HG4041 Theories of Grammar

Long Distance Dependencies

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Lecture 11
Location: LHN-TR+36

Overview

- Some examples of long-distance dependencies
- What is new and different about it
- Broad outlines of our approach
- Details of our approach
- Subject extraction
- Coordinate Structure Constraint

A Note on Adjectives

- Attributive adjectives are related to predicative adjectives by a lexical rule that co-indexes the first element of ARG-ST with MOD and sets SPR to an empty list: *The dog is red* → *The red dog*

$$\left\langle \text{red}, \begin{bmatrix} \textit{word} & \\ \text{HEAD} & \begin{bmatrix} \textit{adj} & \\ \text{PRED} & + \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{1}\ \text{NP} \right\rangle \\ \text{COMPS} & \langle\rangle \\ \text{MOD} & \langle\rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1} \right\rangle \end{bmatrix} \right\rangle \rightarrow \left\langle \text{red}, \begin{bmatrix} \textit{word} & \\ \text{HEAD} & \textit{adj} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\rangle \\ \text{COMPS} & \langle\rangle \\ \text{MOD} & \left\langle \boxed{1}\ \text{NP} \right\rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1} \right\rangle \end{bmatrix} \right\rangle$$

- We can't just co-index SPR and MOD. Why?

- The SPR adjectives need a subject-raising *be* to form a sentence. Why?

Long Distance Dependencies

Examples

- Grammatical:

(1) *Did you find something?*
(2) *Tell me you talked to someone!*

- **wh-questions**:

(3) *What did you find?*
(4) *Tell me who you talked to*

- **relative clauses**:

(5) *the item that I found*
(6) *the guy who(m) I talked to*

- Ungrammatical:

(7) **did you find*
(8) **you talked to*

- **topicalization**:

(9) *The manual, I can't find.*
(10) *Chris, you should talk to.*

- ***easy*-adjectives**:

(11) *My house is easy to find.*
(12) *Pat is hard to talk to.*

What these have in common

- There is a **gap**: nothing following ***find*** and ***to***, even though both normally require objects.

- Something that fills the role of the element missing from the gap occurs at the beginning of the clause.

- We use topicalization and ***easy***-adjectives to illustrate the phenomenon:

(13) *The manual$_g$, I can't find* ______ $_g$

(14) *Chris$_g$ is easy to talk to* ______ $_g$

Gaps and their fillers can be far apart

(15) The solution to this problem$_g$, Pat said that someone claimed you thought I would never find ______ $_g$.

(16) Chri$_g$s is easy to consider it impossible for anyone but a genius to try to talk to ______ $_g$.

- Fillers often have syntactic properties associated with their gaps

(17) a. Him$_g$, I haven't met ______ $_g$.

b. *He$_g$, I haven't met ______ $_g$.

(18) a. The scissors$_g$, Pat told us ______ were missing$_g$.

b. *The scissors$_g$, Pat told us ______ was missing$_g$.

(19) a. On Pat$_g$, you can rely ______ $_g$.

b. *To Pat$_g$, you can rely ______ $_g$.

- That's why we call them **long distance dependencies**

Other relevant facts

- Various languages show morphological marking on the verbs or complementizers of clauses between the filler and the gap.

- Psycholinguistic evidence indicates increased processing load in the region between filler and gap.

A Rough Sketch of Our Approach

- A feature GAP records information about a missing constituent.

- The GAP value is passed up the tree by a new principle.

- A new grammar rule allows us to expand S as a filler followed by another S whose GAP value matches the filler.

- Caveat: Making the details of this general idea work involves several complications.

- The core idea comes from Gazdar (1981)

The Feature gap

- Like valence features and ARG-ST, GAP's value is a list of feature structures (often empty). You can have multiple gaps.

- Subject gaps are introduced by a lexical rule.

- Non-subject gaps are introduced by revising the Argument Realization Principle.

The Revised ARP

$$\begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \boxed{A} \\ \text{COMPS} & \boxed{B} \ominus \boxed{C} \end{bmatrix} \\ \text{GAP} & \boxed{C} \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{A} \oplus \boxed{B} \right\rangle \end{bmatrix}$$

- $\ominus$ is a kind of list subtraction
  - it's not always defined (the sublist must exist on the main list)
  - when defined, it's not always unique
- The ARP now says the non-SPR arguments are distributed between COMPS and GAP.

A Word with a Non-Empty gap Value

$$\left\langle \text{hand}, \begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{1}\ \text{NP}\begin{bmatrix}\text{CASE} & \textit{nom}\\ \text{AGR} & \textit{non-3sing}\end{bmatrix}\right\rangle \\ \text{COMPS} & \left\langle \boxed{3}\ \text{PP:TO}\right\rangle \end{bmatrix} \\ \text{GAP} & \left\langle \boxed{2}\text{NP}\begin{bmatrix}\text{ACC}\end{bmatrix}\right\rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1}, \boxed{2}, \boxed{3} \right\rangle \end{bmatrix} \right\rangle$$

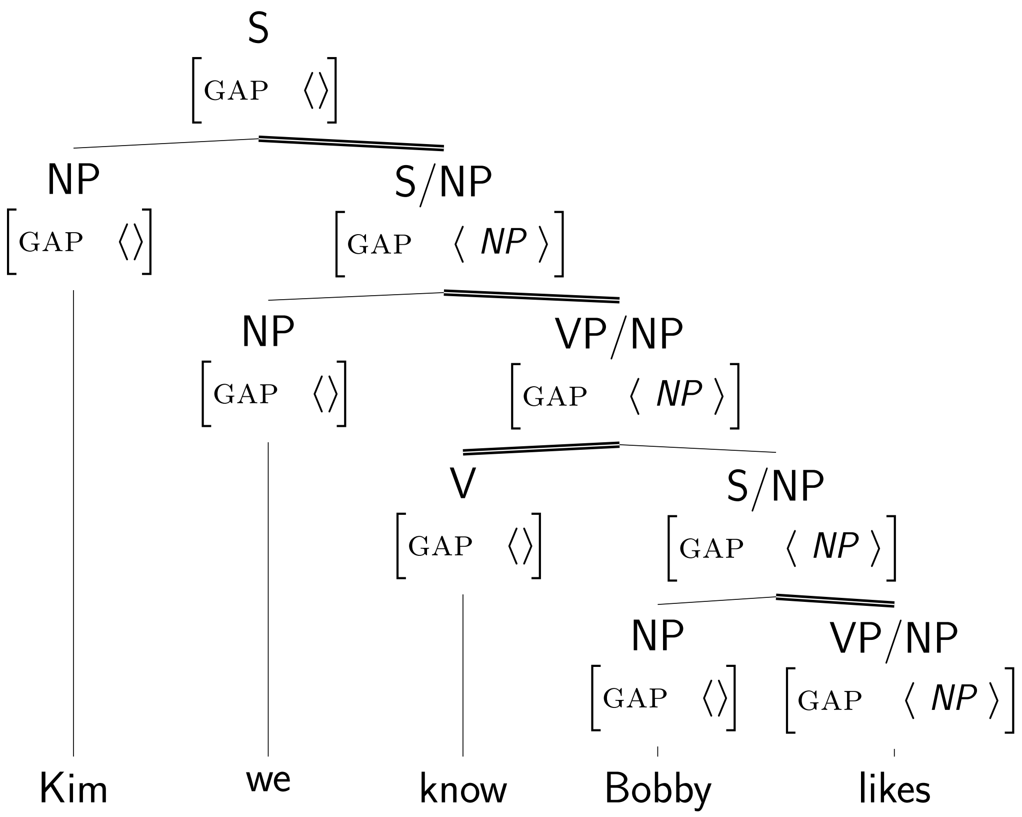
A Word with another Non-Empty gap Value

$$\left\langle \text{hand}, \begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{1}\ \text{NP}\begin{bmatrix}\text{CASE} & \textit{nom}\\ \text{AGR} & \textit{non-3sing}\end{bmatrix}\right\rangle \\ \text{COMPS} & \left\langle \boxed{2}\text{NP}\begin{bmatrix}\text{ACC}\end{bmatrix}\right\rangle \end{bmatrix} \\ \text{GAP} & \left\langle \boxed{3}\ \text{PP:TO}\right\rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1}, \boxed{2}, \boxed{3}\right\rangle \end{bmatrix} \right\rangle$$

The same word with an Empty gap Value

$$\left\langle \text{hand}, \begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{1}\ \text{NP}\begin{bmatrix}\text{CASE} & \textit{nom}\\ \text{AGR} & \textit{non-3sing}\end{bmatrix}\right\rangle \\ \text{COMPS} & \left\langle \boxed{2}\text{NP}\begin{bmatrix}\text{ACC}\end{bmatrix}, \boxed{3}\ \text{PP:TO}\right\rangle \end{bmatrix} \\ \text{GAP} & \langle\rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1}, \boxed{2}, \boxed{3} \right\rangle \end{bmatrix} \right\rangle$$

How We Want GAP to Propagate



Traditionally called SLASH: VP/NP (think of it as a VP missing an NP)

What GAP Propagation should doing

- ➢ Pass any GAP values from daughters up to their mothers,

... except when the filler is found.

- ➢ For topicalization, we can write the exception into the grammar rule
- ➢ For ***easy***-adjectives, the NP that corresponds to the gap is the subject, which is introduced by the Head-Specifier Rule.
- ➢ Since specifiers are not generally gap fillers, we can't write the gap-filling into the HSR.

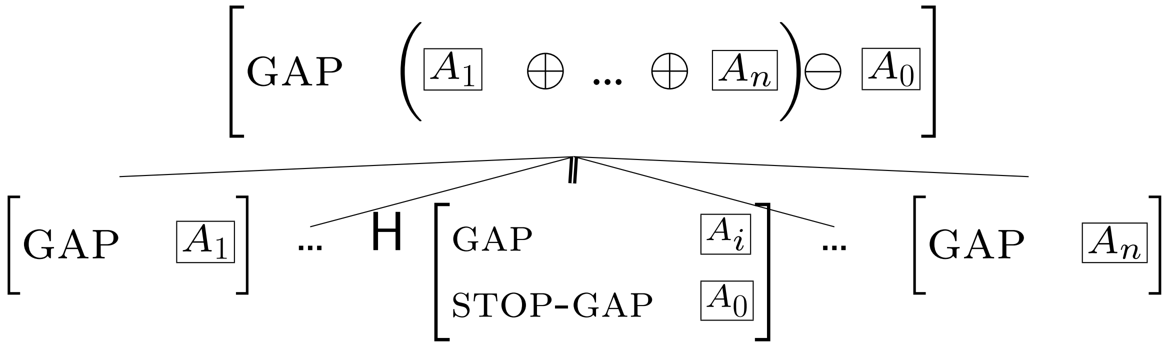
Our Solution to this Problem

- For ***easy***-adjectives, we treat the adjective formally as the filler, marking its SPR value as coindexed with its GAP value.

- We use a feature STOP-GAP to trigger the emptying of the GAP list.
  - STOP-GAP stops gap propagation
  - ***easy***-adjectives mark STOP-GAP lexically
  - a new grammar rule, the **Head-Filler Rule** contains STOP-GAP

The GAP Principle

A local subtree Φ satisfies the GAP Principle with respect to a headed rule if and only if Φ satisfies:



$$\begin{bmatrix}\text{GAP} & \left(\boxed{A_1} \oplus \ldots \oplus \boxed{A_n}\right) \ominus \boxed{A_0}\end{bmatrix}$$

$$\begin{bmatrix}\text{GAP} & \boxed{A_1}\end{bmatrix} \quad \ldots \quad \text{H}\begin{bmatrix}\text{GAP} & \boxed{A_i} \\ \text{STOP-GAP} & \boxed{A_0}\end{bmatrix} \quad \ldots \quad \begin{bmatrix}\text{GAP} & \boxed{A_n}\end{bmatrix}$$

- ➢ The GAP of the mother is the append of the GAPs of the daughters

... minus STOP-GAP on the head daughter

How does stop-gap work?

- STOP-GAP is empty almost everywhere
- When a gap is filled, STOP-GAP is nonempty, and its value is the same as the gap being filled.
- This blocks propagation of that GAP value, so gaps are only filled once.
- The nonempty STOP-GAP values come from two sources:
  - a stipulation in the Head-Filler Rule
  - lexical entries for ***easy***-adjectives
- No principle propagates STOP-GAP

The Head-Filler Rule

$$\begin{bmatrix} \textit{phrase} \end{bmatrix} \rightarrow \boxed{1}\begin{bmatrix}\text{GAP} & \langle\rangle\end{bmatrix} \; \boldsymbol{H}\begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix}\text{SPR} & \langle\rangle \\ \text{COMPS} & \langle\rangle\end{bmatrix} \\ \text{GAP} & \left\langle \boxed{1} \right\rangle \\ \text{STOP-GAP} & \left\langle \boxed{1} \right\rangle \end{bmatrix}$$

- This only covers gap filling in Ss
- The filler has to be identical to the GAP value
- The STOP-GAP value is also identical
- The GAP Principle ensures that the mother's GAP value is the empty list

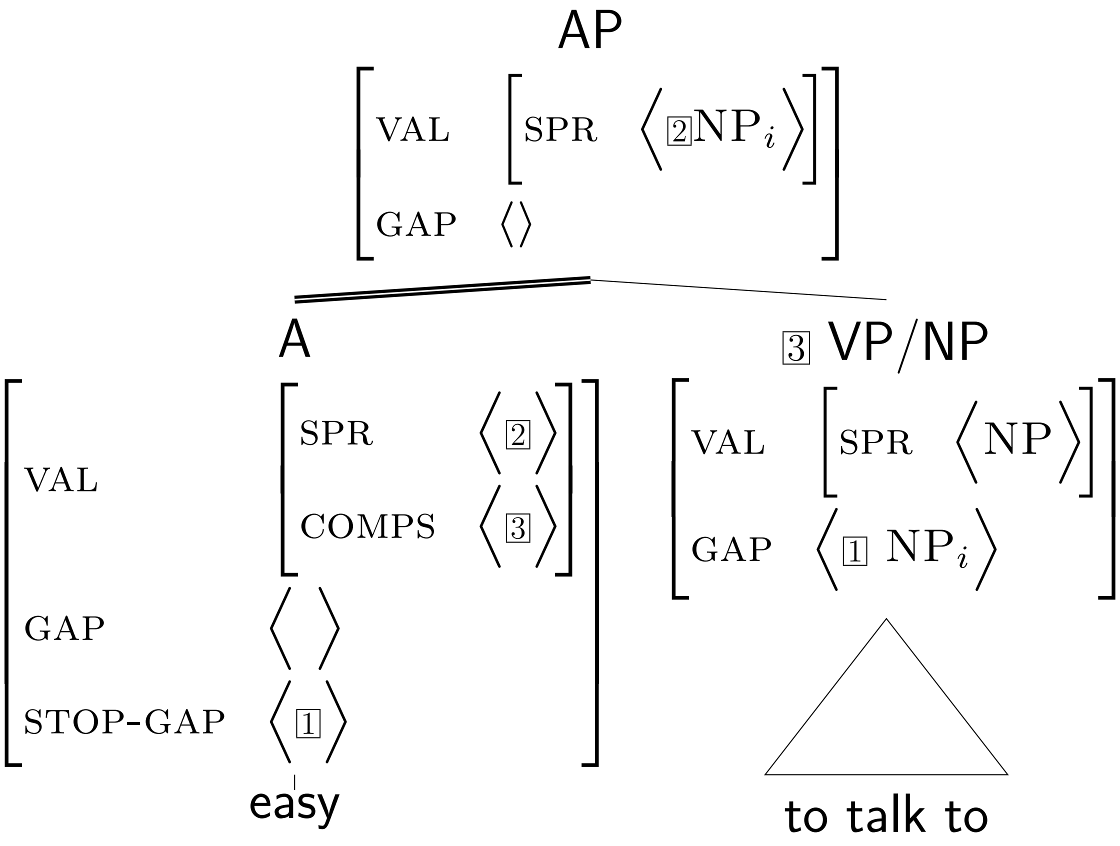
Gap Filling with *easy*-Adjectives

(20)

$$\left\langle \text{easy}, \begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{adj} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle \boxed{1} \rangle \\ \text{COMPS} & \langle \boxed{3} \rangle \end{bmatrix} \\ \text{STOP-GAP} & \langle \boxed{2} \rangle \end{bmatrix} \\ \text{ARG-ST} & \left\langle \boxed{1}\ \text{NP}_i,\ \boxed{3}\ \text{VP}\begin{bmatrix} \text{INF} & + \\ \text{GAP} & \left\langle \boxed{2}\ \text{NP}_i \right\rangle \end{bmatrix}, \ldots \right\rangle \end{bmatrix} \right\rangle$$

- Because STOP-GAP and GAP have the same value, that value will be subtracted from the mother's GAP value.
- The first argument is coindexed with the GAP value, accounting for the interpretation of the subject as the filler.

A Tree for *easy to talk to* ______



AP

$$\begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{2}\text{NP}_i \right\rangle \end{bmatrix} \\ \text{GAP} & \langle\rangle \end{bmatrix}$$

A

$$\begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \boxed{2} \right\rangle \\ \text{COMPS} & \left\langle \boxed{3} \right\rangle \end{bmatrix} \\ \text{GAP} & \langle\ \rangle \\ \text{STOP-GAP} & \left\langle \boxed{1} \right\rangle \end{bmatrix}$$

easy

$\boxed{3}$ VP/NP

$$\begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \text{NP} \right\rangle \end{bmatrix} \\ \text{GAP} & \left\langle \boxed{1}\ \text{NP}_i \right\rangle \end{bmatrix}$$

to talk to

stop-gap Housekeeping

- Lexical entries with nonempty STOP-GAP values (like ***easy***) are rare, so STOP-GAP is by default empty in the lexicon.

- Head-Specifier and Head-Modifier rules need to say [STOP-GAP $<>$]

- Lexical rules preserve STOP-GAP values.

gap Housekeeping

Q The initial symbol must say [GAP $<>$]. Why?

A To block **Pat found* and **Chris talked to* as stand-alone sentences.

Q The Imperative Rule must propagate GAP values. Why?

A It's not a headed rule, so the effect of the GAP Principle must be replicated
A Imperatives can have gaps:
This book, put on the top shelf!

Sentences with Multiple Gaps

- Famous examples:

(21) *This violin$_i$, sonatas$_j$ are easy to play* ______ $_j$ *on* ______ $_i$.

(22) **Sonatas$_j$, this violin$_i$ is easy to play* ______ $_j$ *on* ______ $_i$.

- Our analysis gets this:
  - The subject of ***easy*** is coindexed with the first element of the GAP list.
  - The Head-Filler rule only allows one GAP remaining.

- There are languages that allow multiple gaps more generally.

Where We Are

- **filler-gap** structures:

  (23) *The solution to this problem, nobody understood ______*

  (24) *That problem is easy to understand ______*

- The feature GAP encodes information about missing constituents

- Modified ARP allows arguments that should be on the COMPS list to show up in the GAP list

- GAP values are passed up the tree by the GAP Principle

- The feature STOP-GAP signals where GAP passing should stop
- The Head-Filler Rule matches a filler to a GAP and (via STOP-GAP) empties GAP
- Lexical entries for ***easy***-adjectives require a gap in the complement, coindex the subject with the gap, and (via STOP-GAP) empty GAP on the mother

More Phenomena filler ...

- Sentences with subject gaps
- Gaps in coordinate constructions

Subject Gaps

- ➢ The ARP revision only allowed missing complements.
- ➢ But gaps occur in subject position, too:

  (25) *This problem, everyone thought ________ was too easy.*

- ➢ We handle these via a lexical rule that, in effect, moves the contents of the SPR list into the GAP list

The Subject Extraction Lexical Rule

$$\begin{bmatrix} \textit{pi-rule} & \\ \text{INPUT} & \left\langle \text{X}, \begin{bmatrix} \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \text{Z} \right\rangle \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} & \boxed{A} \end{bmatrix} \right\rangle \\ \text{OUTPUT} & \left\langle \text{Y}, \begin{bmatrix} \text{SYN} & \begin{bmatrix} \text{VAL} & \begin{bmatrix} \text{SPR} & \left\langle \ \right\rangle \\ \text{GAP} & \left\langle \boxed{1} \right\rangle \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} & \boxed{A} \left\langle \boxed{1}, \ ... \right\rangle \end{bmatrix} \right\rangle \end{bmatrix}$$

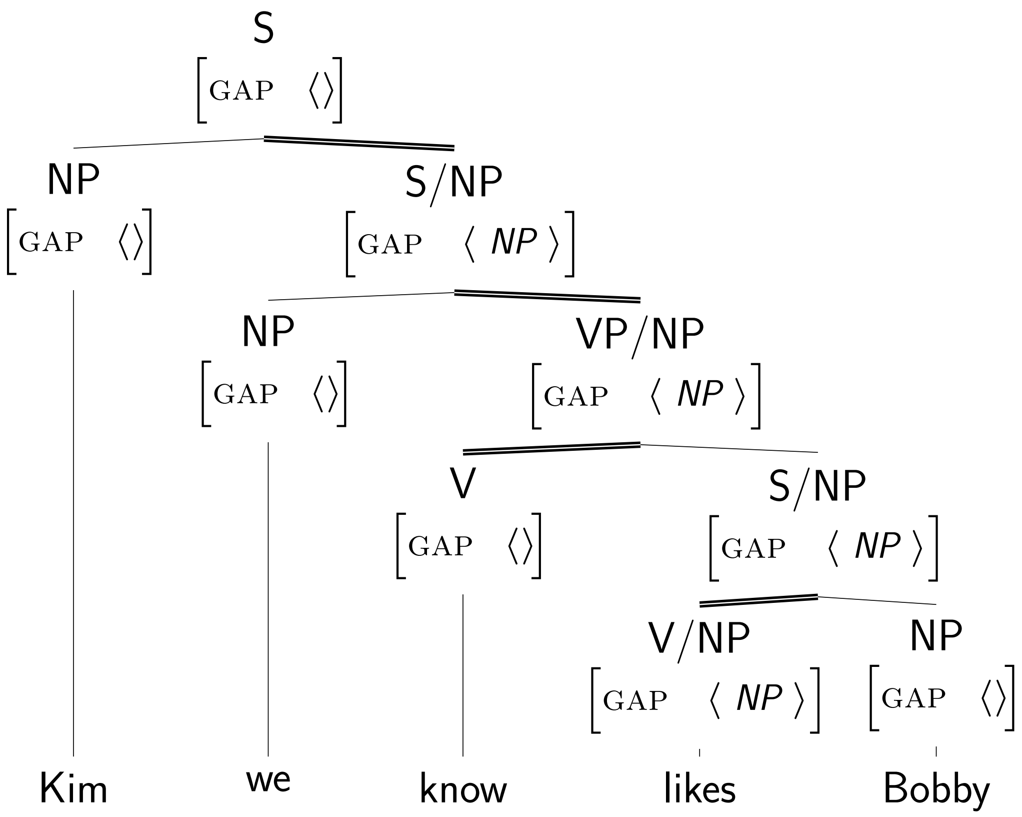
- NB: This says nothing about the phonology, because the default for pi-rules is to leave the phonology unchanged.

A Lexical Sequence This Licenses

$$\left\langle \text{likes}, \begin{bmatrix} \textit{word} & \\ \text{SYN} & \begin{bmatrix} \text{HEAD} & \textit{verb} \\ \text{VAL} & \begin{bmatrix} \text{SPR} & \langle\rangle \\ \text{COMPS} & \langle \boxed{2} \rangle \end{bmatrix} \\ \text{GAP} & \left\langle \boxed{1}\ \text{NP}\begin{bmatrix}\text{CASE} & \textit{nom}\\ \text{AGR} & \textit{3sing}\end{bmatrix}\right\rangle \\ \text{STOP-GAP} & \langle\quad\rangle \end{bmatrix} \\ \text{ARG-ST} & \langle \boxed{1}, \boxed{2}\ \text{NP:}\textsc{acc} \rangle \end{bmatrix} \right\rangle$$

- Note that the ARP is satisfied

A Tree with a Subject Gap



Kim$_i$ we know _____$_i$ likes Bobby

Island Constraints

- There are configurations that block filler-gap dependencies, sometimes called **islands**
- Trying to explain them has been a central topic of syntactic research since the mid 1960s
- We'll look at just one, Ross's so-called **Coordinate Structure Constraint**
- Loose statement of the constraint: a constituent outside a coordinate structure cannot be the filler for a gap inside the coordinate structure.

Coordinate Structure Constraint Examples

(26) **This problem, nobody finished the extra credit and* ______

(27) **This problem, nobody finished* ______ *and the extra credit.*

(28) **This problem, nobody finished* ______ *and started the extra credit.*

(29) **This problem, nobody started the extra credit and finished* ______

(30) *This problem, everybody started* ______ *and nobody finished* ______

- In a coordinate structure,
  - no conjunct can be a gap (**conjunct constraint**)
  - no gap can be contained in a conjunct if its filler is outside of that conjunct (element constraint)

  ... unless each conjunct has a gap that is paired with the same filler (**across-the-board exception**)

These observations cry out for explanation

- In our analysis, the conjunct constraint is an immediate consequence: individual conjuncts are not on the ARG-ST list of any word, so they can't be put on the GAP list

- The element constraint and ATB exception suggest that GAP is one of those features (along with VAL and FORM) that must agree across conjuncts.

- Note: There is no ATB exception to the conjunct constraint.

  (31) **This problem, you can compare only ______ and ______.*

Our Coordination Rule, so far

$$\begin{bmatrix}\text{VAL} & \boxed{0} \\ \text{IND} & s_0\end{bmatrix} \rightarrow \begin{bmatrix}\text{VAL} & \boxed{0} \\ \text{IND} & s_1\end{bmatrix} \ldots \begin{bmatrix}\text{VAL} & \boxed{0} \\ \text{IND} & s_{n-1}\end{bmatrix} \begin{bmatrix}\text{HEAD} & \textit{conj} \\ \text{IND} & s_0 \\ \text{RESTR} & \left\langle \begin{bmatrix}\text{ARGS} & \langle\, s_1, \ldots, s_{n-1}, s_n \,\rangle\end{bmatrix} \right\rangle\end{bmatrix} \begin{bmatrix}\text{VAL} & \boxed{0} \\ \text{IND} & s_n\end{bmatrix}$$

- Recall that we have tinkered with what must agree across conjuncts at various times.

- Now we'll add GAP to the things that conjuncts must share

Our Final Coordination Rule

$$\begin{bmatrix} \text{VAL} & \boxed{0} \\ \text{IND} & s_0 \\ \text{GAP} & \boxed{A} \end{bmatrix} \rightarrow \begin{bmatrix} \text{VAL} & \boxed{0} \\ \text{IND} & s_1 \\ \text{GAP} & \boxed{A} \end{bmatrix} \ldots \begin{bmatrix} \text{VAL} & \boxed{0} \\ \text{IND} & s_{n-1} \\ \text{GAP} & \boxed{A} \end{bmatrix} \begin{bmatrix} \text{HEAD} & \textit{conj} \\ \text{IND} & s_0 \\ \text{RESTR} & \left\langle \begin{bmatrix} \text{ARGS} & \langle\, s_1, \ldots, s_{n-1}, s_n \,\rangle \end{bmatrix} \right\rangle \end{bmatrix} \begin{bmatrix} \text{VAL} & \boxed{0} \\ \text{IND} & s_n \\ \text{GAP} & \boxed{A} \end{bmatrix}$$

- We've just added GAP to all the conjuncts and the mother.

- This makes the conjuncts all have the same gap (if any)

- Why do we need it on the mother?

Closing Remarks on LDDs

- This is a huge topic; we've only scratched the surface
- There are many more kinds of LDDs, which would require additional grammar rules
- There are also more island constraints, which also need to be explained
- Our account of the coordinate structure constraint (based on ideas of Gazdar) is a step in the right direction, but it would be even better to explain why certain features must agree across conjuncts.

Overview of LDD

- Some examples of the phenomenon
- What is new and different about it
- Broad outlines of our approach
- Details of our approach
- Subject extraction
- Coordinate Structure Constraint

P0: Semantics are *easy*

Add the semantics to the lexeme ***easy*** given on slide 20.

Then give the full rels list for the top node (i.e. the whole sentence) for (32) and (33). What is the deep subject of ***easy*** in each sentence?

(32) *My house is easy to find.*

(33) *Pat is easy to talk to.*

P1: A Tree with a Gap

Draw a tree for (34). Use abbreviations for the node labels, and show the value of GAP on all nodes. Show the value of STOP-GAP on any node where it is non-empty.

(34) *This baby, I know that they handed a toy to* _______

Based on Chapter 14, Problem 1, Sag, Wasow and Bender (2003)

P2: Blocking Filled Gaps

Examples (i) and (ii) are well-formed, but example (iii) is ungrammatical:

(i) *Pat thinks that I rely on some sort of trick.*
(ii) *This mnemonic, Pat thinks that I rely on.*
(iii) **This mnemonic, Pat thinks that I rely on some sort of trick.*

Explain in detail why the mechanisms that license (i) and (ii) do not also permit (iii).

P3: Subject Gaps

This problem is to make sure you understand how our analysis accounts for examples like (35).

(35) i. *Which candidates do you think like oysters on the half-shell?*

ii. *That candidate, I think likes oysters on the half-shell.*

A. Sketch the family of lexical sequences for ***likes*** that is the input to the Subject Extraction Lexical Rule.

B. Sketch the family of lexical sequences for ***likes*** that is the corresponding output of the Subject Extraction Lexical Rule.

C. Sketch the tree for the sentence in (35ii). Use abbreviations for node labels, but show the value of GAP on all nodes and the value of STOP-GAP on any node

Based on Chapter 14, Problem 3, Sag, Wasow and Bender (2003) where it is non-empty. You may abbreviate the structure over the NP *oysters on the half-shell* with a triangle.

D. Does our analysis correctly predict the contrast between (35ii) and 36?

(36) **Those candidates, I think likes oysters on the half-shell.*

Explain why or why not.

Acknowledgments and References

- Course design and slides borrow heavily from Emily Bender's course: *Linguistics 566: Introduction to Syntax for Computational Linguistics* `http://courses.washington.edu/ling566`

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References

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Ivan A. Sag, Tom Wasow, and Emily Bender. 2003. *Syntactic Theory: A Formal Introduction*. CSLI Publications, Stanford, second edition.