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*
  • The relevant facts, and our analysis, will be covered next time.

• 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

<table>
<thead>
<tr>
<th><strong>TYPE</strong></th>
<th><strong>FEATURES/CONSTRAINTS</strong></th>
<th><strong>IST</strong></th>
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<tbody>
<tr>
<td><em>verb-lxm</em></td>
<td><img src="feature_representation.png" alt="Feature representation" /></td>
<td><em>infl-lxm</em></td>
</tr>
<tr>
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</tr>
<tr>
<td><em>auxv-lxm</em></td>
<td><img src="feature_representation.png" alt="Feature representation" /></td>
<td><em>srv-lxm</em></td>
</tr>
</tbody>
</table>
A Lexical Entry for \textit{be}

\[
\langle \text{be}, \begin{bmatrix}
\text{auxv-lxm} \\
\text{ARG-ST} \\
\text{SEM}
\end{bmatrix}
\begin{aligned}
\langle \text{X}, \\
\text{SYN} \\
\text{SEM} \\
\text{INDEX} \quad [2] \\
\text{RESTR} \quad \langle \rangle
\end{aligned}
\rangle
\]
The Entry for *be*, with Inherited Information

\[
\begin{array}{c}
\text{ SYN } \begin{bmatrix}
\text{HEAD} \\
\text{VAL} \\
\text{SEM}
\end{bmatrix}
\end{array}
\]

\[
\begin{array}{c}
\text{ ARG-ST } \begin{bmatrix}
\text{SYN} \\
\text{VAL} \\
\text{SEM}
\end{bmatrix}
\end{array}
\]

\[
\begin{array}{c}
\text{ SEM } \begin{bmatrix}
\text{MODE} \\
\text{INDEX} \\
\text{RESTR}
\end{bmatrix}
\end{array}
\]
Entry for have

\[ \langle \text{have}, \begin{array}{c}
\text{auxv-lxm} \\
\text{ARG-ST} \langle X, \begin{array}{c}
\text{SYN} \begin{array}{c}
\text{HEAD} \begin{array}{c}
\text{verb} \\
\text{FORM psp}
\end{array}
\end{array}
\end{array}
\end{array}
\end{array}
\rangle
\begin{array}{c}
\text{SEM} \langle \begin{array}{c}
\text{INDEX } 3
\end{array}
\begin{array}{c}
\text{RESTR} \langle \begin{array}{c}
\text{RELN} \text{ have}
\end{array}
\end{array}
\end{array}
\rangle
\end{array}
\rangle
\end{array}
\]}
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

\[
S \rightarrow \text{NP} \ \text{AUX} \ \text{VP}
\]

\[
\text{AUX} \rightarrow T(M)(\text{PERF})(\text{PROG})
\]
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* 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*

• 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 treatment of ellipsis is presented in the next class
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

<table>
<thead>
<tr>
<th><strong>Negation</strong></th>
<th>Sentences are negated by putting <em>not</em> after the first auxiliary verb; they can be reaffirmed by putting <em>too</em> or <em>so</em> in the same position</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inversion</strong></td>
<td>Questions are formed by putting an auxiliary verb before the subject NP</td>
</tr>
<tr>
<td><strong>Contraction</strong></td>
<td>Auxiliary verbs take negated forms, with <em>n’t</em> affixed</td>
</tr>
<tr>
<td><strong>Ellipsis</strong></td>
<td>Verb phrases immediately following an auxiliary verb can be omitted</td>
</tr>
</tbody>
</table>
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*
The ADV\textsubscript{pol}-Addition Lexical Rule

\[\begin{array}{l}
\text{INPUT} \quad \langle X, \ 0 \rangle \oplus \text{A} \\
\text{ARG-ST} \quad \langle 1 \rangle \oplus \text{A} \\
\text{SEM} \quad \text{INDEX} \ s_1 \\
\text{SYN} \quad \text{HEAD} \ 0 \ 0 \\
\text{OUTPUT} \quad \langle Y, \ 0 \rangle \oplus \langle \text{ADV}_{pol} \ s_2 \rangle \\
\text{ARG-ST} \quad \langle 1 \rangle \oplus \langle \text{INDEX} \ s_2 \rangle \\
\text{SEM} \quad \text{INDEX} \ s_2 \\
\end{array}\]
What does the type \textit{pi-rule} mean?

\begin{itemize}
\item It maps words to words (hence, “post-inflectional”)
\item It preserves MOD values, HEAD values as a default, and (like other lexical rule types) SEM values as a default
\end{itemize}
Why doesn’t $\text{ADV}_{pol}$-Addition LR mention VAL?

\[
\begin{align*}
\text{INPUT} & \quad \langle X, \rangle \\
\text{ARG-ST} & \quad \langle \square \rangle \oplus \text{A} \\
\text{SEM} & \quad \text{INDEX } s_1 \\
\text{SYN} & \quad \text{HEAD } [\verb FORM fin] \\
\text{OUTPUT} & \quad \langle Y, \rangle \\
\text{ARG-ST} & \quad \langle \square \rangle \oplus \left\langle \text{INDEX } s_2 \right\rangle \\
\text{SEM} & \quad \text{INDEX } s_2 \\
\end{align*}
\]
What is the role of these indices?
Which *nots* does the rule license?

Andy must *not* have been sleeping? ✓

Andy must have *not* been sleeping? ✗

Andy must have been *not* sleeping? ✗

*Kleptomaniacs cannot not steal.* ✓

*Kleptomaniacs cannot not steal.* ✗
Negation and Reaffirmation: A Sample Tree

S

NP

Leslie

VP

V

did

ADV_{pol}

so

VP

eat the whole pizza
Inversion

• Yes-no questions begin with an auxiliary: 
  \textit{Will Robin win?}

• The NP after the auxiliary has all the properties of a subject
  • Agreement: \textit{Have they left?} vs. *\textit{Has they left?}
  • Case: *\textit{Have them left?}
  • Raising: \textit{Will there continue to be food at the meetings?}

• What happens if you make a question out of a sentence without an auxiliary?
  \textit{Robin won}
  \textit{Did Robin win?}
The Inversion Lexical Rule

\[ \text{pi-rule} \]

INPUT \( \langle W, \) \)

ARG-ST \[ A \]

SEM \[ \text{MODE prop} \]

SYN \[ \text{HEAD \ FORM fin AUX +} \]

VAL \[ \text{SPR } \langle X \rangle \]

OUTPUT \( \langle Z, \) \)

ARG-ST \[ A \]

SEM \[ \text{MODE ques} \]

SYN \[ \text{HEAD \ INV +} \]

VAL \[ \text{SPR } \langle \rangle \]
How the Rule Yields Inverted Order

\[
\begin{align*}
\pi\text{-rule} & \quad \left[ \begin{array}{c}
\text{INPUT} \quad \left\langle W, \right. \\
\text{ARG-ST} \quad \text{SEM} & \left. \right. \\
\text{SYN} & \left. \right. \\
\text{VAL} & \left. \right. \\
\text{HEAD} & \left. \right. \\
\text{FORM} & \left. \right. \\
\text{FIN} & \left. \right. \\
\text{AUX} & \left. \right. \\
\text{VERB} + & \left. \right. \\
\text{SPR} \left\langle \langle X \rangle \right. \\
\text{VAL} & \left. \right. \\
\text{MODE} & \left. \right. \\
\text{PROP} & \left. \right. \\
\text{SEM} & \left. \right. \\
\text{ARG-ST} & \left. \right. \\
\text{SEM} & \left. \right. \\
\text{SYN} & \left. \right. \\
\text{VAL} & \left. \right. \\
\text{HEAD} & \left. \right. \\
\text{INV} + & \left. \right. \\
\text{SPR} \left\langle \langle \rangle \right. \\
\text{VAL} & \left. \right. \\
\text{MODE} & \left. \right. \\
\text{QUES} & \left. \right. \\
\end{array} \right]
\end{align*}
\]
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-rules) 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

```
S
  /  
V   NP
    /  
Did Leslie
  /  
VP
      /  
      eat the entire pizza?
```
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

\[
\text{\textit{pi-rule}}
\]

\[
\text{INPUT} \quad \left\langle \begin{array}{c}
[2], \\
\text{ARG-ST} \; \mathbf{B}
\end{array} \right\rangle
\]

\[
\text{SYN} \quad \text{HEAD} \quad \begin{bmatrix}
\text{verb} \\
\text{FORM} \\
\text{AUX} \\
\text{POL}
\end{bmatrix}
\]

\[
\text{SEM} \quad \begin{bmatrix}
\text{INDEX} \\
\text{RESTR}
\end{bmatrix}
\]

\[
\text{OUTPUT} \quad \left\langle \begin{array}{c}
\text{F}_{\text{NEG}}(2), \\
\text{ARG-ST} \; \mathbf{B}
\end{array} \right\rangle
\]

\[
\text{SYN} \quad \text{HEAD} \quad \begin{bmatrix}
\text{POL} \\
\text{SPR} \; \langle X \rangle
\end{bmatrix}
\]

\[
\text{VAL} \quad \begin{bmatrix}
\text{POL} \\
\text{SPR} \; \langle X \rangle
\end{bmatrix}
\]

\[
\text{INDEX} \quad \begin{bmatrix}
s_2
\end{bmatrix}
\]

\[
\text{RESTR} \quad \left\langle \begin{array}{c}
\text{RELN} \\
\text{SIT} \\
\text{ARG}
\end{array} \right\rangle \oplus \mathbf{A}
\]

\[
\text{not} \\
\begin{bmatrix}
s_2 \\
\text{not} \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
s_2 \\
\text{not} \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
s_2 \\
\text{not} \\
\end{bmatrix}
\]
Most of the work is in the semantics

\[
\begin{bmatrix}
\pi\text{-rule} \\
\text{INPUT}
\end{bmatrix}
\begin{bmatrix}
\text{SYN} \\
\text{HEAD} \\
\text{ARG-ST} \\
\text{SEM}
\end{bmatrix}
\begin{bmatrix}
\text{verb} \\
\text{FORM fin} \\
\text{AUX +} \\
\text{POL -}
\end{bmatrix}
\begin{bmatrix}
\text{INDEX} s_1 \\
\text{RESTR A}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\text{SYN} \\
\text{VAL} \\
\text{ARG-ST}
\end{bmatrix}
\begin{bmatrix}
\text{HEAD} [\text{POL +}] \\
\text{SPR} \langle X \rangle
\end{bmatrix}
\begin{bmatrix}
\text{INDEX} s_2 \\
\text{RESTR}
\end{bmatrix}
\begin{bmatrix}
\text{RELN not} s_2 \\
\text{SIT s_1}
\end{bmatrix}
\oplus A
\]

Why?
What does POL do?

\[
\begin{align*}
\text{INPUT} & \quad \langle 2, \pi\text{-rule} \rangle \\
\text{ARG-ST} & \quad \langle [\text{INDEX } s_1, \text{RESTRICTION } A] \rangle \\
\text{SEM} & \quad \langle [\text{HEAD } \left[ \begin{array}{c} \text{POL} + \\ \text{SPR} \ 〈 X 〉 \end{array} \right], \text{VAL } \left[ \begin{array}{c} \text{POL} + \\ \text{fin} \\ \text{AUX} + \\ \text{POL} - \end{array} \right] \rangle \rangle \\
\text{OUTPUT} & \quad \langle F_{\text{NEG}}(2), \pi\text{-rule} \rangle \\
\text{ARG-ST} & \quad \langle [\text{INDEX } s_2, \text{RESTRICTION } A] \rangle \\
\text{SEM} & \quad \langle [\text{RELN } \left[ \begin{array}{c} \text{not} \\ \text{SIT} \\ \text{ARG } s_2 \\ s_1 \end{array} \right], \text{SIT } s_2 \rangle \rangle \\
\end{align*}
\]

*We can’t, can’t stop*

*They won’t, won’t TOO mind*
Contraction: Sample Tree

S

NP

Leslie

VP

V

wouldn’t

eat the entire pizza

VP
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

\[
\begin{align*}
\text{INPUT} & \quad \langle 1, \left[ \begin{array}{c}
\text{auxv-lxm} \\
\text{ARG-ST} \langle 2 \rangle \oplus A
\end{array} \right] \rangle \\
\text{OUTPUT} & \quad \langle 1, \left[ \begin{array}{c}
\text{dervv-lxm} \\
\text{ARG-ST} \langle 2 \rangle
\end{array} \right] \rangle
\end{align*}
\]

- Note that this is a derivational LR (\textit{d-rule}) -- that is, lexeme-to-lexeme

- This means that SYN and SEM are unchanged, by default
Ellipsis: A Sample Output

\[
\langle \text{could} , \\
\begin{array}{c}
\text{auxv-lxm} \\
\text{SYN} \\
\text{ARG-ST} \\
\text{SEM}
\end{array}
\begin{array}{c}
\begin{bmatrix}
\text{FORM} & \text{fin} \\
\text{AUX} & + \\
\text{POL} & - \\
\text{AGR} & 1
\end{bmatrix} \\
\begin{bmatrix}
\text{SPR} & \langle [\text{AGR} 1] \rangle \\
\text{MODE} & \text{prop} \\
\text{INDEX} & s_1 \\
\text{RESTR} & \langle [\text{RELN} \text{could}] \rangle \\
\text{SIT} & s_1 \\
\text{ARG} & s_2
\end{bmatrix}
\end{array}
\rangle
\]
Kim could have been attending the conference.
Semantics of Ellipsis

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

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