Possession vs. Location

Possession Ditransitive = Goal Prominent

Location Ditransitive = Theme Prominent

Underlying Configurations



Locative Ditransitive

English: Prep Dative

Kannada: -BEN

Possession Ditransitive

English: DOC

Kannada: +BEN

The point so far

Single abstract object has two consequences:

Possession semantics, Goal Prominence

But surface cues to Prominence vary cross-linguistically

English: word order

Kannada: morphological form of verb

Spanish: IO clitic doubling

Korean: auxiliary verb

Syntactic Explanation

Unified analysis of Kannada/English is explanatory

Treating them independently misses a generalization

But a unified analysis depends on abstractness, inviting a learnability question

A Question

When word order is not a direct reflection of prominence, do children nonetheless show early knowledge of this relation?

The test: Kannada-learning 4-yr-olds

Method

Truth Value Judgement Task (Crain & McKee 1985)

Act out story with props & toys

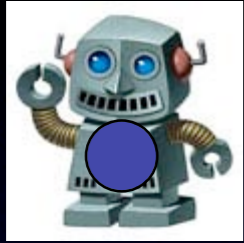
Puppet watches story

Puppet gives summary statement

Child tells Puppet if he's right or wrong



Bound True



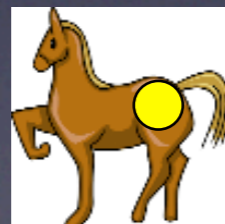
6



5



4



2



3

1

The girl gave **every boy** **his horse**

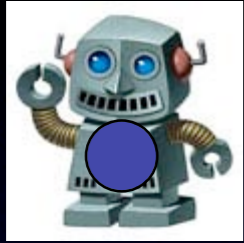
Meaning 1: TRUE

every boy gets his own horse

Meaning 2: FALSE

every boy gets the alien's horse

Bound True



6

girl **every boy his horse** return-(BEN)
 girl **his horse every boy** return-(BEN)



5



Meaning 1: TRUE

every boy gets his own horse



4



3

1

Meaning 2: FALSE

every boy gets the alien's horse

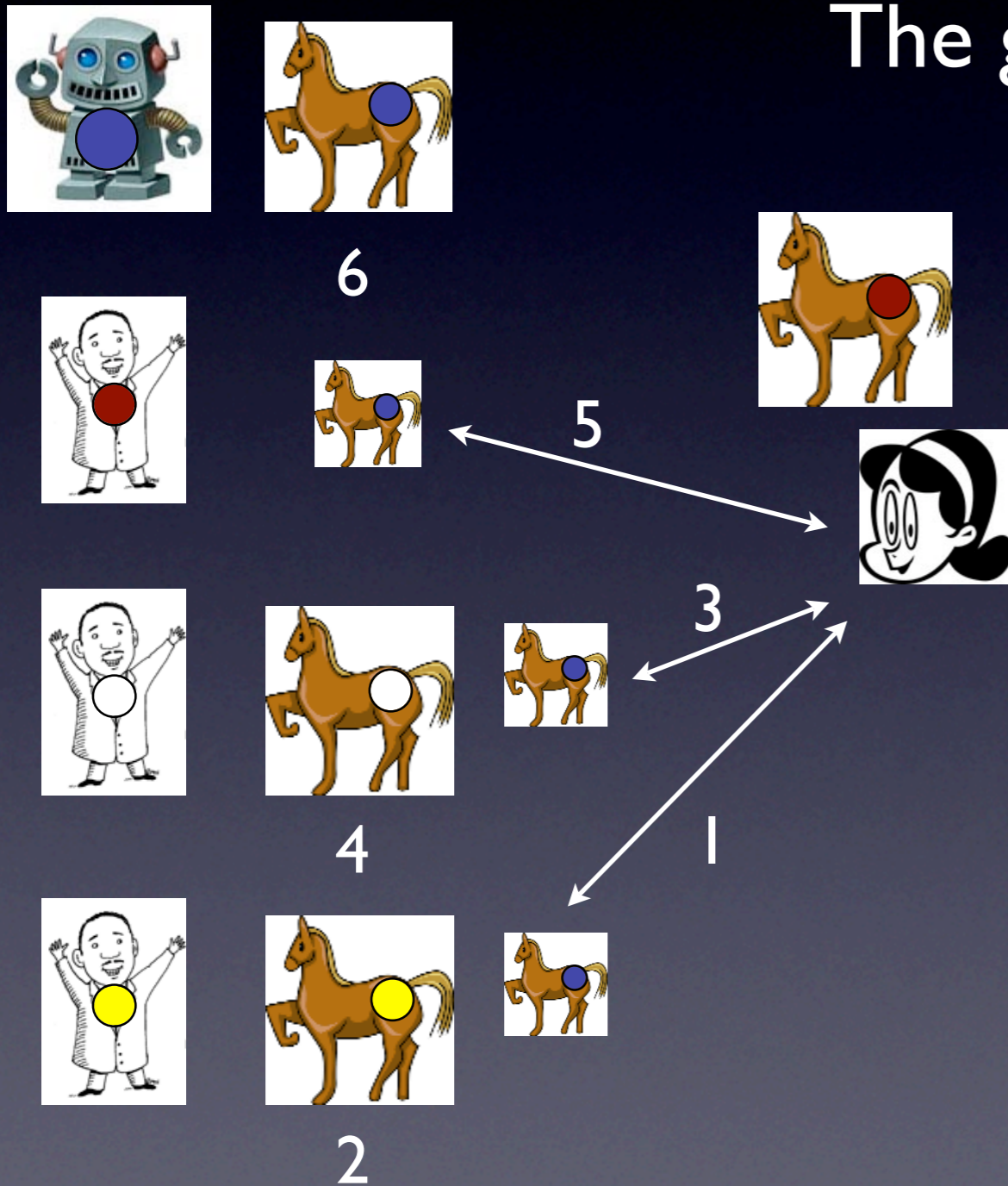


2



Bound False

The girl gave **every boy** his horse



Meaning 1: FALSE

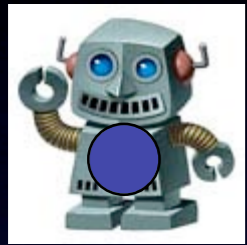
every boy gets his own horse

Meaning 2: True

every boy gets the alien's horse

Bound False

girl **every boy his horse** return-(BEN)
 girl **his horse every boy** return-(BEN)



6



5



3

Meaning 1: FALSE

every boy gets his own horse

4

1

Meaning 2: True

every boy gets the alien's horse



2

Kannada Predictions

| | -Ben | +Ben |
|------------|-------|------|
| Possession | No | Yes |
| Prominence | Theme | Goal |

Kannada Predictions

If 4-yr-olds understand the relation between morphological form and syntactic prominence, then

+BEN: Goal can always bind into Theme

-BEN: Goal can only bind into Theme when Goal comes first

Bound True condition: “yes” except in
-Ben Theme-Goal

Kannada Predictions

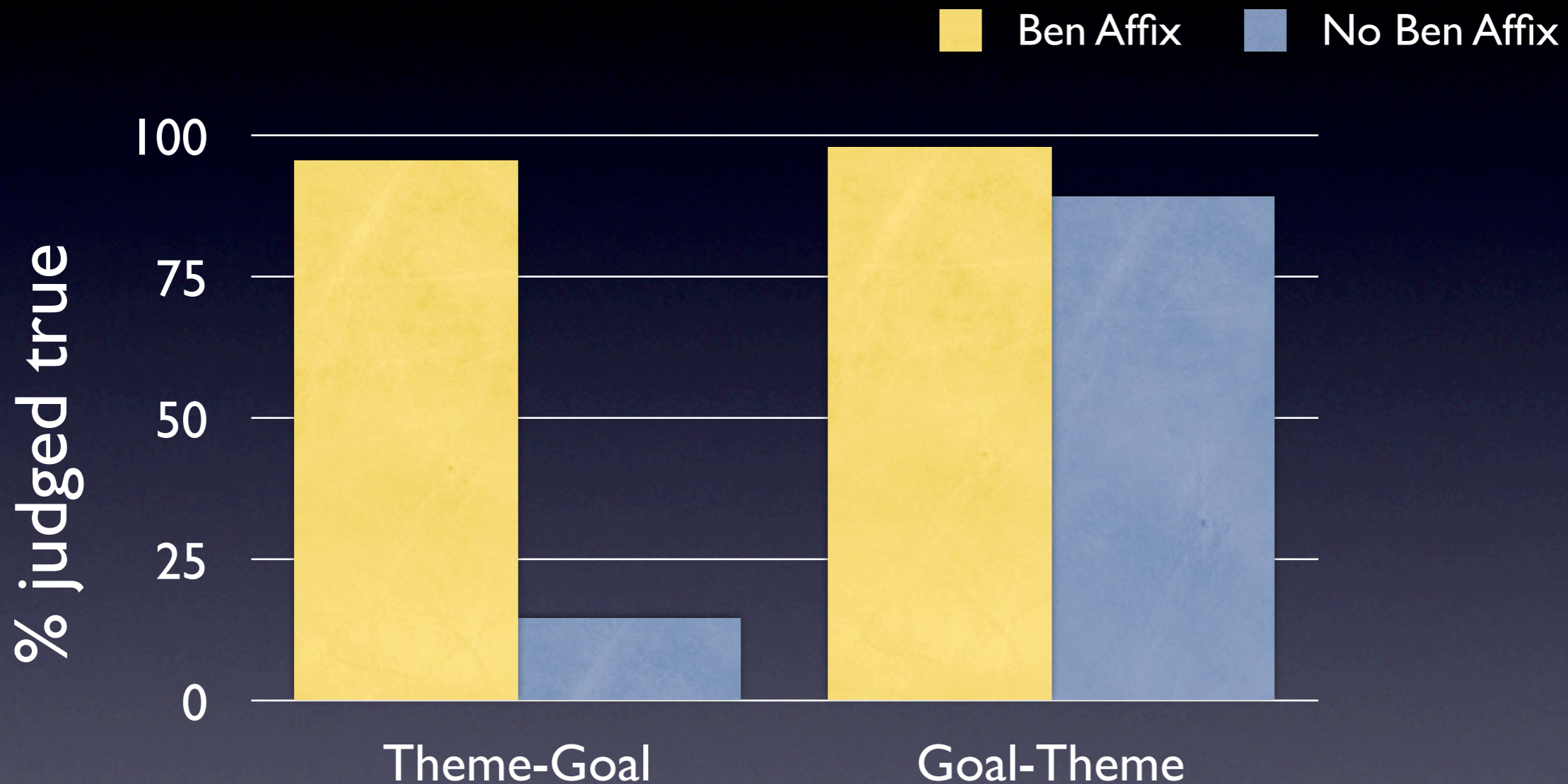
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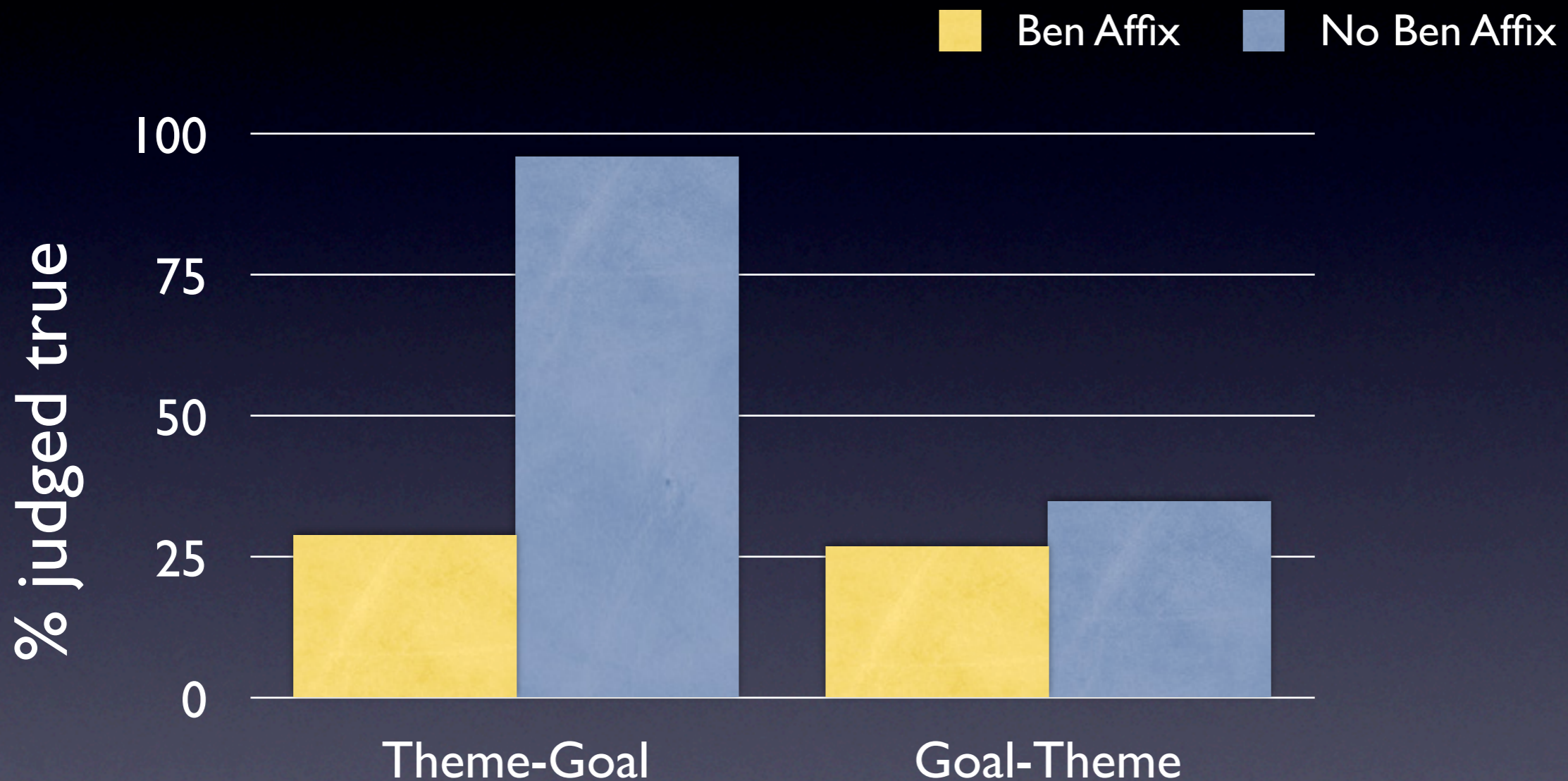
Results: Bound True



The girl gave **every boy his horse**

Viau&Lidz 2008

Results: Bound False



The girl gave **every boy** **his horse**

Viau&Lidz 2008

The point for learning

Link between syntactic representation and surface form is variable.

Link between syntactic representation and abstract relations (possession, prominence) is not.

Children see through surface form to build abstract representation

The point for learning

Morphological form is observable

Word order is observable

Prominence relations are not

Learners acquire prominence relations

The point for learning

Binding data is sparse

Gigaword NYT parsed corpus of English

385M words, 15M sentences

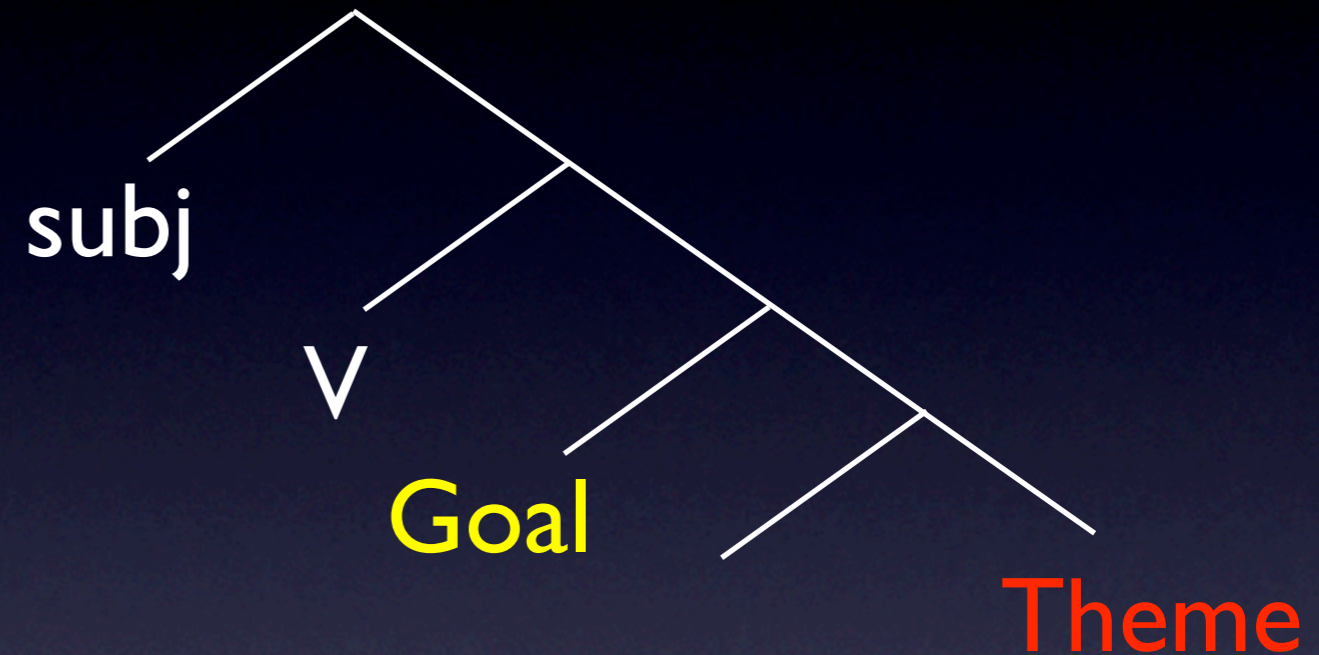
$V [QP] [PP \text{ to } [NP \dots \text{pro}\dots]] = 129$

phi-feature match = 0

$V [QP] [NP \dots \text{pro}\dots] = 87$

phi-feature match = 0

Syntactic Configurations



Locative Ditransitive

English: Prep Dative

Kannada: -BEN

Possession Ditransitive

English: DOC

Kannada: +BEN

Learning consists in selecting the appropriate abstract representation on the basis of surface form

A sketch of learning

Inferences from surface form to abstract structure cued by statistical asymmetry

animacy asymmetry in goal arguments

Inanimate goal 12 times more likely to be used as PP-dative. (Bresnan & Nikitina 2003)

if $p(\text{Str 1} \mid \text{inanimate}) > p(\text{Str 2} \mid \text{inanimate})$,
then Str 1 = locative dative &
 Str 2 = possession dative

A sketch of learning

Skewed distribution of inanimates is a good cue to underlying structure

This inference is licensed only if

- a) the representations are antecedently available
- b) learners expect structures to leave a detectable statistical signature on the input

Conclusions

Learners use statistics to **select** a grammatical system with properties not exhibited in the statistics themselves

Abstract representations must leave a statistical signature in surface form of language in order to be acquired

Learners use this statistical signature to identify grammar, *but only because they know what to look for and what inferences are licensed*

Thank-you

Josh Viau

Norbert Hornstein

Colin Phillips

Central Institute of Indian Languages

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NSF BCS-0604526