Auxiliary Verbs and Movement Phenomena

Allen’s Chapter 5
J&M’s Chapter 11
Auxiliary and Modal Verbs

- I can see the house.
- I will have seen the house.
- I was watching the movie.
- I should have been watching the movie.
- I am not going.
- He could not have seen the car.
- I did eat my carrots.
- Did you see the car?
### Auxiliary Verbs

**Example**: can see the house

**Example**: have seen the house

**Example**: is lifting the box

**Example**: was seen by the crowd

<table>
<thead>
<tr>
<th>Auxiliary</th>
<th>COMPFORM</th>
<th>Construction</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>modal</td>
<td>base</td>
<td>modal</td>
<td>can <em>see the house</em></td>
</tr>
<tr>
<td>have</td>
<td>pastprt</td>
<td>perfect</td>
<td>have <em>seen the house</em></td>
</tr>
<tr>
<td>be</td>
<td>ing</td>
<td>progressive</td>
<td>is <em>lifting the box</em></td>
</tr>
<tr>
<td>be</td>
<td>pastprt</td>
<td>passive</td>
<td>was <em>seen by the crowd</em></td>
</tr>
</tbody>
</table>
Auxiliary Verbs (*Sequence Constraints*)

\[
\text{VP} \rightarrow (\text{AUX \ COMPFORM} \ ?s) (\text{VP \ VFORM} \ ?s)
\]

Modal + have + be (Progressive) + be (Passive)

They might have been being played as they left.
* He has might see the movie already

I regret having been chosen to go
* I must be having been singing
Passive Sentences

\[ VP \rightarrow AUX \ [be] \ VP \ [ing, \ +main] \]

\[ VP \rightarrow AUX \ [be] \ VP \ [ing, \ +pass] \]

\[ VP \ [+pass] \rightarrow AUX \ [be] \ VP \ [pastprt, \ +main] \]
### Lexicon Samples

<table>
<thead>
<tr>
<th>can:</th>
<th>could:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CAT AUX MODAL + VFORM pres AGR {1s 2s 3s 1p 2p 3p} COMPFORM base)</td>
<td>(CAT AUX MODAL + VFORM {pres past} AGR {1s 2s 3s 1p 2p 3p} COMPFORM base)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>do:</th>
<th>did:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CAT AUX MODAL + VFORM pres AGR {1s 2s 1p 2p 3p} COMPFORM base)</td>
<td>(CAT AUX MODAL + VFORM past AGR {1s 2s 3s 1p 2p 3p} COMPFORM base)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>be:</th>
<th>have:</th>
</tr>
</thead>
<tbody>
<tr>
<td>(CAT AUX VFORM base ROOT be COMPFORM ing)</td>
<td>(CAT AUX VFORM base ROOT have COMPFORM pastprt)</td>
</tr>
</tbody>
</table>

**Figure 5.2** Lexicon entries for some auxiliary verbs
Passive Sentences

I will hide my hat in the drawer
My hat will be hidden in the drawer
I hid my hat in the drawer
My hat was hidden in the drawer
I was hiding my hat in the drawer
My hat was being hidden in the drawer
Passive sentences

• VP constituents in passive sentences have a missing NP
• Need a Head binary feature “passgap”

$$\text{VP [-passgap]} \rightarrow \text{V [\_np]} \text{ NP}$$
$$\text{VP [+passgap]} \rightarrow \text{V [\_np]}$$
Passive Sentences

1. \( S[-inv] \rightarrow (NP \ AGR \ ?a) \ (VP \ [fin] \ AGR \ ?a) \)
2. \( VP \rightarrow (AUX \ COMPFORM \ ?v) \ (VP \ VFORM \ ?v) \)
3. \( VP \rightarrow AUX[be] \ VP[ing, +main] \)
4. \( VP \rightarrow AUX[be] \ VP[ing, +pass] \)
5. \( VP[+pass] \rightarrow AUX[be] \ VP[pastprt, main, +passgap] \)
6. \( VP[-passgap, +main] \rightarrow V[\_none] \)
7. \( VP[-passgap, +main] \rightarrow V[\_np] \ NP \)
8. \( VP[+passgap, +main] \rightarrow V[\_np] \)
9. \( NP \rightarrow (ART \ AGR \ ?a) \ (N \ AGR \ ?a) \)
10. \( NP \rightarrow NAME \)
11. \( NP \rightarrow PRO \)

Head features for S, VP: AGR and VFORM
Head features for NP: AGR

Figure 5.3  A fragment handling auxiliaries including passives
Rule 1 & 2 & ((7 & 9) or (5 & 8))

Figure 5.4  An active and a passive form sentence
Movement phenomena

• Local (bounded) movement
  Subject-aux inversion
  Jack is giving Sue a book
  Is Jack giving Sue a book?
  He will run in the marathon next year
  Will he run in the marathon next year?
  John went to the store
  Did John go to the store?
  Henry goes to school everyday
  Does Henry go to school everyday?
Movement Phenomena

• Unbounded movement

wh-questions

The fat man will angrily put the book in the corner
Which man will angrily put the book in the corner
Who will angrily put the book in the corner
How will the fat man put the book in the corner
In what way will the fat man put the book in the corner
What will the fat man put angrily in the corner
Where will the fat man angrily put the book
What will the fat man angrily put the book in
Similar to yes/no questions

I found a book case
Did I find a book case?
What did I find?

• So we can use part of the grammar for Yes/no questions
• But there is a missing constituent
  What will the fat man angrily put in the corner

* I angrily put in the corner
Holes and Fillers

• There is a Hole somewhere in a constituent

• The moved part is a Filler for that hole
What will the fat man angrily put in the corner
• Is parsed as if it were:
  … angrily put what in the corner

What did you put in the cupboard?
* What did you put the bottle in the cupboard
Questions in CFGs

\[ S[+inv] \rightarrow (\text{AUX AGR } ?a \text{ SUBCAT } ?v) \]
\[ (\text{NP AGR } ?a) (\text{VP VFORM } ?v) \]

\[ (\text{NP GAP (CAT NP AGR } ?a) \text{ AGR } ?a) \rightarrow \varepsilon \]

- Inserting GAP Features automatically
  1. Lexical Head
     \[ \text{VP} \rightarrow \text{V } [\_np_vp:inf] \text{ NP VP} \]
     \[ (\text{VP GAP } ?g) \rightarrow \text{V } [\_np_vp:inf] (\text{NP GAP } ?g) (\text{VP GAP } -) \]
     \[ (\text{VP GAP } ?g) \rightarrow \text{V } [\_np_vp:inf] (\text{NP GAP } -) (\text{VP GAP } ?g) \]

  2. Non Lexical Head
     \[ (\text{S GAP } ?g) \rightarrow (\text{NP GAP } -) (\text{VP GAP } ?g) \]
Adding Gap features to a grammar

For each rule $Y \rightarrow X_1 \ldots H_i \ldots X_n$ with head constituent $H_i$

1. If the rule specifies a Gap feature in some constituent already, then skip.
2. If the head $H_i$ is not a lexical category, then add a Gap feature to the head and the mother, and $\neg$Gap to the other subconstituents, producing a rule of form:
   $$(Y \text{ GAP } ?g) \rightarrow (X_1 \text{ GAP } -) \ldots (H_i \text{ GAP } ?g) \ldots (X_n \text{ GAP } -)$$
3. If the head $H_i$ is a lexical category, then for each nonlexical subconstituent $X_j$, add a rule of the form:
   $$(Y \text{ GAP } ?g) \rightarrow (X_1 \text{ GAP } -) \ldots (X_j \text{ GAP } ?g) \ldots (X_n \text{ GAP } -)$$

**Figure 5.5** An algorithm for adding Gap features to a grammar
### Wh-words in Lexicon

| What:          | CAT PRO | when:       | CAT PP-WRD |
|               | WH Q    | WH {Q R}   | |
|               | AGR {3s 3p} | PFORM TIME | |
| What:          | CAT QDET | who:       | CAT PRO |
|               | WH Q    | WH {Q R}   | |
|               | AGR {3s 3p} | AGR {3s 3p} | |
| Which:         | CAT QDET | where:     | CAT PP-WRD |
|               | WH Q    | WH {Q R}   | |
|               | AGR {3s 3p} | PFORM {LOC MOT} | |
| Which:         | CAT PRO | whose:     | CAT PRO |
|               | WH R    | WH {Q R}   | |
|               | AGR {3s 3p} | POSS +    | |
|               |         | AGR {3s 3p} | |

**Figure 5.6** A lexicon for some of the wh-words
Wh – words Grammar rules

1. $\text{(NP POSS ?p WH ?w)} \rightarrow (\text{PRO POSS ?p WH ?w})$
2. $\text{(NP WH ?w)} \rightarrow (\text{DET WH ?w AGR ?a}) (\text{CNP AGR ?a})$
3. $\text{CNP} \rightarrow N$
4. $\text{CNP} \rightarrow \text{ADJ} N$
5. $\text{DET} \rightarrow \text{ART}$
6. $\text{(DET WH ?w)} \rightarrow (\text{NP[+POSS]} \text{ WH ?a})$
7. $\text{(DET WH ?w)} \rightarrow (\text{QDET WH ?w})$
8. $\text{(PP WH ?w)} \rightarrow P (\text{NP WH ?w})$
9. $\text{(PP WH ?w)} \rightarrow (\text{PP-WRD WH ?w})$

Head feature for NP, DET and CNP: AGR
Head feature for PP: PFORM

Grammar 5.7 A simple NP and PP grammar handling wh-words
10. \((S[-\text{inv}] \text{ WH } \text{?w}) \rightarrow\)
   \((\text{NP WH ?w AGR ?a})\)
   \((\text{VP[fin] AGR ?a})\)
11. \((S[+\text{inv}] \text{ WH ?w GAP ?g}) \rightarrow\)
   \((\text{AUX COMPFORM ?s AGR ?a})\)
   \((\text{NP WH ?w AGR ?a GAP }\rightarrow)\)
   \((\text{VP VFORM ?s GAP ?g})\)
12. \(S \rightarrow (\text{NP[Q,–gap] AGR ?a}) (S[+\text{inv}] \text{ GAP (NP AGR ?a)})\)
13. \(S \rightarrow (\text{PP[Q,–gap] PFORM ?p}) (S[+\text{inv}] \text{ GAP (PP PFORM ?p)})\)
14. \(\text{VP} \rightarrow (\text{AUX COMPFORM ?s}) (\text{VP VFORM ?s})\)
15. \(\text{VP} \rightarrow \text{V[\_none ]}\)
16. \(\text{VP} \rightarrow \text{V[\_np ] NP}\)
17. \(\text{VP} \rightarrow \text{V[\_vp:inf] VP[inf]}\)
18. \(\text{VP} \rightarrow \text{V[\_np_vp:inf] NP VP[inf]}\)
19. \(\text{VP[ inf]} \rightarrow \text{TO VP[base]}\)
20. \(\text{VP} \rightarrow \text{V[\_np_pp:loc ] NP PP[loc]}\)

Head features for \(S, \text{VP}: \text{VFORM}, \text{AGR}\)

**Grammar 5.8** The unexpanded \(S\) grammar for wh-questions
Ws-questions grammar rules (expanded)

10. \((S[-inv] \textbf{WH} \,?w \,\textbf{GAP} \,?g) \rightarrow\)
    \((\textbf{NP} \,\textbf{WH} \,?w \,\textbf{AGR} \,?a)\)
    \((\textbf{VP} \,[\text{fin}] \,\textbf{AGR} \,?a \,\textbf{GAP} \,?g)\)

11. \((S[+inv] \,\textbf{WH} \,?w \,\textbf{GAP} \,?g) \rightarrow\)
    \((\textbf{AUX} \,\textbf{COMPFORM} \,?s \,\textbf{AGR} \,?a)\)
    \((\textbf{NP} \,\textbf{WH} \,?w \,\textbf{AGR} \,?a \,\textbf{GAP} \,\rightarrow)\)
    \((\textbf{VP} \,\textbf{VFORM} \,?s \,\textbf{GAP} \,?g)\)

12. \(S \rightarrow (\textbf{NP}[Q,-gap] \,\textbf{AGR} \,?a) \,(S[+inv] \,\textbf{GAP} \,(\textbf{NP} \,\textbf{AGR} \,?a))\)

13. \(S \rightarrow (\textbf{PP}[Q,-gap] \,\textbf{PFORM} \,?p) \,(S[+inv] \,\textbf{GAP} \,(\textbf{PP} \,\textbf{PFORM} \,?p))\)

14. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow (\textbf{AUX} \,\textbf{COMPFORM} \,?s) \,(\textbf{VP} \,\textbf{VFORM} \,?s \,\textbf{GAP} \,?g)\)

15. \(\textbf{VP} \rightarrow \texttt{\_\_none}\]

16. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_np} \,(\textbf{NP} \,\textbf{GAP} \,?g)\)

17. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_vp:inf} \,(\textbf{VP}[inf] \,\textbf{GAP} \,?g)\)

18. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_np_vp:inf} \,(\textbf{NP} \,\textbf{GAP} \,?g) \,(\textbf{VP}[inf] \,\textbf{GAP} \,\rightarrow)\)

18'. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_np_vp:inf} \,(\textbf{NP} \,\textbf{GAP} \,\rightarrow) \,(\textbf{VP}[inf] \,\textbf{GAP} \,?g)\)

19. \((\textbf{VP}[inf] \,\textbf{GAP} \,?g) \rightarrow \texttt{TO} \,(\textbf{VP}[base] \,\textbf{GAP} \,?g)\)

20. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_np_pp:loc} \,(\textbf{NP} \,\textbf{GAP} \,?g) \,(\textbf{PP}[loc] \,\textbf{GAP} \,\rightarrow)\)

20'. \((\textbf{VP} \,\textbf{GAP} \,?g) \rightarrow \texttt{\_\_np_pp:loc} \,(\textbf{NP} \,\textbf{GAP} \,\rightarrow) \,(\textbf{PP}[loc] \,\textbf{GAP} \,?g)\)

Head features for \(S, \textbf{VP}: \textbf{VFORM}, \textbf{AGR}\)

\textbf{Grammar 5.9}  The S grammar for wh-questions with the GAP feature
Parsing with Gaps

\[(\text{NP GAP (} \text{CAT NP AGR } \text{?a)} \text{ AGR ?a)} \rightarrow \varepsilon\]

\[(\text{VP GAP (NP AGR 3s)}) \rightarrow \]
\[V [\_np\_pp:\text{loc}] \bullet (\text{NP GAP (NP AGR 3s) PP [LOC]}\]

\[(\text{NP AGR 3s EMPTY +})\]

\[(\text{VP GAP (NP AGR 3s)}) \rightarrow \]
\[V [\_np\_pp:\text{loc}] (\text{NP GAP (NP AGR 3s) } \bullet \text{ PP [LOC]}\]
Whenever an arc of the form

\[ X \rightarrow \ldots \circ (C \mathbf{F}_1 \mathbf{V}_1 \ldots \mathbf{F}_n \mathbf{V}_n \mathbf{GAP} (C \mathbf{G}_1 \ ?v_{g1} \ldots \mathbf{G}_m \ ?v_{gm})) \ldots \]

is suggested by the parser, and the constituent pattern that is the \text{GAP} feature, that is,

\[(C \mathbf{G}_1 \ ?v_{g1} \ldots \mathbf{G}_m \ ?v_{gm})\]

matches the constituent itself

\[(C \mathbf{F}_1 \mathbf{V}_1 \ldots \mathbf{F}_n \mathbf{V}_n \mathbf{GAP} (C \mathbf{G}_1 \ \text{VG}_1 \ldots \mathbf{G}_m \ \text{VG}_m))\]

then add a new constituent \((C \mathbf{G}_1 \ ?v_{g1} \ldots \mathbf{G}_m \ ?v_{gm} \text{EMPTY} +)\), with the variables bound as necessary, to the chart. Use this constituent to extend the original arc.

\textbf{Figure 5.10}  The algorithm to insert empty constituents as needed
Which 2 dogs 3 did 4 he 5 see 6

<table>
<thead>
<tr>
<th>NP1</th>
<th>DET1</th>
<th>CNP1</th>
<th>NP2</th>
</tr>
</thead>
<tbody>
<tr>
<td>WH Q</td>
<td>WH Q</td>
<td>AGR 3p</td>
<td>AGR 3s</td>
</tr>
<tr>
<td>AGR 3p</td>
<td>AGR 3p</td>
<td>1 N1</td>
<td>1 PRO1</td>
</tr>
<tr>
<td>1 DET1</td>
<td>1 QDET1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 CNP1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QDET1</td>
<td>N1</td>
<td>AUX1</td>
<td>PRO1</td>
</tr>
<tr>
<td>WH Q</td>
<td>AGR 3p</td>
<td>AGR 3s</td>
<td>AGR 3s</td>
</tr>
<tr>
<td>AGR 3p</td>
<td></td>
<td>VFORM past</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>SUBCAT base</td>
<td></td>
</tr>
</tbody>
</table>

Which dogs did he

S → NP[Q] ⊙ (S GAP (NP AGR 3p))

(S GAP ?g) → AUX NP ⊙ (VP GAP ?g)

Figure 5.11 The chart after the word *he*
The final chart for *Which dogs did he see?*
Relative clauses

CNP → CNP REL

REL → (NP WH R AGR ?a) (S[-inv, fin] GAP (NP AGR ?a)))

REL → (PP WH R PFORM ?p) ( S[-inv, fin] GAP (PP PFORM ?p)))

The man who we saw at the store.
The exam in which you found the error
The man whose book you stole
The man who read the paper (who is the subject)

So Need the following rule

REL → NP [R] VP [fin]

The man that we saw at the party

The man that read the paper

“That” need to be regarded as a relative pronoun with WH = R
Relative clauses (Cont.)

Relative clauses that do not start with an appropriate wh-phrase:

1. The Paper John read
2. The damage caused by the storm
3. The issue creating the argument

2 and 3 are called Reduced Relative clauses

REL → (S[fin] GAP (NP AGR ?a)))
REL → ( VP VFORM {ing, pastprt})
Can we have Relative clauses within wh_questions?

Which dog_1 did the man [who_2 we saw ___2 holding the bone] feed ___1 ?

CNP → CNP REL
(CNP GAP ?g) → (CNP GAP ?g) (REL GAP -)

*Which dog_1 did the man [who_2 we saw ___2 petting ___1] laughed?