Ling 566
Nov 23, 2009
Auxiliaries

Overview

- What are auxiliaries?
- General properties of auxiliaries
- Lexical type/lexical entries for auxiliaries
- NICE properties (lexical rules)

What Auxiliaries Are

- Sometimes called "helping verbs," auxiliaries are little words that come before the main verb of a sentence, including forms of *be*, *have*, *do*, *can*, *could*, *may*, *might*, *must*, *shall*, *should*, *will*, and *would*

- They tend to be involved in the expression of time, necessity, possibility, permission, and obligation, as well as such things as negation, affirmation, and questioning

Some Basic Facts about Auxiliaries

- They are optional
  Pat tapdanced. Pat can tapdance. Pat is tapdancing.
- They precede any non-auxiliary verbs
  **Pat tapdance can. *Pat tapdancing is.*
- They determine the form of the following verb
  **Pat can tapdancing. *Pat is tapdance.*
- When they co-occur, their order is fixed
  *Pat must be tapdancing. *Pat is musting tapdance.*
- Auxiliaries of any given type cannot iterate
  **Pat could should tapdance.*

A Little History

- Chomsky's first book, *Syntactic Structures* (1957), contained a detailed analysis of the English system of auxiliary verbs
- It showed how formal analysis could reveal subtle generalizations
- The power of Chomsky's analysis of auxiliaries was one of the early selling points for transformational grammar
  - Especially, his unified treatment of auxiliary *do*
- So it's a challenge to any theory of grammar to deal with the same phenomena

Two Approaches to Analyzing Auxiliaries

- Treat auxiliaries as a special category, and formulate specialized transformations sensitive to their presence

- Assimilate their properties to existing types as much as possible, and elaborate the lexicon to handle what is special about them

- We adopt the latter, treating auxiliaries as a subtype of *srv-lxm*

Consequences of Making *auxv-lxm* a Subtype of *srv-lxm*

- Auxiliaries should express one-place predicates
- Auxiliaries should allow non-referential subjects (dummy *there*, *it*, and idiom chunks)
- Passivization of the main verb (the auxiliary's complement) should preserve truth conditions

- Are these borne out?

Why call auxiliaries verbs?

- *be*, *have*, and *do* exhibit verbal inflections (tense, agreement)
- *be*, *have*, and *do* can all appear as main verbs (that is, as the only verb in a sentence)
  - Their inflections are the same in main and auxiliary uses
  - *be* exhibits auxiliary behavior, even in its main verb uses
- Modals (*can*, *might*, *will*, etc.) don't inflect, but they occur in environments requiring a finite verb with no (other) finite verb around.

What's special about auxiliaries?

- Unlike other subject-raising verbs we have looked at, their complements aren't introduced by *to*
- The modals and *do* have defective paradigms
- There are restrictions on the ordering and iterability of auxiliaries
- They have a set of special characteristics known as the NICE properties.

Some Type Constraints

TYPE	FEATURES/CONSTRAINTS	IST
verb-lxm	$\begin{bmatrix} \text{SYN} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{AUX} \quad / & - \end{bmatrix} \end{bmatrix} \\ \text{ARG-ST} & \langle\, [\text{HEAD } \textit{nominal}] \,,\, \ldots \,\rangle \\ \text{SEM} & \begin{bmatrix} \text{MODE} & \text{prop} \end{bmatrix} \end{bmatrix}$	*infl-lxm*
srv-lxm	$\begin{bmatrix} \text{ARG-ST} & \left\langle \boxed{1} \,,\, \begin{bmatrix} \text{SPR} & \langle\, \boxed{1} \,\rangle \\ \text{COMPS} & \langle\, \rangle \end{bmatrix} \right\rangle \end{bmatrix}$	*verb-lxm*
ic-srv-lxm	$\begin{bmatrix} \text{ARG-ST} & \left\langle \text{X} \,,\, \begin{bmatrix} \overset{\text{VP}}{\text{INF}} & + \\ \text{INDEX} & s \end{bmatrix} \right\rangle \\ \text{SEM} & \begin{bmatrix} \text{RESTR} & \left\langle \begin{bmatrix} \text{ARG} & s \end{bmatrix} \right\rangle \end{bmatrix} \end{bmatrix}$	*srv-lxm*
auxv-lxm	$\begin{bmatrix} \text{SYN} & \begin{bmatrix} \text{HEAD} & \begin{bmatrix} \text{AUX} & + \end{bmatrix} \end{bmatrix} \end{bmatrix}$	*srv-lxm*

A Lexical Entry for *be*

$$\left\langle \text{be} , \left[\begin{array}{l} auxv\text{-}lxm \\ \\ \text{ARG-ST} \left\langle \text{X} , \left[\text{SYN} \left[\text{HEAD} \left[\text{PRED} \; + \right] \right] \right] \right\rangle \\ \\ \text{SEM} \left[\begin{array}{ll} \text{INDEX} & \boxed{2} \\ \text{RESTR} & \langle \; \rangle \end{array} \right] \end{array} \right] \right\rangle$$

The Entry for *be*, with Inherited Information

$$\left\langle \text{be} , \left[\begin{array}{ll} \textit{auxv-lxm} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \textit{verb} & \\ \text{AUX} & + \\ \text{AGR} & \boxed{0} \end{array} \right] \\ \text{VAL} & \left[\text{SPR} \quad \langle \, [\text{AGR} \quad \boxed{0}] \, \rangle \right] \end{array} \right] \\ \text{ARG-ST} & \left\langle \boxed{3} , \left[\begin{array}{ll} \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\text{PRED} \quad + \right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle \, \boxed{3} \, \rangle \\ \text{COMPS} & \langle \, \rangle \end{array} \right] \end{array} \right] \\ \text{SEM} & \left[\text{INDEX} \quad \boxed{2} \right] \end{array} \right] \right\rangle \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \text{prop} \\ \text{INDEX} & \boxed{2} \\ \text{RESTR} & \langle \, \rangle \end{array} \right] \end{array} \right] \right\rangle$$

Entry for *have*

$$\left\langle \text{have} , \left[\begin{array}{l} \textit{auxv-lxm} \\ \text{ARG-ST} \left\langle \text{X} , \left[\begin{array}{l} \text{SYN} \left[\text{HEAD} \left[\begin{array}{l} \textit{verb} \\ \text{FORM} \quad \text{psp} \end{array} \right] \right] \\ \text{SEM} \left[\text{INDEX} \quad \boxed{3} \right] \end{array} \right] \right\rangle \\ \text{SEM} \left[\begin{array}{l} \text{INDEX} \quad s \\ \text{RESTR} \left\langle \left[\begin{array}{ll} \text{RELN} & \text{have} \\ \text{SIT} & s \\ \text{ARG} & \boxed{3} \end{array} \right] \right\rangle \end{array} \right] \end{array} \right] \right\rangle$$

- Note the FORM restriction on the complement VP
- What accounts for the analogous FORM restriction on verbs following *be*?

Lexical Entry for a Modal

$$\left\langle \text{would} , \left[\begin{array}{ll} \textit{auxv-lxm} & \\ \text{SYN} & \left[\text{HEAD} \quad \left[\text{FORM} \quad \text{fin}\right]\right] \\ \text{ARG-ST} & \left\langle \text{X} , \left[\begin{array}{ll} \text{SYN} & \left[\text{HEAD} \quad \left[\begin{array}{ll} \textit{verb} & \\ \text{INF} & - \\ \text{FORM} & \text{base} \end{array}\right]\right] \\ \text{SEM} & \left[\text{INDEX} \quad s_2\right] \end{array}\right] \right\rangle \\ \text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_1 \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \textbf{would} \\ \text{SIT} & s_1 \\ \text{ARG} & s_2 \end{array}\right] \right\rangle \end{array}\right] \end{array}\right] \right\rangle$$

- Note the restriction on the form of the complement VP
- What inflectional lexical rules apply to this lexeme?

Accounting for the Basic Facts Cited Earlier

- Optionality of auxiliaries:
  As raising verbs, their subjects and complements go together.
- Auxiliaries precede non-auxiliary verbs:
  Auxiliaries are heads, and complements follow heads in English.
- Auxiliaries determine the form of the following verb:
  This is built into their lexical entries.
- When auxiliaries co-occur, their order is fixed:
  Different explanations for different combinations; see next slide.
- Non-iterability of auxiliaries:
  Ditto.

Accounting for Restrictions on Order and Iterability

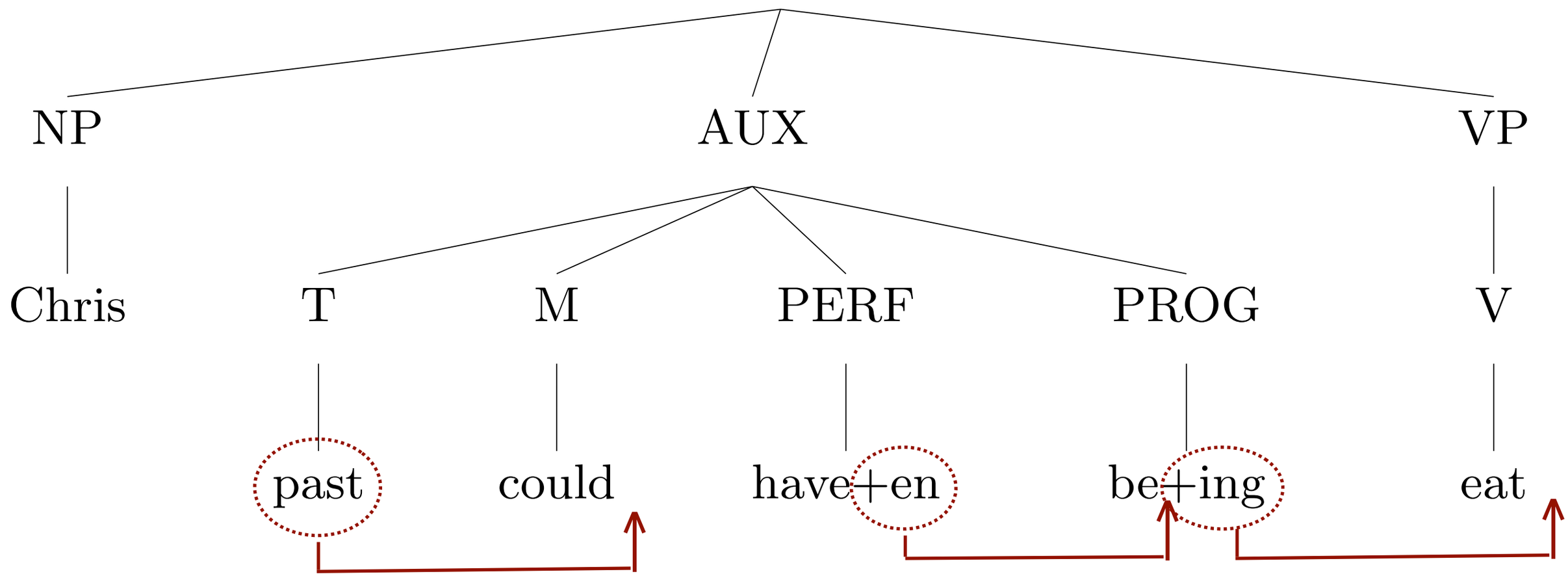
- Order
  - Modals are finite, and all auxiliaries take non-finite complements. Hence, modals must come first.
  - Stative verbs (like *own*) don't have present participles, and auxiliary *have* is stative. Hence, **Pat is having tapdanced*.

- Iterability
  - Auxiliary *be* is also stative, so **Pat is being tapdancing*.
  - Modals must be finite, and their complements must be base, so **Pat can should tapdance*.
  - **Pat has had tapdanced* can be ruled out in various ways, e.g. stipulating that auxiliary *have* has no past participle.

Sketch of Chomsky's Old Analysis

$$S \rightarrow NP \;\; AUX \;\; VP$$

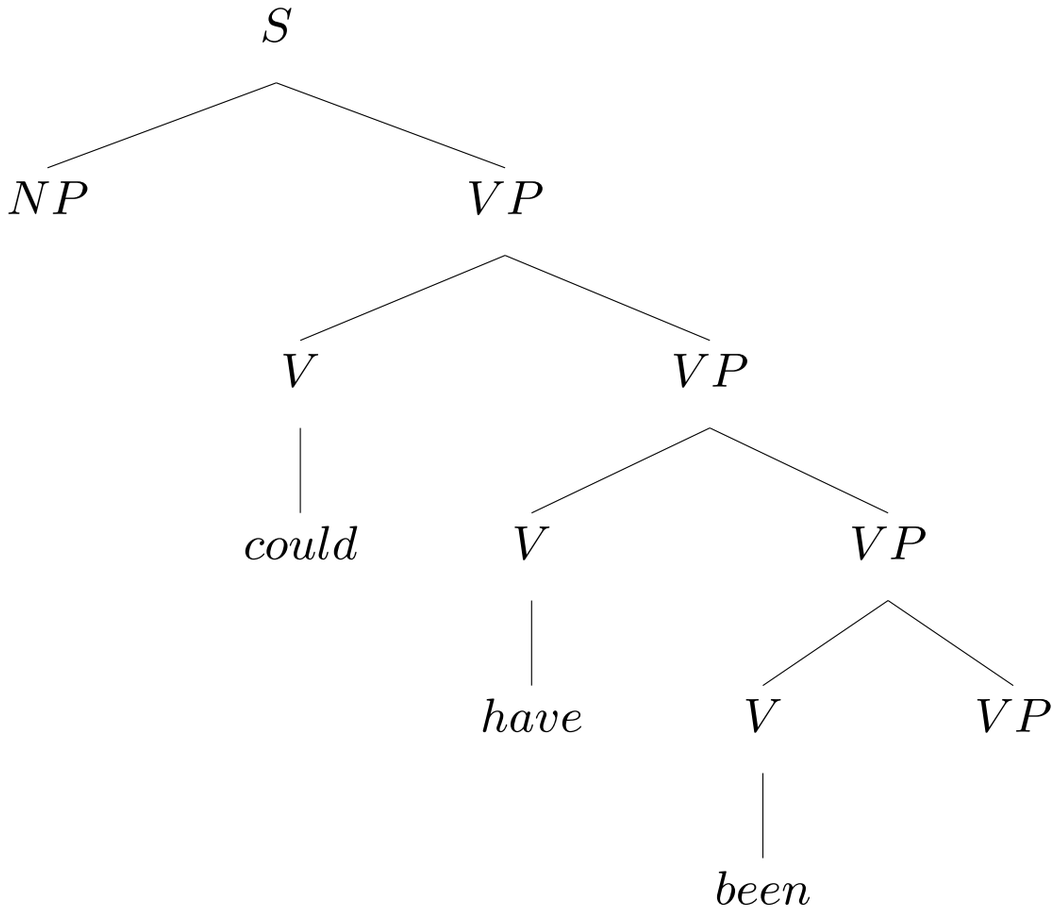
$$AUX \rightarrow T(M)(PERF)(PROG)$$



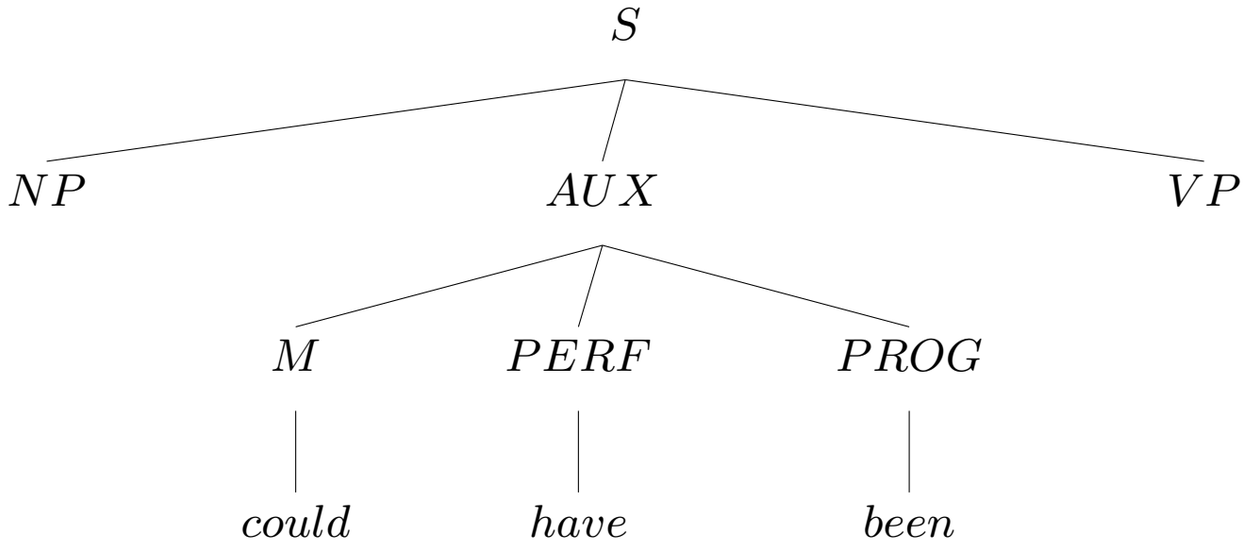
How this Analysis Handles the Basic Facts

- Optionality of auxiliaries:
  Stipulated in the phrase structure rule (with parentheses)
- Auxiliaries precede non-auxiliary verbs:
  Built into the phrase structure rule, with AUX before VP
- Auxiliaries determine the form of the following verb:
  Inflections are inserted with the auxiliaries and moved onto the following verb transformationally.
- When auxiliaries co-occur, their order is fixed:
  Stipulated in the phrase structure rule for AUX
- Non-iterability of auxiliaries:
  Ditto.

The two analyses assign very different trees



- *could have been* VP, *have been* VP, and *been* VP are all constituents
- *could have been* is not a constituent



- *could have been* VP, *have been* VP, and *been* VP are not constituents
- *could have been* is a constituent

Ellipsis and Constituency

- Consider:

  Pat couldn't have been eating garlic, but Chris could have been
  Pat couldn't have been eating garlic, but Chris could have
  Pat couldn't have been eating garlic, but Chris could

- On the nested analysis, the missing material is a (VP) constituent in each case
- On the flat analysis, the missing material is never a constituent
- This argues for our analysis over the old transformational one.

Our Analysis of Auxiliaries So Far

- Auxiliaries are subject-raising verbs
- Most basic distributional facts about them can be handled through selectional restrictions between auxiliaries and their complements (that is, as ARG-ST constraints)
- Auxiliaries are identified via a HEAD feature AUX, which we have not yet put to use

Descriptive Summary of the NICE Properties

Negation	Sentences are negated by putting *not* after the first auxiliary verb; they can be reaffirmed by putting *too* or *so* in the same position
Inversion	Questions are formed by putting an auxiliary verb before the subject NP
Contraction	Auxiliary verbs take negated forms, with *n't* affixed
Ellipsis	Verb phrases immediately following an auxiliary verb can be omitted

Negation (and Reaffirmation)

- Polar adverbs (sentential *not*, *so*, and *too*) appear immediately following an auxiliary
  Pat will not leave
  Pat will SO leave
  Pat will TOO leave
- What about examples like *Not many people left*?
- What happens when you want to deny or reaffirm a sentence with no auxiliary?
  Pat left
  *Pat **did not** leave*
  *Pat **did TOO** leave*

The Auxiliary *do*

- Like modals, *do* only occurs in finite contexts:
  **Pat continued to do not leave*
- Unlike modals, *do* cannot be followed by other auxiliaries:
  **Pat did not have left*

$$\left\langle \text{do} , \left[\begin{array}{ll} \textit{auxv-lxm} & \\ \text{SYN} & \left[\text{HEAD} \left[\text{FORM} \quad \text{fin}\right]\right] \\ \text{ARG-ST} & \left\langle \text{X} , \left[\begin{array}{ll} \text{SYN} & \left[\text{HEAD} \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{base} \\ \text{AUX} & - \end{array} \right]\right] \\ \text{SEM} & \left[\text{INDEX} \quad s\right] \end{array} \right] \right\rangle \\ \text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s \\ \text{RESTR} & \langle\ \rangle \end{array} \right] \end{array} \right] \right\rangle$$

The ADV$_{pol}$-Addition Lexical Rule

$$\left[\begin{array}{l}
\textit{pi-rule} \\
\\
\text{INPUT} \quad \left\langle \text{X} , \left[\begin{array}{ll}
\text{SYN} & \left[\text{HEAD} \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{POL} & - \\ \text{AUX} & + \end{array}\right]\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\text{INDEX} \quad s_1\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{Y} , \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\text{POL} \;\; +\right] \\ \text{VAL} & \left[\text{SPR} \quad \langle\, \text{Z} \,\rangle\right] \end{array}\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \left\langle \left[\begin{array}{ll} \text{INDEX} & s_2 \\ \text{RESTR} & \left\langle \left[\text{ARG} \quad s_1\right] \right\rangle \end{array}\right]_{\text{ADV}_{pol}} \right\rangle \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\text{INDEX} \quad s_2\right]
\end{array}\right] \right\rangle
\end{array}\right]$$

What does the type *pi-rule* mean?

- It maps words to words (hence, "post-inflectional")
- It preserves MOD values, HEAD values as a default, and (like other lexical rule types) SEM values as a default

$$\left[\begin{array}{ll} \text{INPUT} & \left\langle \boxed{0}, \left[\begin{array}{ll} word & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{1} \\ \text{VAL} & \left[\text{MOD} \quad \boxed{A}\right] \end{array}\right] \\ \text{SEM} & \boxed{2} \end{array}\right] \right\rangle \\ \text{OUTPUT} & \left\langle \boxed{0}, \left[\begin{array}{ll} word & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \boxed{1} \\ \text{VAL} & \left[\text{MOD} \quad \boxed{A}\right] \end{array}\right] \\ \text{SEM} & \boxed{2} \end{array}\right] \right\rangle \end{array}\right]$$

Why doesn't ADV$_{pol}$-Addition LR mention VAL?

$$\left[\begin{array}{l}\textit{pi-rule}\\ \\ \text{INPUT}\quad \left\langle \text{X}\,, \left[\begin{array}{ll}\text{SYN} & \left[\text{HEAD}\ \left[\begin{array}{ll}\textit{verb} & \\ \text{FORM} & \text{fin}\\ \text{POL} & -\\ \text{AUX} & +\end{array}\right]\right]\\ \text{ARG-ST} & \langle\, \boxed{1}\,\rangle \oplus \boxed{\text{A}}\\ \text{SEM} & \left[\text{INDEX}\ \ s_1\right]\end{array}\right]\right\rangle\\ \\ \text{OUTPUT}\quad \left\langle \text{Y}\,, \left[\begin{array}{ll}\text{SYN} & \left[\begin{array}{ll}\text{HEAD} & \left[\text{POL}\ +\right]\\ \text{VAL} & \left[\text{SPR}\ \ \langle\, \text{Z}\,\rangle\right]\end{array}\right]\\ \text{ARG-ST} & \langle\, \boxed{1}\,\rangle \oplus \left\langle \left[\begin{array}{ll}\text{INDEX} & s_2\\ \text{RESTR} & \left\langle \left[\text{ARG}\ \ s_1\right]\right\rangle\end{array}\right]_{\text{ADV}_{pol}}\right\rangle \oplus \boxed{\text{A}}\\ \text{SEM} & \left[\text{INDEX}\ \ s_2\right]\end{array}\right]\right\rangle\end{array}\right]$$

What is the role of these indices?

$$
\left[\begin{array}{l}
\textit{pi-rule} \\
\\
\text{INPUT} \quad \left\langle \text{X} \,, \left[\begin{array}{ll}
\text{SYN} & \left[\text{HEAD} \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{POL} & - \\ \text{AUX} & + \end{array}\right]\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\textbf{INDEX} \; \textbf{s}_1\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{Y} \,, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\text{POL} \;\; +\right] \\ \text{VAL} & \left[\text{SPR} \;\; \langle\, \text{Z} \,\rangle\right] \end{array}\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \left\langle \left[\begin{array}{ll} \textbf{INDEX} & \textbf{s}_2 \\ \text{RESTR} & \left\langle \left[\text{ARG} \; \textbf{s}_1\right] \right\rangle \end{array}\right] \right\rangle_{\text{ADV}_{pol}} \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\textbf{INDEX} \; \textbf{s}_2\right]
\end{array}\right] \right\rangle
\end{array}\right]
$$

Which *not*s does the rule license?

$$
\left[\begin{array}{ll}
\textit{pi-rule} & \\
\text{INPUT} & \left\langle \text{X} , \left[\begin{array}{ll}
\text{SYN} & \left[\text{HEAD} \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{POL} & - \\ \text{AUX} & + \end{array}\right]\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\text{INDEX} \quad s_1\right]
\end{array}\right]\right\rangle \\
\text{OUTPUT} & \left\langle \text{Y} , \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\text{POL} \quad +\right] \\ \text{VAL} & \left[\text{SPR} \quad \langle\, \text{Z} \,\rangle\right] \end{array}\right] \\
\text{ARG-ST} & \langle\, \boxed{1} \,\rangle \oplus \left\langle \left[\begin{array}{ll} \text{INDEX} & s_2 \\ \text{RESTR} & \left\langle \left[\text{ARG} \quad s_1\right] \right\rangle \end{array}\right]^{\text{ADV}_{pol}} \right\rangle \oplus \boxed{\text{A}} \\
\text{SEM} & \left[\text{INDEX} \quad s_2\right]
\end{array}\right]\right\rangle
\end{array}\right]
$$

Andy must <u>not</u> have been sleeping? ✓

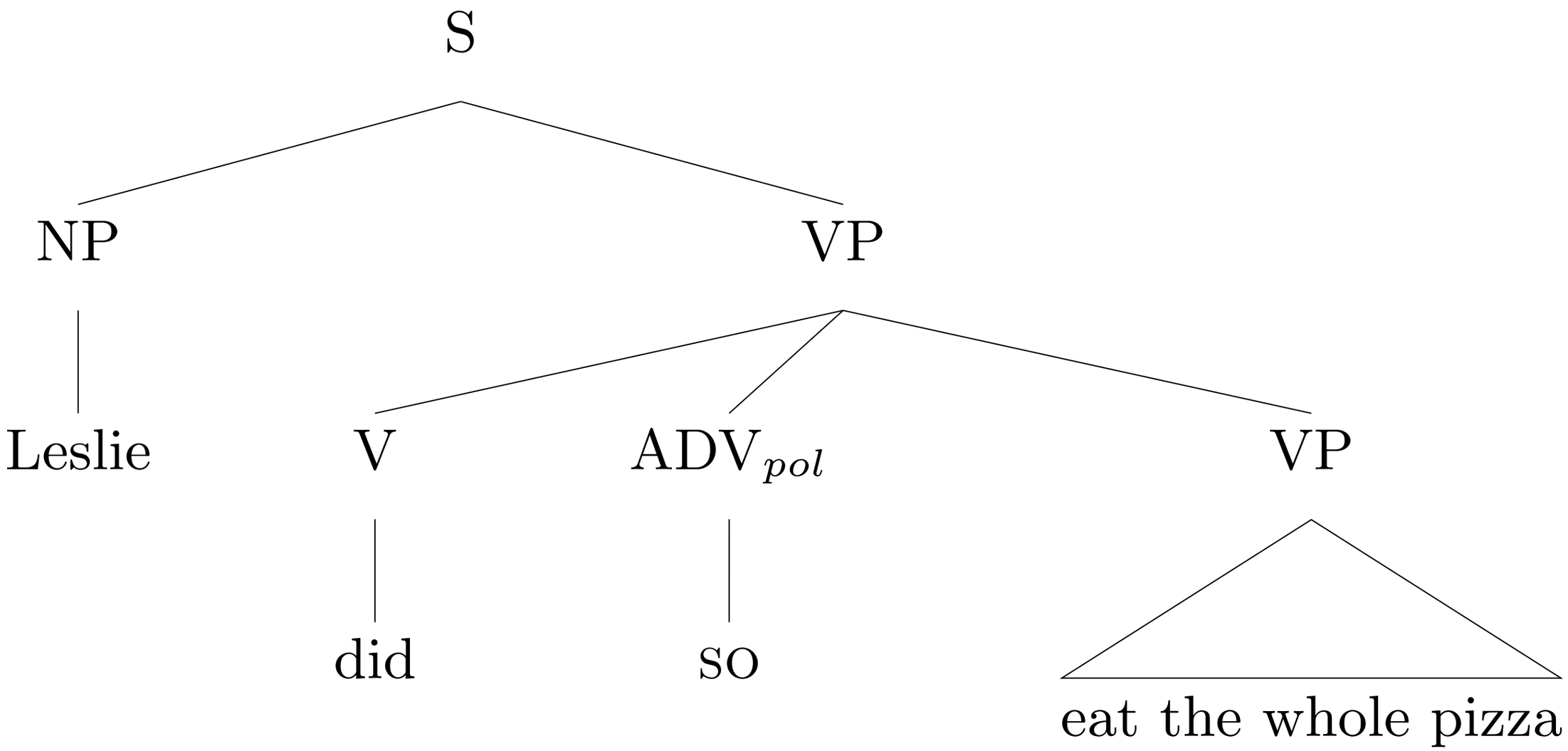
Andy must have <u>not</u> been sleeping? ✗

Andy must have been <u>not</u> sleeping? ✗

Kleptomaniacs can<u>not</u> not steal. ✓

Kleptomaniacs cannot <u>not</u> steal. ✗

Negation and Reaffirmation: A Sample Tree



Inversion

- Yes-no questions begin with an auxiliary:
  Will Robin win?
- The NP after the auxiliary has all the properties of a subject
  - Agreement: *Have they left?* vs. **Has they left?*
  - Case: **Have them left?*
  - Raising: *Will there continue to be food at the meetings?*
- What happens if you make a question out of a sentence without an auxiliary?
  Robin won
  Did Robin win?

The Inversion Lexical Rule

$$\left[\begin{array}{l}\textit{pi-rule} \\ \\ \text{INPUT} \quad \left\langle \text{W} \,, \left[\begin{array}{ll}\text{SYN} & \left[\begin{array}{ll}\text{HEAD} & \left[\begin{array}{ll}\textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{AUX} & + \end{array}\right] \\ \text{VAL} & \left[\text{SPR} \quad \langle\ \text{X}\ \rangle\right] \end{array}\right] \\ \text{ARG-ST} & \boxed{\text{A}} \\ \text{SEM} & \left[\text{MODE} \quad \text{prop}\right] \end{array}\right] \right\rangle \\ \\ \text{OUTPUT} \quad \left\langle \text{Z} \,, \left[\begin{array}{ll}\text{SYN} & \left[\begin{array}{ll}\text{HEAD} & \left[\text{INV} \quad +\right] \\ \text{VAL} & \left[\text{SPR} \quad \langle\ \rangle\right] \end{array}\right] \\ \text{ARG-ST} & \boxed{\text{A}} \\ \text{SEM} & \left[\text{MODE} \quad \text{ques}\right] \end{array}\right] \right\rangle \end{array}\right]$$

How the Rule Yields Inverted Order

$$\left[\begin{array}{l}
\textit{pi-rule} \\
\\
\text{INPUT} \quad \left\langle \text{W} \,, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{AUX} & + \end{array}\right] \\
\text{VAL} & \left[\mathbf{SPR} \quad \langle\, \mathbf{X} \,\rangle\right]
\end{array}\right] \\
\text{ARG-ST} & \boxed{\text{A}} \\
\text{SEM} & \left[\text{MODE} \quad \text{prop}\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{Z} \,, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\text{INV} \quad +\right] \\
\text{VAL} & \left[\mathbf{SPR} \quad \langle\ \rangle\right]
\end{array}\right] \\
\text{ARG-ST} & \boxed{\text{A}} \\
\text{SEM} & \left[\text{MODE} \quad \text{ques}\right]
\end{array}\right] \right\rangle
\end{array}\right]$$

...plus the ARP

The Feature INV

- What is the INV value of inputs to the Inversion LR?
  - Perhaps surprisingly, the input is [INV +]
  - Word-to-word rules (*pi-rule*s) have default identity of HEAD features, and no INV value is given on the input
- Then what work is the feature doing?
  - It's used to mark auxiliaries that can't or must be inverted

    You better watch out *vs.* **Better you watch out*

    I shall go (*shall* ~ 'will') *vs.* *Shall I go?* (*shall* ~ 'should')

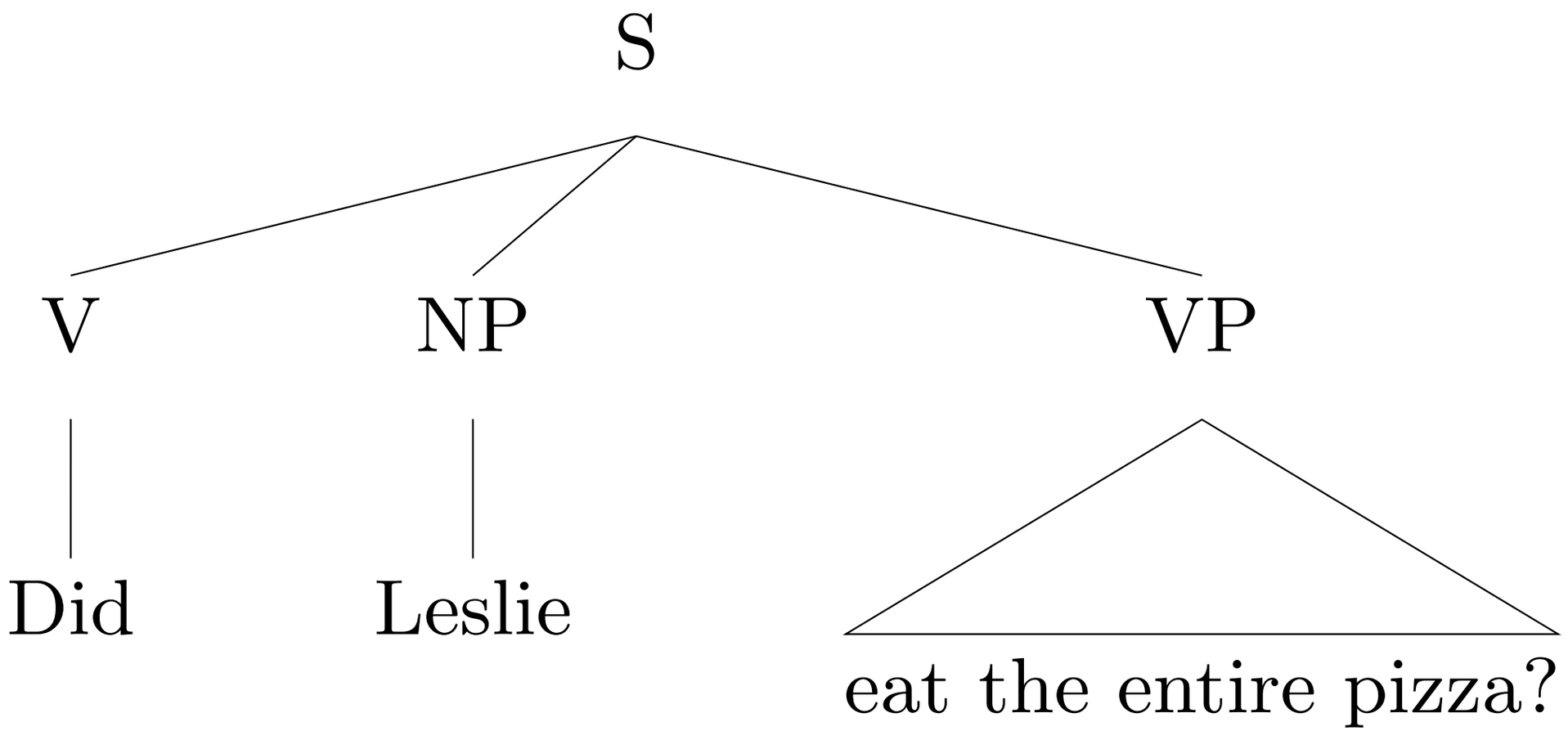
Other Cases of Inversion

- Inversion is not limited to questions
  - Preposed negatives: *Never **have I** been so upset!*
  - Conditionals: ***Had we** known, we would have left.*
  - Exclamations: ***May your teeth** fall out!*

- Does our rule account for these?
  - No. Our rule's output says [MODE ques]. And each construction has slightly different idiosyncrasies.

- How might we extend our analysis to cover them?
  - Define a type of inversion lexical rules, sharing certain properties, but with some differences.

Inversion: A Sample Tree



Contraction

- There are several types of contraction in English, but we're only talking about words ending in *n't*
- It may seem like just *not* said fast, but there's more to it
  - Only finite verbs can take *n't*:
    **Terry must haven't seen us*
  - There are morphological irregularities:
    won't, not **willn't* *%shan't*, not **shalln't*
    mustn't pronounced *mussn't*
    don't pronounced *doen't*, not *dewn't*
    **amn't*

The Contraction Lexical Rule

$$
\left[\begin{array}{l}
\textit{pi-rule} \\
\\
\text{INPUT} \quad \left\langle \boxed{2}\,, \left[\begin{array}{ll}
\text{SYN} & \left[\text{HEAD} \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{AUX} & + \\ \text{POL} & - \end{array}\right]\right] \\
\text{ARG-ST} & \boxed{B} \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{F}_{NEG}(\boxed{2})\,, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\text{POL} \quad +\right] \\ \text{VAL} & \left[\text{SPR} \quad \langle\ \text{X}\ \rangle\right] \end{array}\right] \\
\text{ARG-ST} & \boxed{B} \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_2 \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \textbf{not} \\ \text{SIT} & s_2 \\ \text{ARG} & s_1 \end{array}\right] \right\rangle \oplus \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle
\end{array}\right]
$$

Most of the work is in the semantics

$$
\left[\begin{array}{l}
\textit{pi-rule} \\
\\
\text{INPUT} \quad \left\langle \boxed{2}, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{AUX} & + \\ \text{POL} & - \end{array}\right] \\
\text{ARG-ST} & \boxed{B}
\end{array}\right] \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{F}_{NEG}(\boxed{2}), \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\text{POL} \quad +\right] \\
\text{VAL} & \left[\text{SPR} \quad \langle\ \text{X}\ \rangle\right]
\end{array}\right] \\
\text{ARG-ST} & \boxed{B} \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_2 \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \textbf{not} \\ \text{SIT} & s_2 \\ \text{ARG} & s_1 \end{array}\right] \right\rangle \oplus \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle
\end{array}\right]
$$

Why?

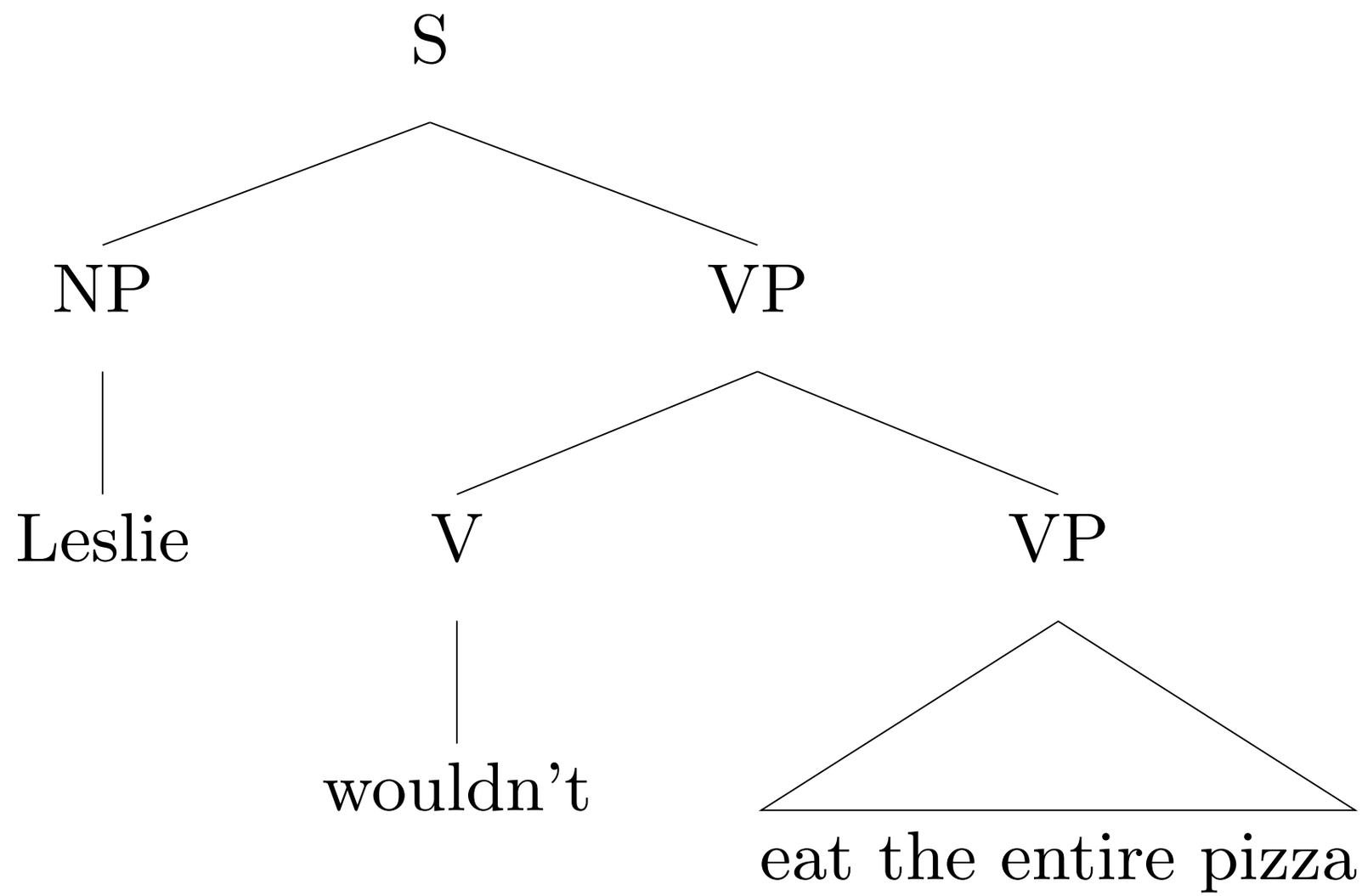
What does POL do?

$$
\left[\begin{array}{l}
\textit{pi-rule} \\
\text{INPUT} \quad \left\langle \boxed{2}, \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\begin{array}{ll} \textit{verb} & \\ \text{FORM} & \text{fin} \\ \text{AUX} & + \\ \text{POL} & - \end{array}\right] \\
\text{ARG-ST} & \boxed{B}
\end{array}\right] \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_1 \\ \text{RESTR} & \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle \\
\\
\text{OUTPUT} \quad \left\langle \text{F}_{NEG}(\boxed{2}), \left[\begin{array}{ll}
\text{SYN} & \left[\begin{array}{ll}
\text{HEAD} & \left[\text{POL} \quad +\right] \\
\text{VAL} & \left[\text{SPR} \quad \langle\ \text{X}\ \rangle\right]
\end{array}\right] \\
\text{ARG-ST} & \boxed{B} \\
\text{SEM} & \left[\begin{array}{ll} \text{INDEX} & s_2 \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \textbf{not} \\ \text{SIT} & s_2 \\ \text{ARG} & s_1 \end{array}\right] \right\rangle \oplus \boxed{A} \end{array}\right]
\end{array}\right] \right\rangle
\end{array}\right]
$$

**We can'tn't stop*

**They won't TOO mind*

Contraction: Sample Tree



Ellipsis

- Ellipsis allows VPs to be omitted, so long as they would have been preceded by an auxiliary

Pat couldn't have been watching us, but
Chris could have been watching us.

- Unlike the other NICE properties, this holds of all auxiliaries, not just finite ones.

- What is the elliptical counterpart to a sentence with no auxiliary?

Whenever Pat watches TV, Chris watches TV
Whenever Pat watches TV, Chris does

The Ellipsis Lexical Rule

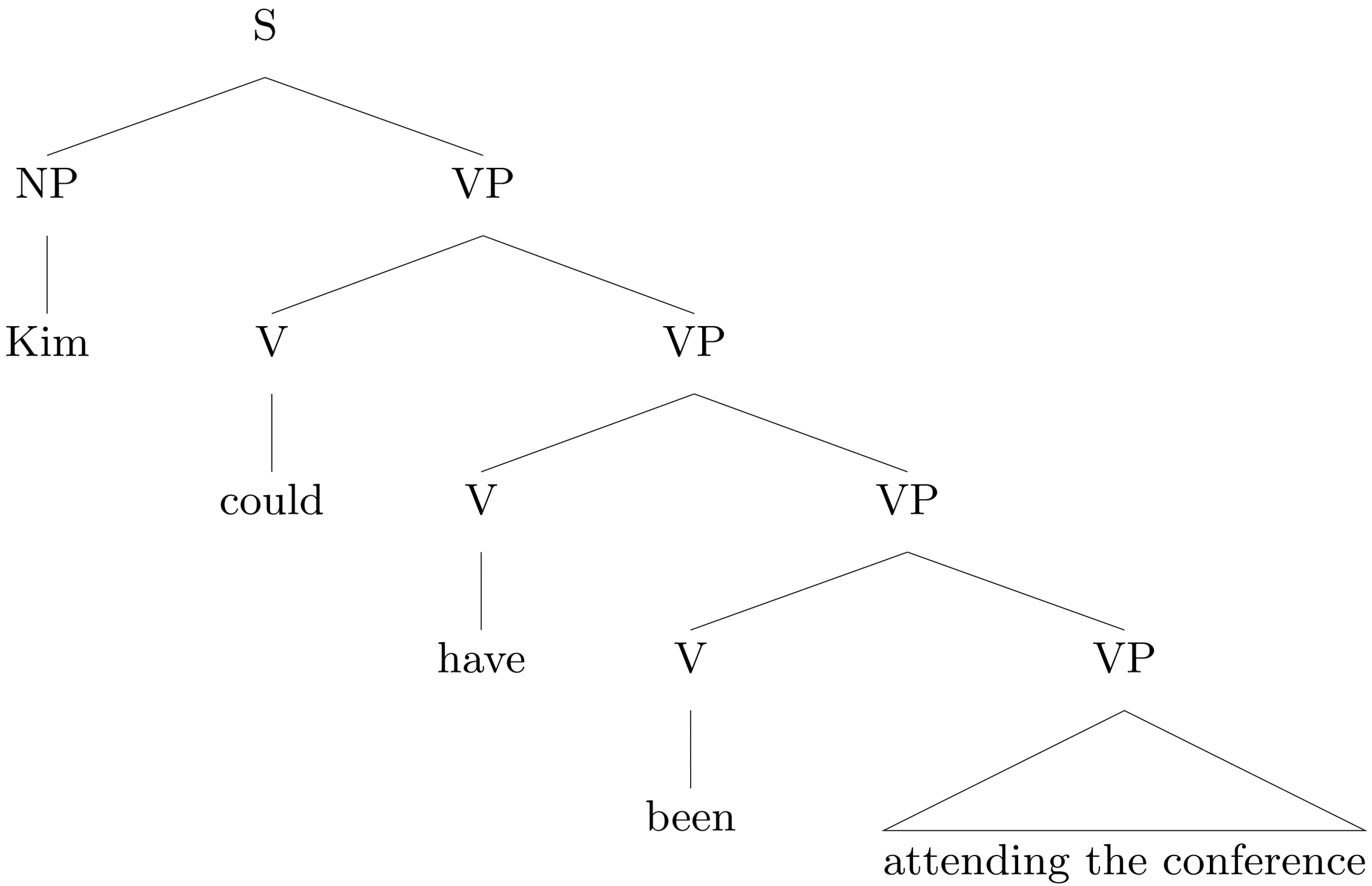
$$\left[\begin{array}{l} \textit{d-rule} \\ \text{INPUT} \quad \left\langle \boxed{1}, \left[\begin{array}{l} \textit{auxv-lxm} \\ \text{ARG-ST} \quad \langle\, \boxed{2} \,\rangle \;\oplus\; \boxed{\text{A}} \end{array}\right] \right\rangle \\ \text{OUTPUT} \quad \left\langle \boxed{1}, \left[\begin{array}{l} \textit{dervv-lxm} \\ \text{ARG-ST} \quad \langle\, \boxed{2} \,\rangle \end{array}\right] \right\rangle \end{array}\right]$$

- Note that this is a derivational LR (*d-rule*) -- that is, lexeme-to-lexeme
- This means that SYN and SEM are unchanged, by default

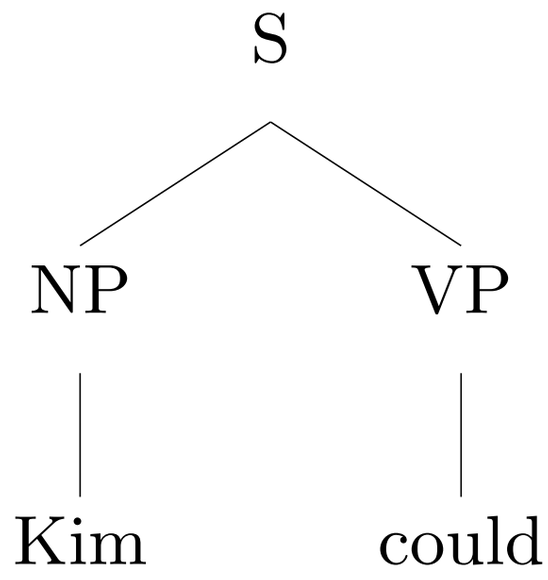
Ellipsis: A Sample Output

$$\left\langle \text{could} , \left[\begin{array}{ll} \textit{auxv-lxm} & \\ \text{SYN} & \left[\begin{array}{ll} \text{HEAD} & \left[\begin{array}{ll} \text{FORM} & \text{fin} \\ \text{AUX} & + \\ \text{POL} & - \\ \text{AGR} & \boxed{1} \end{array}\right] \\ \text{VAL} & \left[\begin{array}{ll} \text{SPR} & \langle\, [\text{AGR } \boxed{1}] \,\rangle \end{array}\right] \end{array}\right] \\ \text{ARG-ST} & \langle\, \text{NP} \,\rangle \\ \text{SEM} & \left[\begin{array}{ll} \text{MODE} & \text{prop} \\ \text{INDEX} & s_1 \\ \text{RESTR} & \left\langle \left[\begin{array}{ll} \text{RELN} & \text{could} \\ \text{SIT} & s_1 \\ \text{ARG} & s_2 \end{array}\right] \right\rangle \end{array}\right] \end{array}\right] \right\rangle$$

Ellipsis: A Sample Tree



Semantics of Ellipsis



What is the SEM value of the S node of this tree?

$$\begin{bmatrix} \text{INDEX} & s_1 \\ \text{MODE} & \text{prop} \\ \text{RESTR} & \left\langle \begin{bmatrix} \text{RELN} & \text{name} \\ \text{NAME} & \text{Kim} \\ \text{NAMED} & i \end{bmatrix}, \begin{bmatrix} \text{RELN} & \text{could} \\ \text{SIT} & s_1 \\ \text{ARG} & s_2 \end{bmatrix} \right\rangle \end{bmatrix}$$

Note: s_2 has to be filled in by context.

Infinitival *to* Revisited

- VP Ellipsis can occur after *to*:

  We didn't find the solution, but we tried to.

- This is covered by our Ellipsis LR if we say *to* is [AUX +].

- Since AUX is declared on type *verb*, it follows that *to* is a verb.

do Revisited

- Chomsky's old analysis: in sentences w/o auxiliaries...
  - Tense can get separated from the verb in various ways
    - Negation/Reaffirmation inserts something between Tense and the following verb
    - Inversion moves Tense to the left of the subject NP
    - Ellipsis deletes what follows Tense
    - When this happens, *do* is inserted to support Tense

- Our counterpart:
  - NICE properties hold only of auxiliaries
  - *do* is a semantically empty auxiliary, so negated, reaffirmed, inverted, and elliptical sentences that are the semantic counterparts to sentences w/o auxiliaries are ones with *do*.

Summary

- Our analysis employs straightforward mechanisms
  - Lexical entries for auxiliaries
  - 3 new features (AUX, POL, INV)
  - 4 lexical rules
- We handle a complex array of facts
  - co-occurrence restrictions (ordering & iteration)
  - the NICE properties
  - auxiliary *do*
  - combinations of NICE constructions