

Natural Language Processing

Tutorial 5: Grammar and Parsing

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Q1. Consider the LI grammar used in our lectures.

$S \rightarrow NPVP$	$Nominal \rightarrow Noun$	$NP \rightarrow Verb PP$
$S \rightarrow Aux NPVP$	$Nominal \rightarrow Nominal Noun$	$VP \rightarrow VP PP$
$S \rightarrow VP$	$Nominal \rightarrow Nominal PP$	$PP \rightarrow Preposition NP$
$NP \rightarrow Pronoun$	$VP \rightarrow Verb$	
$NP \rightarrow Proper-Noun$	$VP \rightarrow Verb NP$	
$NP \rightarrow Det Nominal$	$VP \rightarrow Verb NP PP$	

➤ Draw the parse table for the following sentence using the LI grammar

- Reserve a room at MBS

➤ Parse table → CKY Parsing



- CKY algorithm requires grammars to be in Chomsky Normal Form (CNF).
 - CNF rules can only be in two forms: $A \rightarrow BC$ or $A \rightarrow w$.
 - That is, the right-hand side of each rule must expand either to **two non-terminals** or to **a single terminal**.

- Any CFG can be converted into a corresponding equivalent CNF grammar
 - Rules that mix terminals with non-terminals on the right-hand side
 - e.g., $INF-VP \rightarrow to VP$. Create a dummy non-terminal TO
 - $INF-VP \rightarrow to VP$ becomes $INF-VP \rightarrow TO VP$ and $TO \rightarrow to$
 - Rules that have a single non-terminal on the right-hand side
 - e.g., $S \rightarrow VP$. Rewrite the right-hand side and expand VP with all its corresponding rules. $S \rightarrow VP$ becomes $S \rightarrow Verb NP$, $S \rightarrow Verb NP PP$, and ...
 - Rules that the length of the right-hand side is greater than 2
 - e.g., $S \rightarrow Verb NP PP$. Create a dummy non-terminal $X1$. $S \rightarrow Verb NP PP$ becomes $S \rightarrow X1 NP$, $X1 \rightarrow Verb NP$

An example CFG grammar in its CNF form

Review

\mathcal{L}_1 Grammar	\mathcal{L}_1 in CNF
$S \rightarrow NP VP$	$S \rightarrow NP VP$
$S \rightarrow Aux NP VP$	$S \rightarrow XI VP$
	$XI \rightarrow Aux NP$
$S \rightarrow VP$	$S \rightarrow book \mid include \mid prefer$
	$S \rightarrow Verb NP$
	$S \rightarrow X2 PP$
	$S \rightarrow Verb PP$
	$S \rightarrow VP PP$
$NP \rightarrow Pronoun$	$NP \rightarrow I \mid she \mid me$
$NP \rightarrow Proper-Noun$	$NP \rightarrow TWA \mid Houston$
$NP \rightarrow Det Nominal$	$NP \rightarrow Det Nominal$
$Nominal \rightarrow Noun$	$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal Noun$	$Nominal \rightarrow Nominal Noun$
$Nominal \rightarrow Nominal PP$	$Nominal \rightarrow Nominal PP$
$VP \rightarrow Verb$	$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb NP$	$VP \rightarrow Verb NP$
$VP \rightarrow Verb NP PP$	$VP \rightarrow X2 PP$
	$X2 \rightarrow Verb NP$
$VP \rightarrow Verb PP$	$VP \rightarrow Verb PP$
$VP \rightarrow VP PP$	$VP \rightarrow VP PP$
$PP \rightarrow Preposition NP$	$PP \rightarrow Preposition NP$

CNF rules can only be in two forms: **$A \rightarrow BC$** or **$A \rightarrow w$** .

Each non-terminal node above the POS level in a parse tree will have **exactly two daughters**

That is: a non-terminal node can be derived from **exactly TWO constituents** (that can be derived earlier).



An example CFG grammar in its CNF form

\mathcal{L}_1 Grammar	\mathcal{L}_1 in CNF
$S \rightarrow NP VP$	$S \rightarrow NP VP$
$S \rightarrow Aux NP VP$	$S \rightarrow XI VP$
	$XI \rightarrow Aux NP$
$S \rightarrow VP$	$S \rightarrow book \mid include \mid prefer \mid reserve$
	$S \rightarrow Verb NP$
	$S \rightarrow X2 PP$
	$S \rightarrow Verb PP$
	$S \rightarrow VP PP$
$NP \rightarrow Pronoun$	$NP \rightarrow I \mid she \mid me$
$NP \rightarrow Proper-Noun$	$NP \rightarrow TWA \mid Houston \mid MBS$
$NP \rightarrow Det Nominal$	$NP \rightarrow Det Nominal$
$Nominal \rightarrow Noun$	$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal Noun$	$Nominal \rightarrow Nominal Noun$
$Nominal \rightarrow Nominal PP$	$Nominal \rightarrow Nominal PP$
$VP \rightarrow Verb$	$VP \rightarrow book \mid include \mid prefer \mid reserve$
$VP \rightarrow Verb NP$	$VP \rightarrow Verb NP$
$VP \rightarrow Verb NP PP$	$VP \rightarrow X2 PP$
	$X2 \rightarrow Verb NP$
$VP \rightarrow Verb PP$	$VP \rightarrow Verb PP$
$VP \rightarrow VP PP$	$VP \rightarrow VP PP$
$PP \rightarrow Preposition NP$	$PP \rightarrow Preposition NP$

Reserve a room at MBS

reserve | room

 reserve
/rɪ zəv/

See definitions in:

All Ecclesiastical Finance Military Sport Amerindian Ecology Textiles

verb

1. retain for future use.

"roll out half the dough and reserve the other half"

Similar: put to one side put aside set aside lay aside keep back keep

2. arrange for (a room, seat, ticket, etc.) to be kept for the use of a particular person.

"a place was reserved for her in the front row"

Similar: book make a reservation for order arrange in advance arrange for

noun

1. a supply of a commodity not needed for immediate use but available if required.

"Australia has major coal, gas, and uranium reserves"

Similar: stock store supply stockpile reservoir pool fund bank

2. a body of troops withheld from action to reinforce or protect others, or additional to the regular forces and available in an emergency.

"the men were stationed as a central reserve ready to be transported wherever necessary"



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

0	1	2	3	4	5
Reserve	a	room	at	MBS	
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	

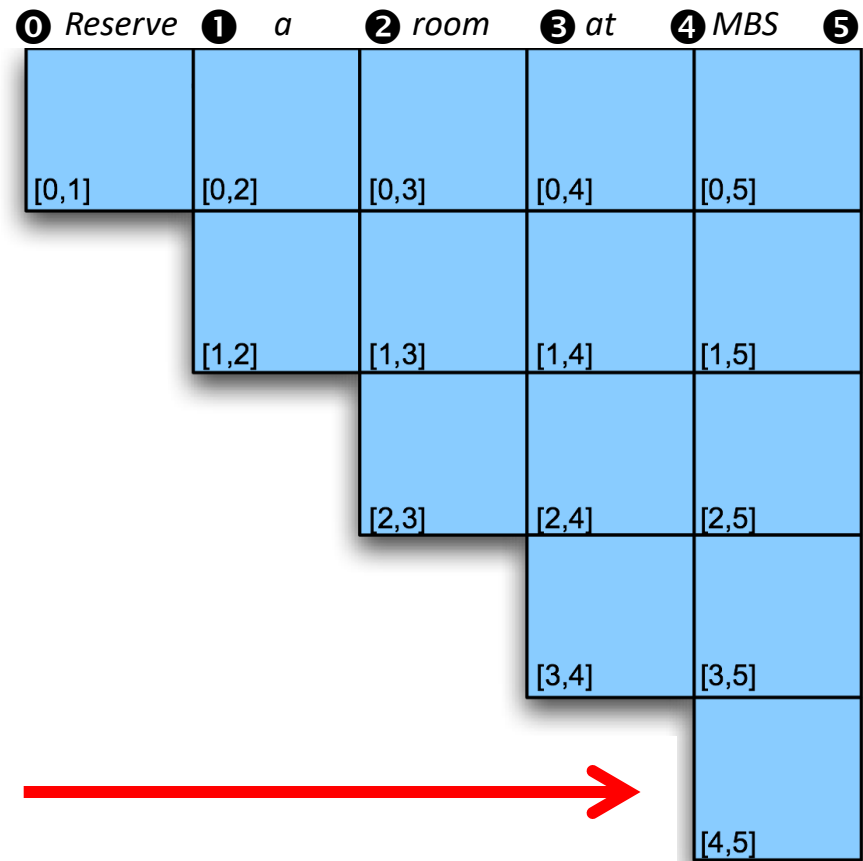
“reserve” can be a noun or verb, similar to “book”



Q2(i)

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 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
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Q2(i)

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 $Nominal \rightarrow book \mid flight \mid meal \mid money \mid reserve$
 $Nominal \rightarrow Nominal Noun$
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 $VP \rightarrow book \mid include \mid prefer \mid reserve$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

① Reserve	① a	② room	③ at	④ MBS	⑤
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	[1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	



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 $Nominal \rightarrow book \mid flight \mid meal \mid money$
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 $X2 \rightarrow Verb NP$
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 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

0	1	2	3	4	5
Reserve	a	room	at	MBS	
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	Det [1,2]	[1,3]	[1,4]	[1,5]	
		[2,3]	[2,4]	[2,5]	
			[3,4]	[3,5]	
				[4,5]	

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 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

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S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
Det [1,2]	[1,3]	[1,4]	[1,5]	
	[2,3]	[2,4]	[2,5]	
		[3,4]	[3,5]	
			[4,5]	



Q2(i)

\mathcal{L}_1 in CNF

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 $S \rightarrow XI VP$
 $XI \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money \mid room$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
Det [1,2]	[1,3]	[1,4]	[1,5]	
	Nominal, Noun [2,3]	[2,4]	[2,5]	
		[3,4]	[3,5]	
			[4,5]	



Q2(i)

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 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
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①	②	③	④	⑤
Reserve	a	room	at	MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	[0,3]	[0,4]	[0,5]
	Det [1,2]	NP [1,3]	[1,4]	[1,5]
		Nominal, Noun [2,3]	[2,4]	[2,5]
			[3,4]	[3,5]
				[4,5]



Q2(i)

\mathcal{L}_1 in CNF

$$S \rightarrow NP VP$$
$$S \rightarrow XI \ VP$$
$$X1 \rightarrow Aux NP$$

$S \rightarrow book \mid include \mid prefer$

$$S \rightarrow Verb NP$$
$$S \rightarrow X^2 PP$$
$$S \rightarrow Verb PP$$
$$S \rightarrow VP PP$$
$$NP \rightarrow I \mid she \mid me$$

$NP \rightarrow TWA \mid Houston$

$$NP \rightarrow Det \textit{ Nominal}$$

Nominal \rightarrow *book* | *flight* | *meal* | *money*

Nominal \rightarrow *Nominal Noun*

Nominal \rightarrow *Nominal PP*

$VP \rightarrow book \mid include \mid prefer$

$$VP \rightarrow Verb NP$$
$$VP \rightarrow X^2 PP$$
$$X2 \rightarrow Verb NP$$
$$VP \rightarrow Verb PP$$
$$VP \rightarrow VP PP$$
$$PP \rightarrow \textit{Preposition NP}$$

0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]						
	Det [1,2]	NP [1,3]	[1,4]	[1,5]						
		Nominal, Noun [2,3]	[2,4]	[2,5]						
			[3,4]	[3,5]						
				[4,5]						



Q2(i)

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 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$

0	1	2	3	4	5
Reserve	a	room	at	MBS	
S, VP, Verb, Nominal, Noun [0,1]		S,VP,X2 [0,3]			
	Det [1,2]	NP [1,3]			
		Nominal, Noun [2,3]			
			Prep [3,4]		
					[4,5]



Q2(i)

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① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]
	Det [1,2]	NP [1,3]	[1,4]	[1,5]
		Nominal, Noun [2,3]	[2,4]	[2,5]
			Prep [3,4]	[3,5]
				[4,5]



Q2(i)

\mathcal{L}_1 in CNF

$$S \rightarrow NP VP$$
$$S \rightarrow XI \ VP$$
$$X1 \rightarrow Aux NP$$

$S \rightarrow book \mid include \mid prefer$

$$S \rightarrow Verb NP$$
$$S \rightarrow X^2 PP$$
$$S \rightarrow Verb PP$$
$$S \rightarrow VP PP$$
$$NP \rightarrow I \mid she \mid me$$

$NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$

$$NP \rightarrow Det \textit{ Nominal}$$

Nominal \rightarrow *book* | *flight* | *meal* | *money*

Nominal \rightarrow *Nominal Noun*

Nominal \rightarrow *Nominal PP*

$VP \rightarrow book \mid include \mid prefer$

$$VP \rightarrow Verb NP$$
$$VP \rightarrow X^2 PP$$
$$X2 \rightarrow Verb NP$$
$$VP \rightarrow Verb PP$$
$$VP \rightarrow VP PP$$
$$PP \rightarrow \textit{Preposition NP}$$

0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun [0,1]	[0,2]		S,VP,X2 [0,3]			[0,4]		[0,5]		
	Det [1,2]		NP [1,3]			[1,4]		[1,5]		
			Nominal, Noun [2,3]			[2,4]		[2,5]		
						Prep [3,4]		[3,5]		
								[4,5]		



Q2(i)

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$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
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0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun				S,VP,X2						
[0,1]	[0,2]			[0,3]	[0,4]			[0,5]		
	Det			NP						
	[1,2]			[1,3]	[1,4]			[1,5]		
				Nominal, Noun						
				[2,3]	[2,4]			[2,5]		
					Prep					
					[3,4]			[3,5]		
								[4,5]		



Q2(i)

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 $NP \rightarrow I \mid she \mid me$
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① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]
Det [1,2]	NP [1,3]	[1,4]	[1,5]	
	Nominal, Noun [2,3]	[2,4]	[2,5]	
		Prep [3,4]	[3,5]	
			NP, Proper- Noun [4,5]	



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① Reserve	② a	③ room	④ at	⑤ MBS
S, VP, Verb, Nominal, Noun [0,1]	[0,2]	S,VP,X2 [0,3]	[0,4]	[0,5]
	Det [1,2]	NP [1,3]	[1,4]	[1,5]
		Nominal, Noun [2,3]	[2,4]	[2,5]
			Prep [3,4]	PP [3,5]
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0	Reserve	1	a	2	room	3	at	4	MBS	5
	S, VP, Verb, Nominal, Noun			S,VP,X2						
	[0,1]	[0,2]		[0,3]	[0,4]			[0,5]		
		Det		NP						
		[1,2]		[1,3]	[1,4]			[1,5]		
				Nominal, Noun				Nominal		
				[2,3]	[2,4]			[2,5]		
					Prep			PP		
					[3,4]			[3,5]		
								NP, Proper- Noun		
								[4,5]		



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 $X2 \rightarrow Verb NP$
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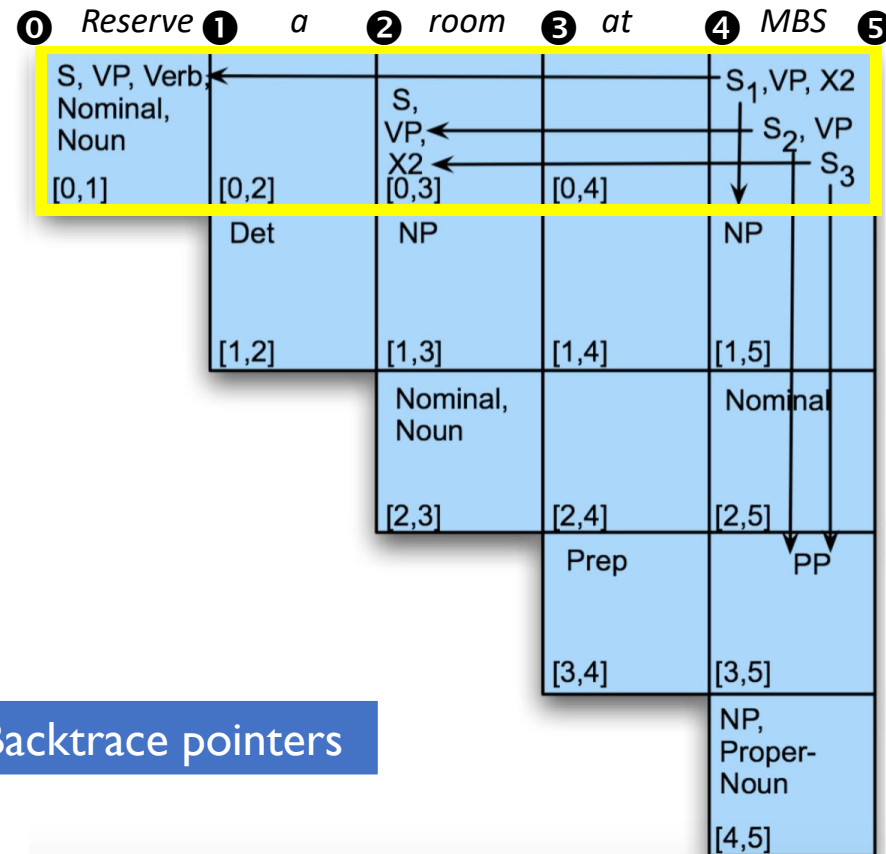
0	Reserve	1	a	2	room	3	at	4	MBS	5
S, VP, Verb, Nominal, Noun				S,VP,X2						
[0,1]	[0,2]			[0,3]	[0,4]			[0,5]		
	Det			NP				NP		
	[1,2]			[1,3]	[1,4]			[1,5]		
				Nominal, Noun				Nominal		
				[2,3]	[2,4]			[2,5]		
					Prep			PP		
					[3,4]			[3,5]		
								NP, Proper- Noun		
								[4,5]		



Q2(i)

\mathcal{L}_1 in CNF

$S \rightarrow NP VP$
 $S \rightarrow X1 VP$
 $X1 \rightarrow Aux NP$
 $S \rightarrow book \mid include \mid prefer$
 $S \rightarrow Verb NP$
 $S \rightarrow X2 PP$
 $S \rightarrow Verb PP$
 $S \rightarrow VP PP$
 $NP \rightarrow I \mid she \mid me$
 $NP \rightarrow TWA \mid Houston$
 $NP \rightarrow Det Nominal$
 $Nominal \rightarrow book \mid flight \mid meal \mid money$
 $Nominal \rightarrow Nominal Noun$
 $Nominal \rightarrow Nominal PP$
 $VP \rightarrow book \mid include \mid prefer$
 $VP \rightarrow Verb NP$
 $VP \rightarrow X2 PP$
 $X2 \rightarrow Verb NP$
 $VP \rightarrow Verb PP$
 $VP \rightarrow VP PP$
 $PP \rightarrow Preposition NP$



Q2 You are provided with the phrase structures for the following sentences:

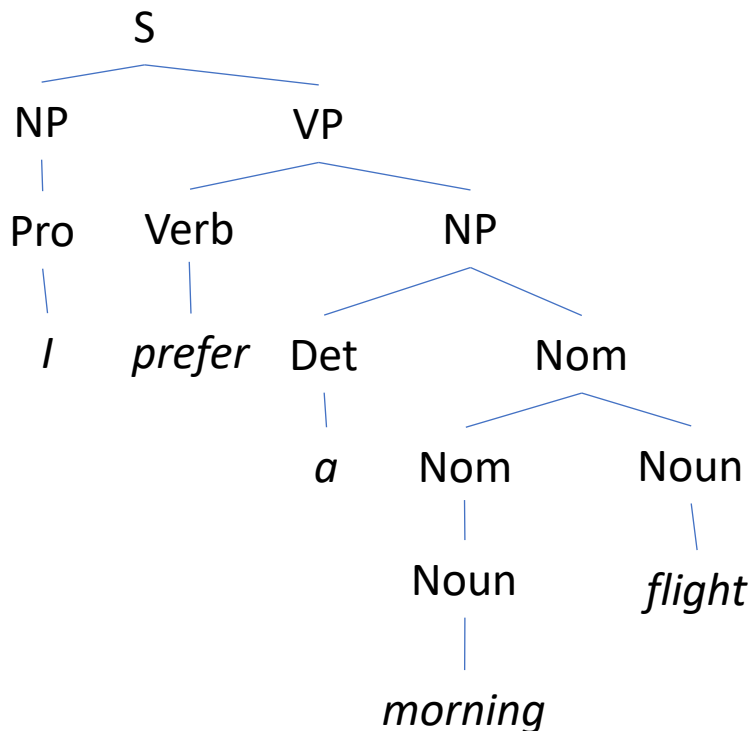
➤ Sentences:

- I would like to fly on American airlines.
- Please repeat that.
- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?

➤ Revise the L1 grammar Q1 such that the revised grammar can be used to parse the above four sentences

$S \rightarrow NPVP$	Nominal \rightarrow Noun	$NP \rightarrow$ Verb PP
$S \rightarrow \text{Aux } NPVP$	Nominal \rightarrow Nominal Noun	$VP \rightarrow$ VP PP
$S \rightarrow VP$	Nominal \rightarrow Nominal PP	$PP \rightarrow$ Preposition NP
$NP \rightarrow$ Pronoun	$VP \rightarrow$ Verb	
$NP \rightarrow$ Proper-Noun	$VP \rightarrow$ Verb NP	
$NP \rightarrow$ Det Nominal	$VP \rightarrow$ Verb NP PP	

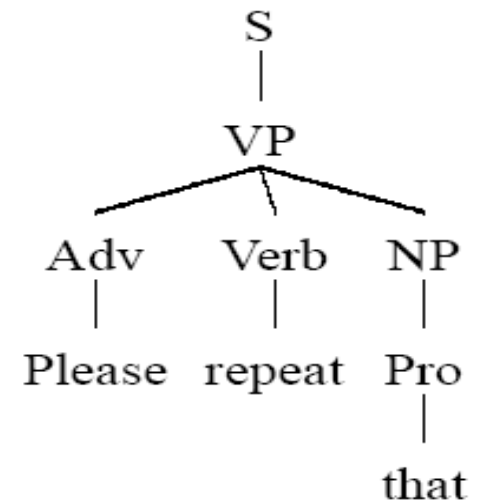
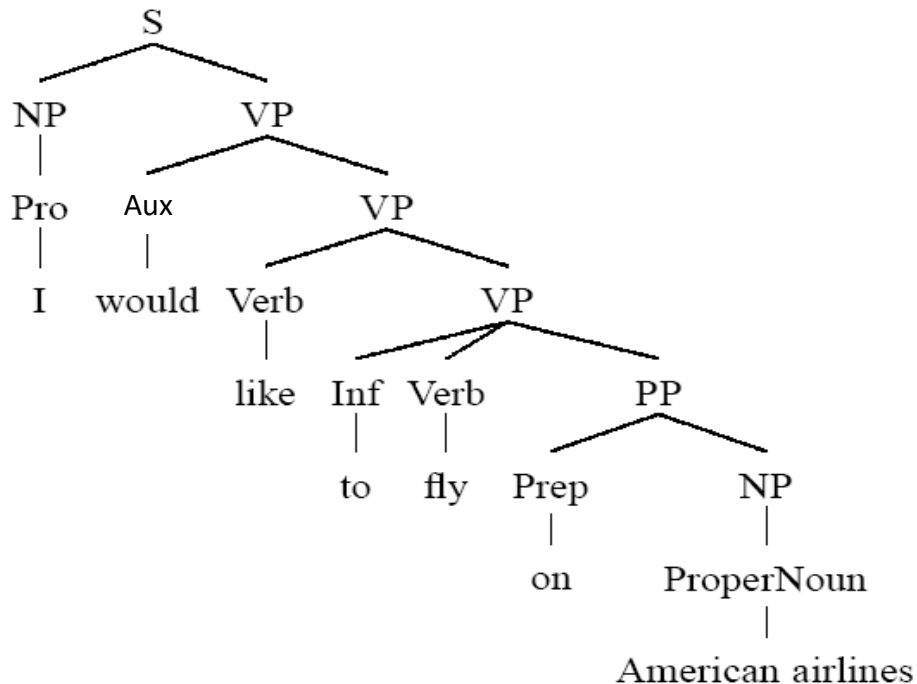
- A derivation (parse tree) consists of the bag of grammar rules that are in the tree



1. $S \rightarrow NP VP$
2. $NP \rightarrow Pro$
 $Pro \rightarrow I$
3. $VP \rightarrow Verb NP$
 $Verb \rightarrow prefer$
4. $NP \rightarrow Det Nom$
 $Det \rightarrow a$
5. $Nom \rightarrow Nom Noun$
 $Noun \rightarrow morning$
6. $Nom \rightarrow Noun$
 $Noun \rightarrow flight$

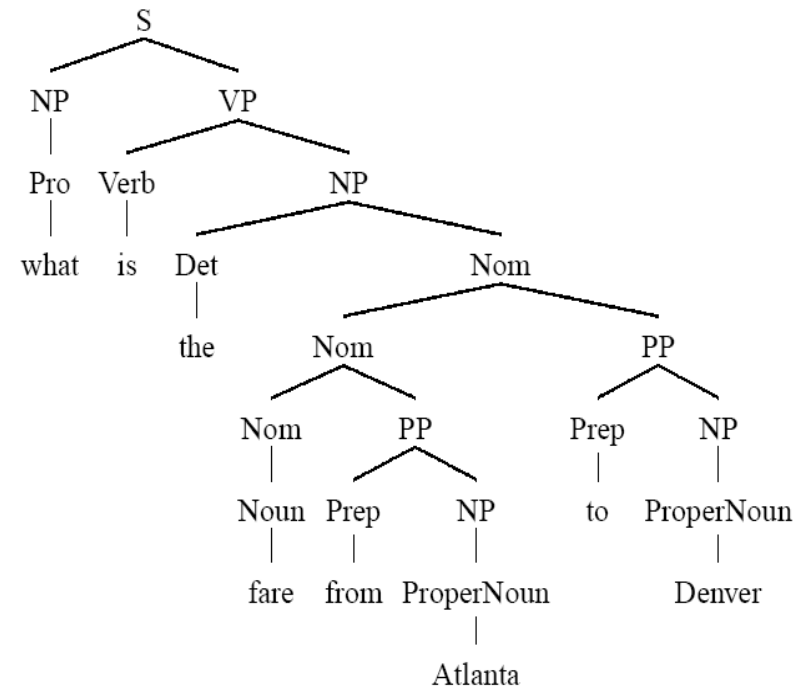
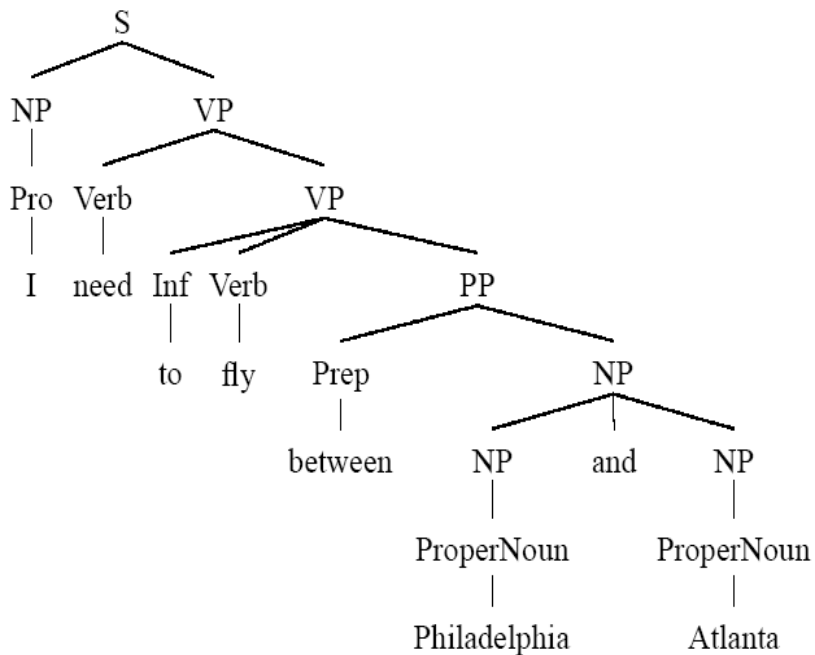
The first two sentences

- I would like to fly on American airlines.
- Please repeat that.



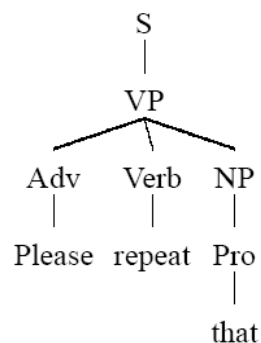
The next two sentences

- I need to fly between Philadelphia and Atlanta.
- What is the fare from Atlanta to Denver?



Q2 Solution: Include the rules that are not listed in L1

- $S \rightarrow NP VP$
- $S \rightarrow Aux NP VP$
- $S \rightarrow VP$
- $NP \rightarrow Pronoun$
- $NP \rightarrow ProperNoun$
- $NP \rightarrow Det Nominal$
- $NP \rightarrow NP Conj NP$
- $Nominal \rightarrow Noun$
- $Nominal \rightarrow Nominal Noun$
- $Nominal \rightarrow Nominal PP$
- $VP \rightarrow Verb$
- $VP \rightarrow Verb NP$
- $VP \rightarrow Verb NP PP$
- $VP \rightarrow Verb PP$



- $VP \rightarrow VP PP$
- $VP \rightarrow Aux VP$
- $VP \rightarrow Verb VP$
- $VP \rightarrow InfVerb PP$
- $VP \rightarrow AdvVerb NP$
- $PP \rightarrow Preposition NP$
- -----
- $Det \rightarrow the$
- $Noun \rightarrow fare$
- $Verb \rightarrow like \mid fly \mid repeat \mid need \mid is$
- $Pronoun \rightarrow I \mid that \mid what$
- $ProperNoun \rightarrow American\ airlines \mid Philadelphia \mid Atlanta \mid Denver$
- $Aux \rightarrow would$
- $Preposition \rightarrow from \mid to \mid on \mid between$
- $Conj \rightarrow and$
- $Inf \rightarrow to$
- $Adv \rightarrow please$



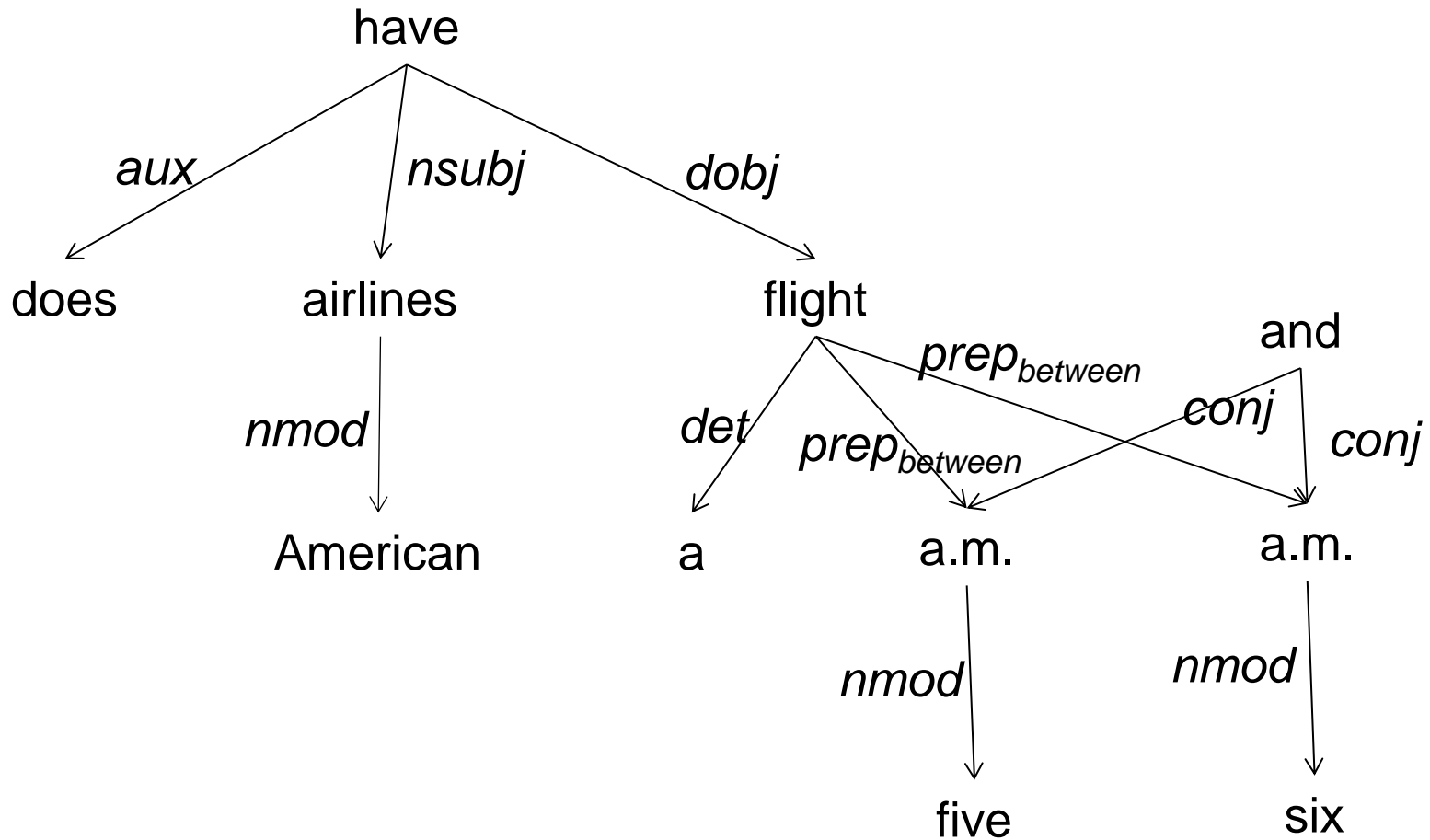
Q3. Use the following sentences as examples to observe the dependency structures

<https://demos.explosion.ai/displacy>

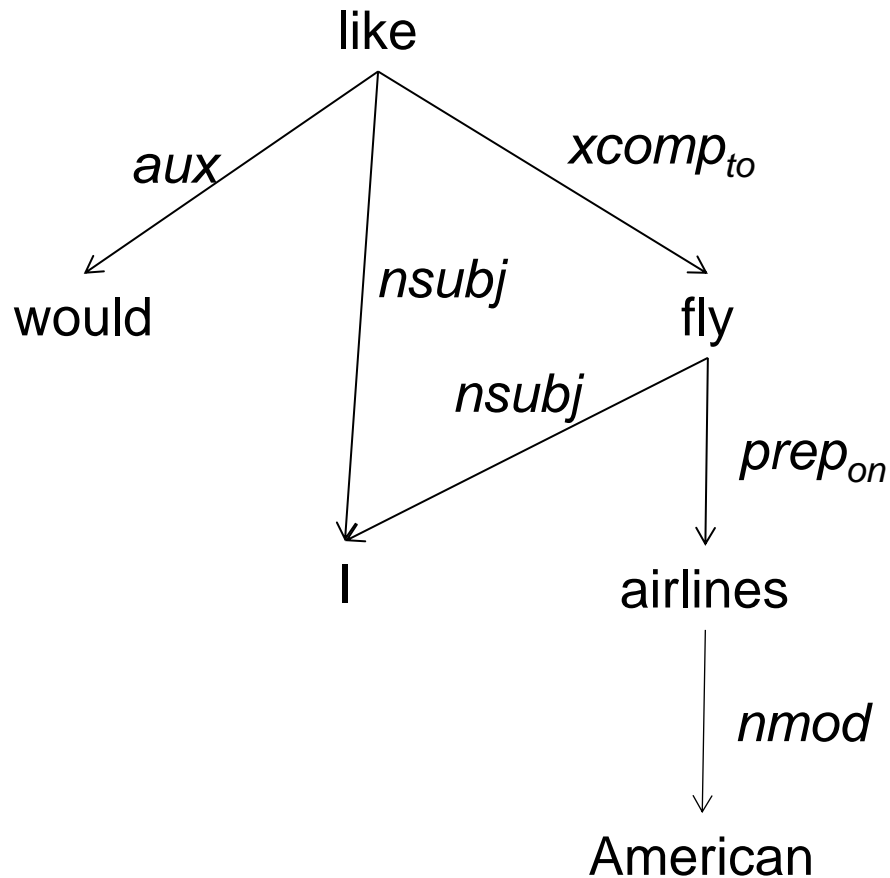
- a) Does American airlines have a flight between five a.m. and six a.m.?
- b) I would like to fly on American airlines.
- c) Please repeat that.
- d) I need to fly between Philadelphia and Atlanta.
- e) What is the fare from Atlanta to Denver?



Q3 a). Does American airlines have a flight between five a.m. and six a.m.?



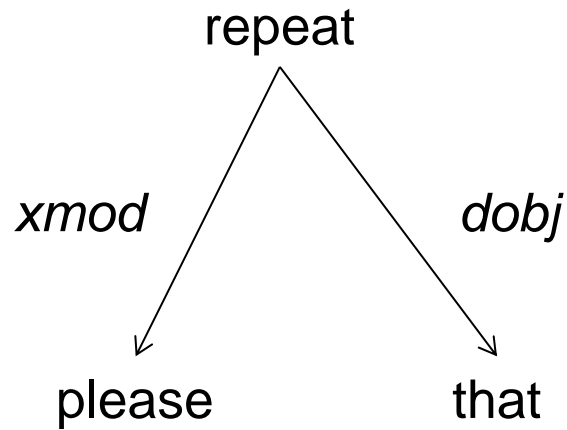
Q3 b). I would like to fly on American airlines.



➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)

Q3 c). Please repeat that.



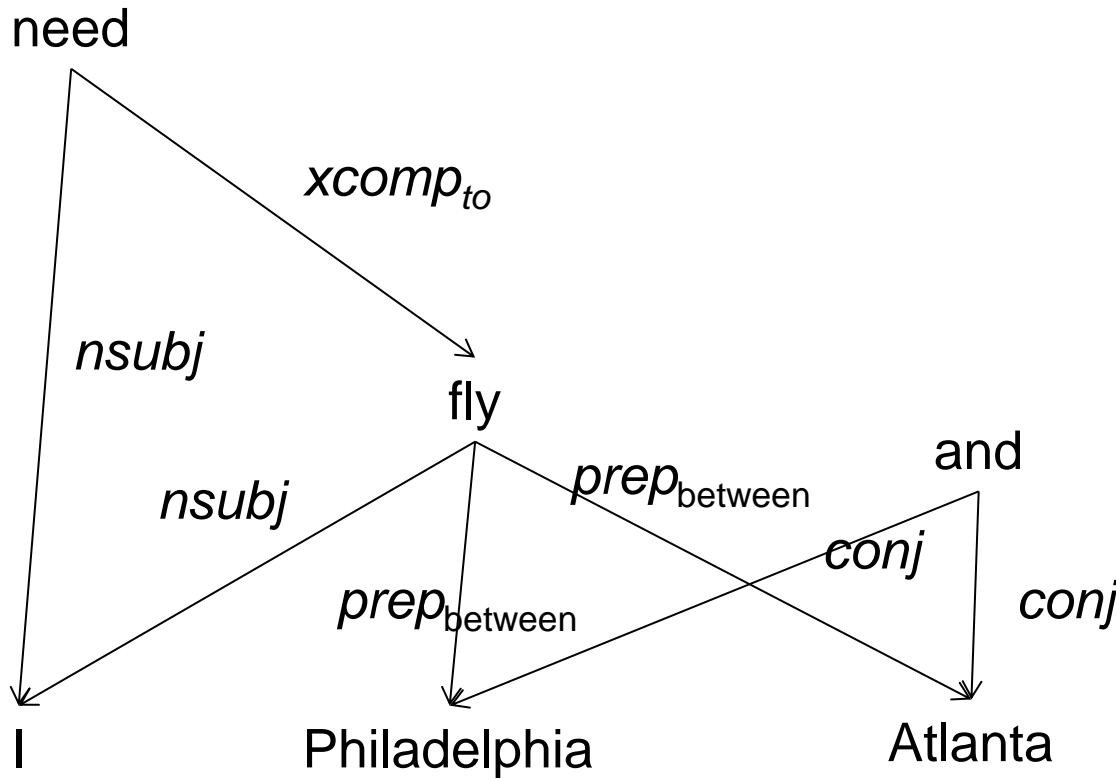
➤ Verb relations

- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)

Q3 d). I need to fly between Philadelphia and Atlanta.

➤ Verb relations

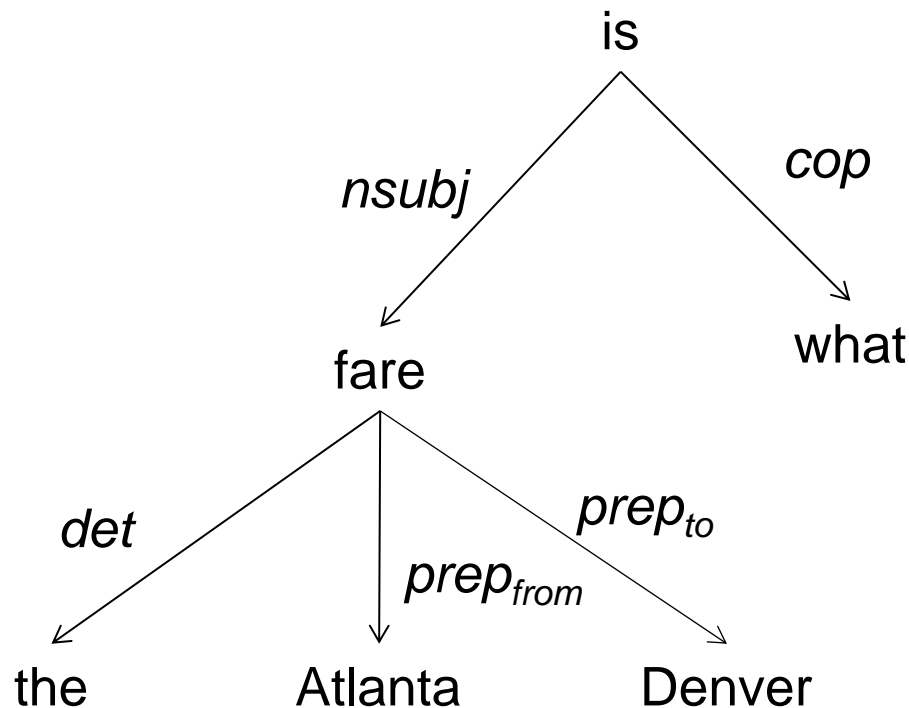
- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)



Q3 e). What is the fare from Atlanta to Denver?

➤ Verb relations

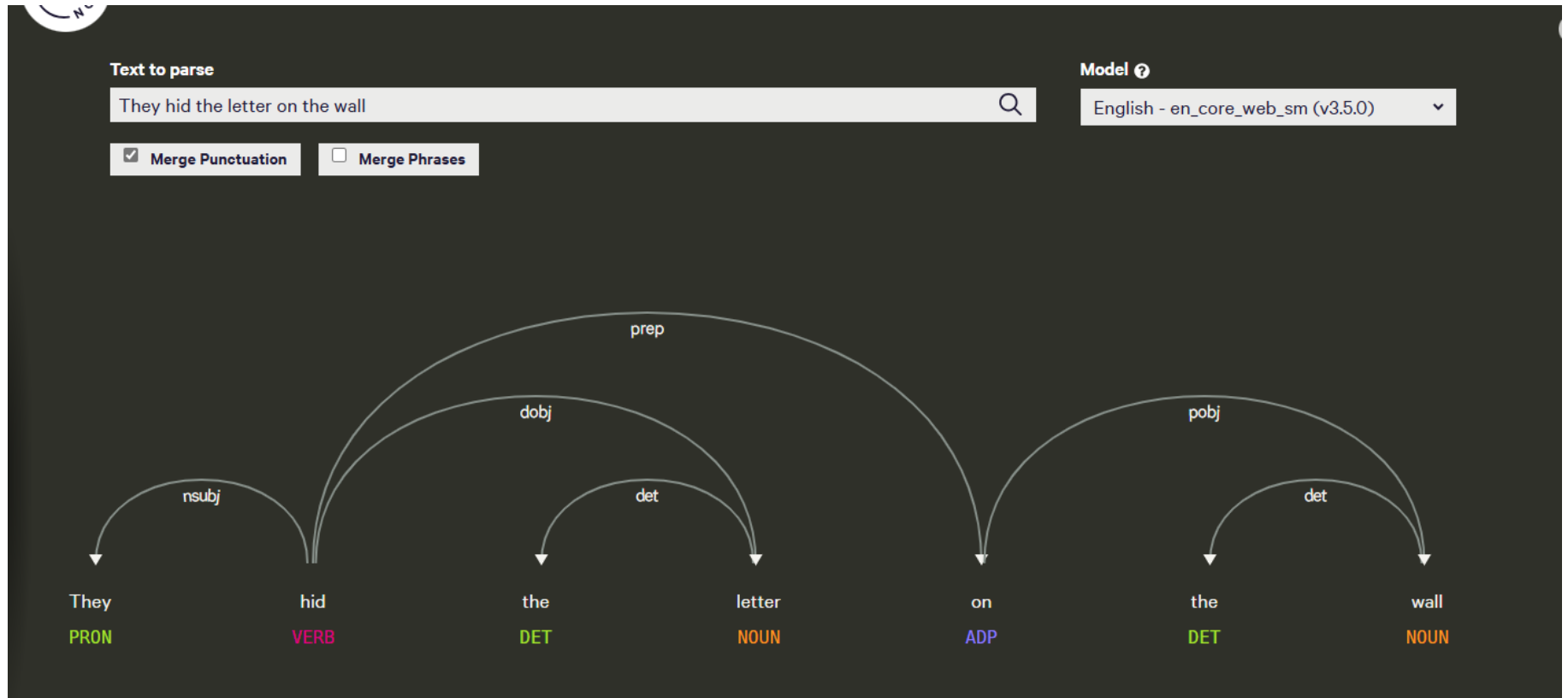
- nsubj
- dobj
- aux (auxiliary verb – main verb)
- xmod (verb – adverb)
- xcomp_{to} (verb – to-infinitive)



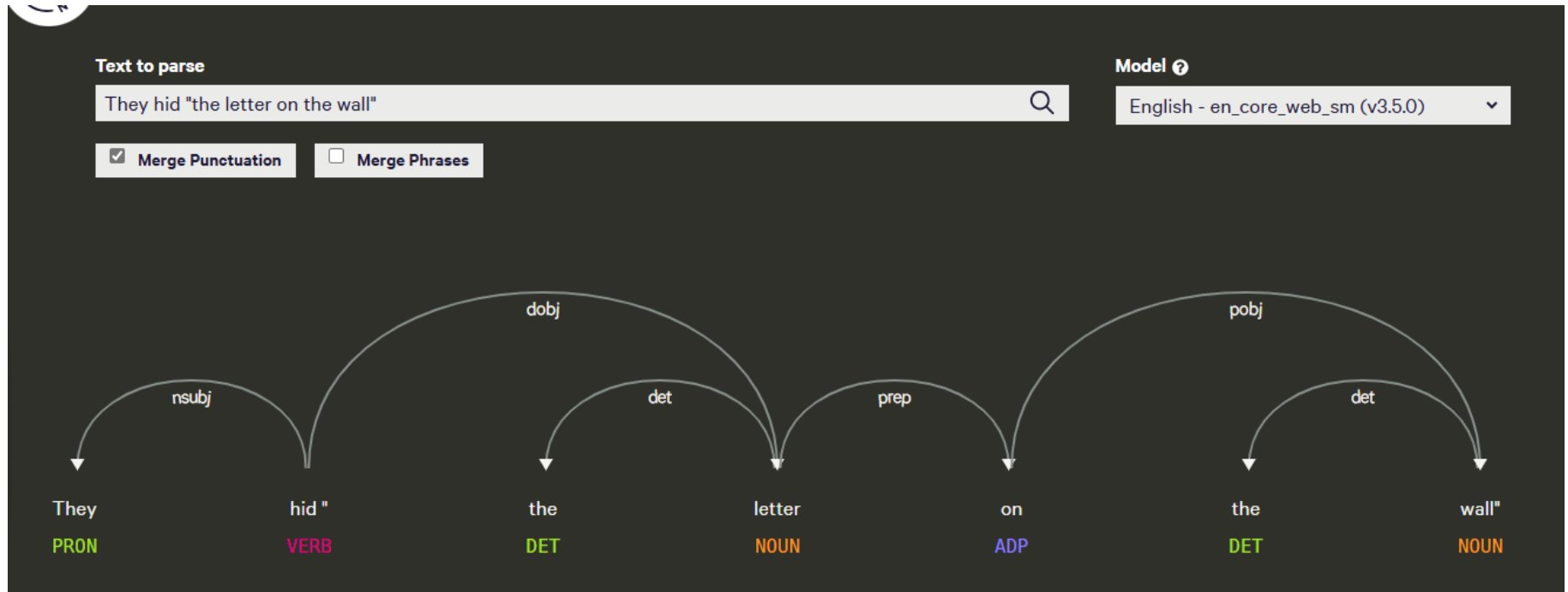
Q4 Draw two dependency structures for the following sentence: *They hid the letter on the wall.*

- There was a letter on the wall, but they hid it, and now I've searched the entire wall and can't find it anymore.
- There was a letter on the table, and they hid it on the wall, like behind a painting

Structure I



Structure 2



Q5.Open question

- Try and explore the Rule-based Matcher

<https://demos.explosion.ai/matcher>

- Define a pattern and explain why it could be useful for a real-life use case for some text data (e.g., news articles, financial reports, medical reports, product reviews)

