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

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FEATURES/CONSTRAINTS</th>
<th>IST</th>
</tr>
</thead>
</table>
| **verb-lxm** | SYN \[HEAD \[verb \AUX / −\]\]\]
ARG-ST \{ [HEAD nominal] , ... \}
SEM \[MODE prop]\] | **infl-lxm** |
| **srv-lxm** | ARG-ST \[1, [SPR \[1]\] COMPS \[\]\]\] | **verb-lxm** |
| **ic-srv-lxm** | ARG-ST \[X, [INF + INDEX s]\]
SEM \[RESTR \[ARG s]\]\] | **srv-lxm** |
| **auxv-lxm** | SYN \[HEAD \[AUX +\]\]\] | **srv-lxm** |
A Lexical Entry for \textit{be}

\[
\langle \text{be} , \begin{align*}
\text{ARG-ST} & : \langle X , \begin{align*}
\text{SYN} & : \langle \text{X} , \\
\text{SEM} & : \langle \text{X} , \\
\text{INDEX} & : 2, \\
\text{RESTRICTION} & \rangle
\end{align*} \rangle \\
\text{SEM} & : \langle \text{INDEX} : 2, \\
\text{RESTRICTION} & \rangle
\end{align*} \rangle
\]

\[
\langle \text{auxv-lxm} \rangle
\]

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The Entry for *be*, with Inherited Information

\[ \langle \text{be} , \rangle \]

ARG-ST \[ \langle 3 , \rangle \]

SEM \[ [\text{MODE prop}] \]

INDEX \[ 2 \]

RESTR \[ \langle \rangle \]

SEM \[ [\text{INDEX 2}] \]

SYN \[ [\text{SYN}] \]

VAL \[ [\text{VAL}] \]

HEAD \[ [\text{HEAD}] \]

AUX + \[ [\text{AUX +}] \]

AGR \[ [\text{AGR}] \]

SPR \[ [\text{SPR}] \]

PRED + \[ [\text{PRED +}] \]

COMPS \[ [\text{COMPS}] \]

INDEX \[ 2 \]

MODE \[ [\text{MODE}] \]

prop \[ [\text{prop}] \]

RESTR \[ [\text{RESTR}] \]
Entry for *have*

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

\[ \langle \text{would} , \rangle \]

\[
\begin{align*}
\text{auxv-lxm} & : \begin{cases}
\text{SYN} : \begin{cases}
\text{HEAD} : \begin{cases}
\text{FORM} : \text{fin}
\end{cases}
\end{cases}
\end{cases}
\end{align*}
\]

\[
\begin{align*}
\text{ARG-ST} & \begin{cases}
\langle X , \rangle \\
\text{SYN} : \begin{cases}
\text{HEAD} : \begin{cases}
\text{INF} : - \\
\text{FORM} : \text{base}
\end{cases}
\end{cases}
\end{cases}
\end{align*}
\]

\[
\begin{align*}
\text{SEM} & \begin{cases}
\text{INDEX} : s_2 \\
\text{INDEX} : s_1 \\
\text{RESTR} \begin{cases}
\text{RELN} : \text{would} \\
\text{SIT} : s_1 \\
\text{ARG} : s_2 
\end{cases}
\end{cases}
\end{align*}
\]

- 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

\[
S \rightarrow \text{NP AUX VP} \\
\text{AUX} \rightarrow T(M)(\text{PERF})(\text{PROG})
\]

```
Chris
  └╴T
    ├── past
    └╴M
        └╴could

have+en
  └╴PERF
    └╴be+ing

eat
  └╴PROG
    └╴V
```

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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*

• 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

<table>
<thead>
<tr>
<th>N</th>
<th>Negation</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>I</td>
<td>Inversion</td>
<td>Questions are formed by putting an auxiliary verb before the subject NP.</td>
</tr>
<tr>
<td>C</td>
<td>Contraction</td>
<td>Auxiliary verbs take negated forms, with <em>n’t</em> affixed.</td>
</tr>
<tr>
<td>E</td>
<td>Ellipsis</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 \textit{do}

- Like modals, \textit{do} only occurs in finite contexts:
  *\textit{Pat continued to do not leave}*

- Unlike modals, \textit{do} cannot be followed by other auxiliaries:
  *\textit{Pat did not have left}*
The ADV\textsubscript{pol} Addition Lexical Rule

\[
\begin{align*}
\text{INPUT} & \quad \langle X, \rangle \\
\text{SYN} & \quad \langle \text{HEAD} \rangle \\
\text{ARG-ST} & \quad \langle 1 \rangle \oplus [A] \\
\text{SEM} & \quad \langle \text{INDEX} \rangle \\
\langle \text{Y,} \rangle \\
\text{SYN} & \quad \langle \text{HEAD} \rangle \\
\text{VAL} & \quad \langle \text{POL} \rangle \\
\langle \text{ADV}_{\text{pol}} \rangle \\
\text{ARG-ST} & \quad \langle 1 \rangle \oplus \langle \text{INDEX} \rangle \\
\text{SEM} & \quad \langle \text{INDEX} \rangle
\end{align*}
\]
What does the type \textit{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
Why doesn’t $\text{ADV}_{pol}$-Addition LR mention VAL?

\[
\begin{align*}
\text{INPUT} & \quad \left\langle X, \begin{array}{l}
\text{SYN} \quad \begin{bmatrix}
\text{HEAD} \quad \begin{bmatrix}
\text{verb} \quad \begin{bmatrix}
\text{FORM} \quad \text{fin} \\
\text{POL} \quad - \\
\text{AUX} \quad + 
\end{bmatrix}
\end{bmatrix} \\
\text{ARG-ST} \quad \left\langle 1 \right\rangle \oplus A
\end{array}
\end{bmatrix} \\
\text{SEM} & \quad \begin{bmatrix}
\text{INDEX} \quad s_1
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\text{OUTPUT} & \quad \left\langle Y, \begin{array}{l}
\text{SYN} & \quad \begin{bmatrix}
\text{HEAD} \quad \begin{bmatrix}
\text{POL} \quad + 
\end{bmatrix}
\end{bmatrix} \\
\text{VAL} & \quad \begin{bmatrix}
\text{SPR} \quad \left\langle Z \right\rangle
\end{bmatrix}
\end{array}
\end{bmatrix} \\
\text{ARG-ST} & \quad \left\langle 1 \right\rangle \oplus \begin{bmatrix}
\text{INDEX} \quad s_2 \\
\text{RESTR} \quad \left\langle [\text{ARG} \quad s_1] \right\rangle
\end{bmatrix} \oplus A \\
\text{SEM} & \quad \begin{bmatrix}
\text{INDEX} \quad s_2
\end{bmatrix}
\end{align*}
\]
What is the role of these indices?

```
pi-rule
```

**INPUT**

\[
\langle X, \quad \text{SYN} \quad \text{HEAD} \quad \text{POL} \quad \text{AUX} \quad \text{verb} \quad \text{FORM} \quad \text{fin} \quad \text{POL} \quad \text{AUX} \quad + \rangle
\]

\[
\langle 0 \rangle \oplus \langle A \rangle
\]

\[
\text{SEM} \quad \text{INDEX} \quad s_1
\]

**OUTPUT**

\[
\langle Y, \quad \text{SYN} \quad \text{HEAD} \quad \text{POL} \quad \text{SPR} \quad \text{ADV}_{pol} \rangle
\]

\[
\langle 0 \rangle \oplus \langle \text{RESTRICTION} \quad \text{INDEX} \quad s_2 \quad \text{ARG} \quad s_1 \rangle \oplus \langle A \rangle
\]

\[
\text{SEM} \quad \text{INDEX} \quad s_2
\]
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

NP
  Leslie

VP
  V
  did

ADV_{pol}
  so

VP
  eat the whole pizza
Inversion

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

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

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

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

INPUT \[ \langle W, \begin{array}{l} 
\text{SYN} \\
\text{ARG-ST} \\
\text{SEM} 
\end{array} \begin{array}{l} 
\text{HEAD} \\
\text{VAL} 
\end{array} \begin{array}{l} 
\text{FORM} \ 	ext{fin} \\
\text{AUX} \ + 
\end{array} \begin{array}{l} 
\text{SPR} \langle X \rangle 
\end{array} \rangle \]

OUTPUT \[ \langle Z, \begin{array}{l} 
\text{SYN} \\
\text{ARG-ST} \\
\text{SEM} 
\end{array} \begin{array}{l} 
\text{HEAD} \\
\text{VAL} 
\end{array} \begin{array}{l} 
\text{INV} \ + \\
\text{SPR} \langle \rangle 
\end{array} \begin{array}{l} 
\text{MODE} \ 	ext{prop} \\
\text{ques} 
\end{array} \rangle \]
How the Rule Yields Inverted Order

...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-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’)

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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

Did

NP

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 /mussn’t* pronounced *don’t /dewn’t*
  *amn’t* pronounced *doesn’t, not dewn’t*
The Contraction Lexical Rule

\[
\begin{align*}
\text{INPUT} & \quad \langle 2 \rangle, \\
\text{ARG-ST} & \quad \boxed{B} \\
\text{SEM} & \quad \begin{bmatrix}
\text{INDEX} & s_1 \\
\text{RESTR} & A
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\text{OUTPUT} & \quad F_{NEG}(2), \\
\text{ARG-ST} & \quad \boxed{B} \\
\text{SEM} & \quad \begin{bmatrix}
\text{INDEX} & s_2 \\
\text{RESTR} & \begin{bmatrix}
\text{RELN} & \text{not} \\
\text{SIT} & s_2 \\
\text{ARG} & s_1
\end{bmatrix}
\end{bmatrix}
\end{align*}
\]
Most of the work is in the semantics

Why?
What does POL do?

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

INPUT

\[ \left\langle 2, \begin{bmatrix} \text{SYN} \cr \text{HEAD} \cr \text{AUX} \cr \text{POL} \end{bmatrix} \right\rangle \]

arg-st \[ \begin{bmatrix} \text{INDEX} \cr \text{RESTR} \cr \text{SPR} \langle X \rangle \end{bmatrix} \]

sem

\[ \left\langle F_{\text{NEG}}(2), \begin{bmatrix} \text{SYN} \cr \text{VAL} \cr \text{ARG} \end{bmatrix} \right\rangle \]

output

\[ \begin{bmatrix} \text{INDEX} \\ \text{SIT} \\ \text{ARG} \end{bmatrix} \]

\[ \oplus \]

\[ *\text{We can’tn’t stop} \]
\[ *\text{They won’t TOO mind} \]
Contraction: Sample Tree

S

NP  VP

Leslie  V  VP

wouldn’t  eat the entire pizza
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

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

• 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

\[
\begin{array}{c}
\langle \text{could} , \\
\text{ARG-ST} \langle \text{NP} \rangle \\
\text{SEM} \\
\end{array}
\]

\[
\begin{array}{c}
\langle \text{auxv-lxm} \\
\text{SYN} \\
\text{SEM} \\
\end{array}
\]

\[
\begin{array}{c}
\text{FORM fin} \\
\text{AUX +} \\
\text{POL } - \\
\text{AGR } 1 \\
\text{SPR } \langle \text{[AGR } 1 \text{]} \rangle \\
\text{prop} \\
\text{s}_1 \\
\text{RELN could} \\
\text{SIT } s_1 \\
\text{ARG } s_2 \\
\end{array}
\]
Ellipsis: A Sample Tree

S
  NP
    Kim
  VP
    V
could
  VP
    V
    have
    VP
    V
    been
attending the conference
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