

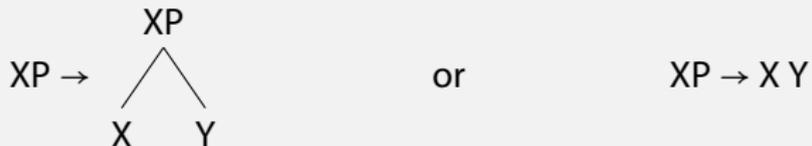
Syntax II

Andrew Murphy
andrew.murphy@uChicago.edu

Week 7
05.09.22

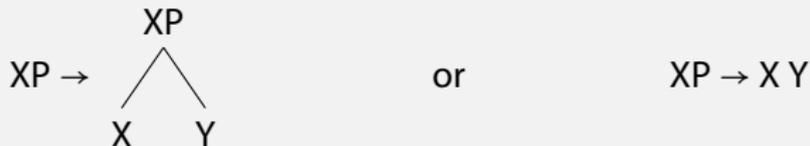
LING 20001: Introduction to Linguistics

Phrase Structure Rule



A phrase XP contains X and Y as its daughters.

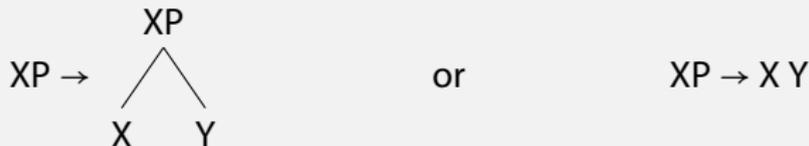
Phrase Structure Rule



A phrase XP contains X and Y as its daughters.

Phrase Structure Rules are a way of stating what daughters a phrase can have.

Phrase Structure Rule



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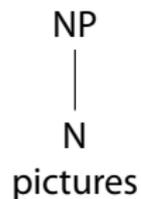
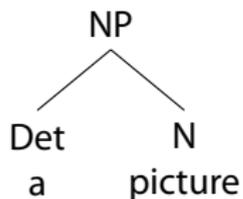
Phrase Structure Rules are a way of stating what daughters a phrase can have. We can use them to describe what a well-formed structure is (or isn't).

Noun phrases

- What rules do we need for these two NP structures?

Noun phrases

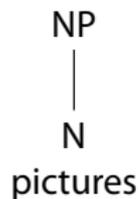
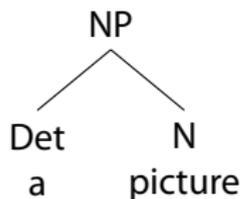
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Phrase Structure Rules

Noun phrases

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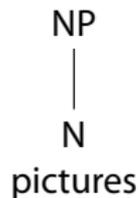
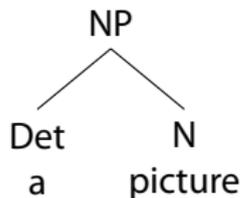


Phrase Structure Rules

$NP \rightarrow Det\ N$

Noun phrases

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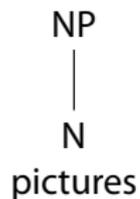
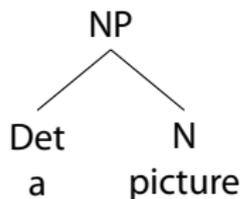


Phrase Structure Rules

$NP \rightarrow \text{Det } N$ $NP \rightarrow N$

Noun phrases

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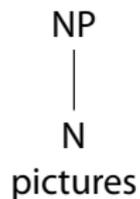
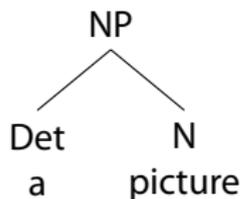
- What about these structures?

Phrase Structure Rules

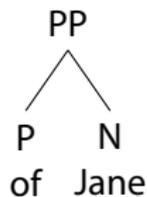
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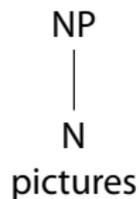
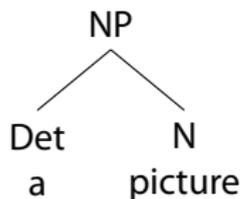


Phrase Structure Rules

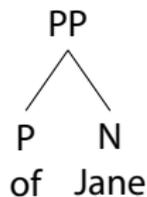
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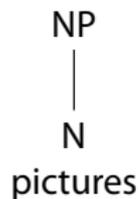
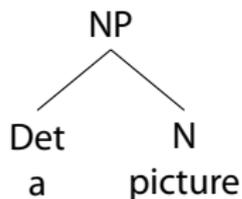
Phrase Structure Rules

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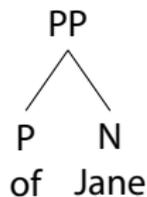
$PP \rightarrow P\ N$

Noun phrases

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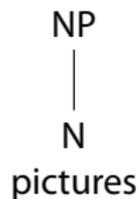
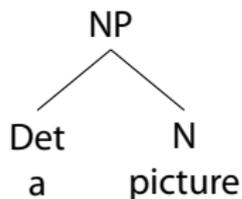
Phrase Structure Rules

NP \rightarrow Det N NP \rightarrow N

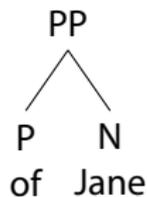
PP \rightarrow P N *PP \rightarrow P

Noun phrases

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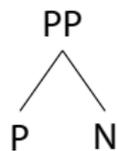
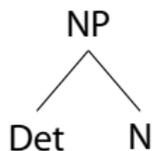
Phrase Structure Rules

$NP \rightarrow Det\ N$ $NP \rightarrow N$

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Lexical rules

Right now, our Phrase Structure Rules give us structures like this:



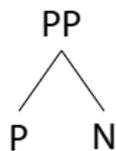
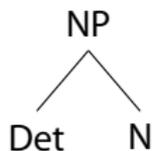
Phrase Structure Rules

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But how do we know what words can be N or P?

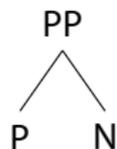
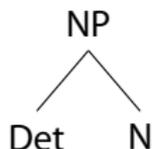
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Phrase Structure Rules

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Lexical Rules

$N \rightarrow \textit{picture}$

$P \rightarrow \textit{of}$

$N \rightarrow \textit{newspaper}$

$P \rightarrow \textit{on}$

$N \rightarrow \textit{essay}$

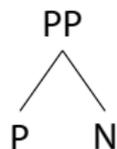
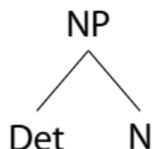
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...

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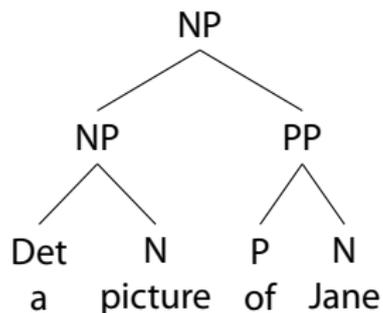
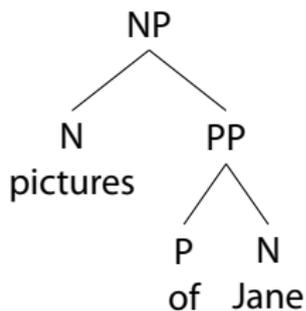
$P \rightarrow \textit{about}$

...

...

Lexical rules are not particularly interesting for us, we just have to list what word belongs to which category.

- Now consider these structures:

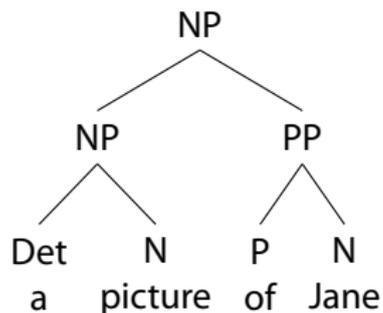
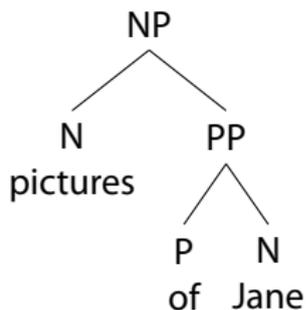


Phrase Structure Rules

NP \rightarrow Det N NP \rightarrow N

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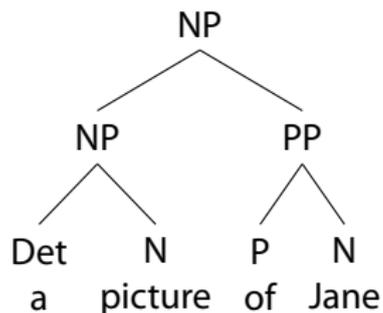
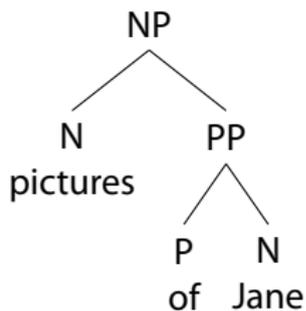


Phrase Structure Rules

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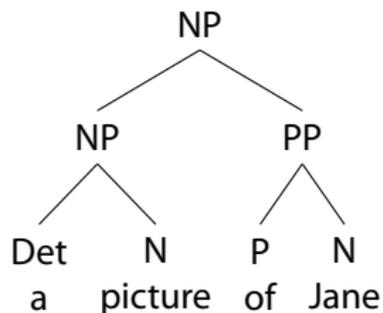
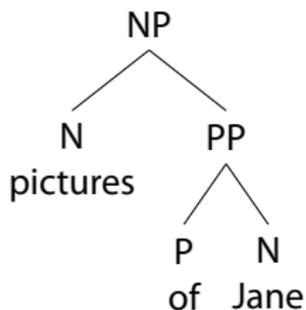
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Phrase Structure Rules

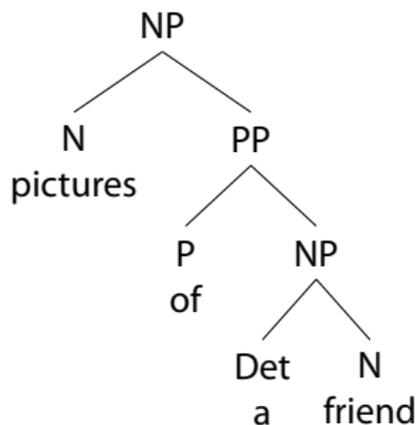
NP \rightarrow Det N NP \rightarrow N
PP \rightarrow P N NP \rightarrow N PP

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Phrase Structure Rules

NP \rightarrow Det N NP \rightarrow N
PP \rightarrow P N NP \rightarrow N PP
NP \rightarrow NP PP



Phrase Structure Rules

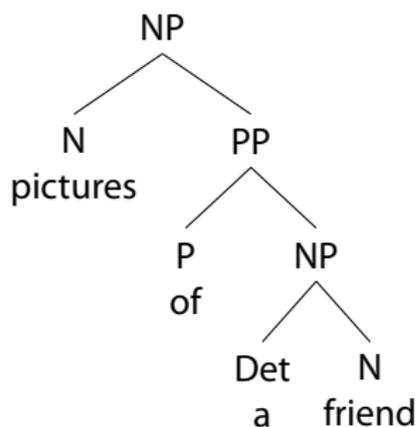
NP → Det N

NP → N

PP → P N

NP → N PP

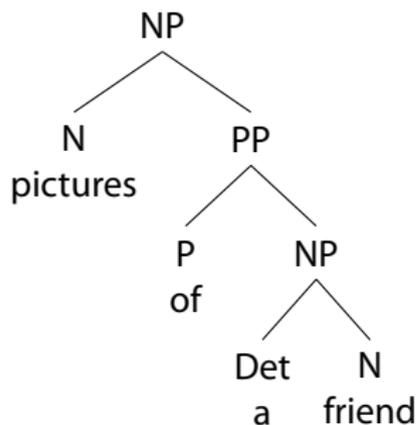
NP → NP PP



What additional rule do we need?

Phrase Structure Rules

$NP \rightarrow Det\ N$ $NP \rightarrow N$
 $PP \rightarrow P\ N$ $NP \rightarrow N\ PP$
 $NP \rightarrow NP\ PP$



What additional rule do we need?

Phrase Structure Rules

$NP \rightarrow Det\ N$	$NP \rightarrow N$
$PP \rightarrow P\ N$	$NP \rightarrow N\ PP$
$NP \rightarrow NP\ PP$	$PP \rightarrow P\ NP$

- Do you notice any redundancy in these rules?

Phrase Structure Rules

$NP \rightarrow \text{Det } N$	$NP \rightarrow N$
$PP \rightarrow P N$	$NP \rightarrow N PP$
$NP \rightarrow NP PP$	$PP \rightarrow P NP$

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Phrase Structure Rules

NP → Det N	NP → N
PP → P N	NP → N PP
NP → NP PP	PP → P NP

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NP → Det N	<u>NP → N</u>
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Phrase Structure Rules

$NP \rightarrow \text{Det } N$	$\underline{NP} \rightarrow \underline{N}$
$PP \rightarrow P N$	$\underline{NP} \rightarrow \underline{N} PP$
$NP \rightarrow NP PP$	$PP \rightarrow P NP$

- Since we have $NP \rightarrow N$, we can conflate these rules

- Do you notice any redundancy in these rules?

Phrase Structure Rules

$NP \rightarrow \text{Det } NP$	$NP \rightarrow N$
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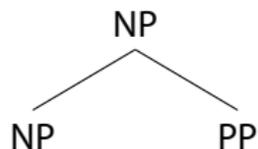
a picture of Jane

NP

Phrase Structure Rules

NP \rightarrow Det NP NP \rightarrow N
PP \rightarrow P NP NP \rightarrow NP PP

a picture of Jane



Phrase Structure Rules

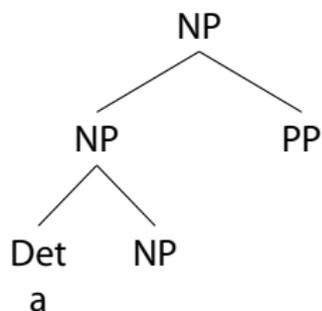
NP → Det NP

NP → N

PP → P NP

NP → NP PP

a picture of Jane



Phrase Structure Rules

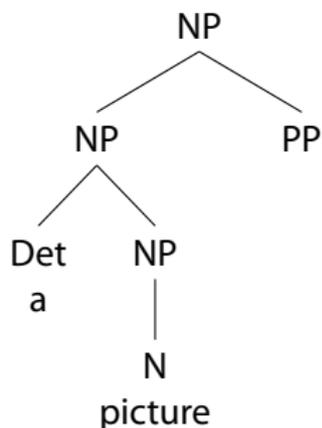
$\underline{NP} \rightarrow \text{Det NP}$

$PP \rightarrow P NP$

$NP \rightarrow N$

$NP \rightarrow NP PP$

a picture of Jane



Phrase Structure Rules

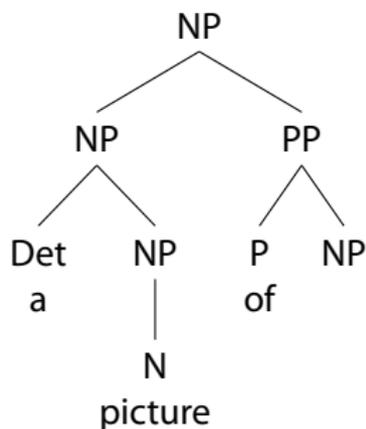
$NP \rightarrow \text{Det } NP$

$\underline{NP} \rightarrow N$

$PP \rightarrow P \text{ } NP$

$NP \rightarrow NP \text{ } PP$

a picture of Jane



Phrase Structure Rules

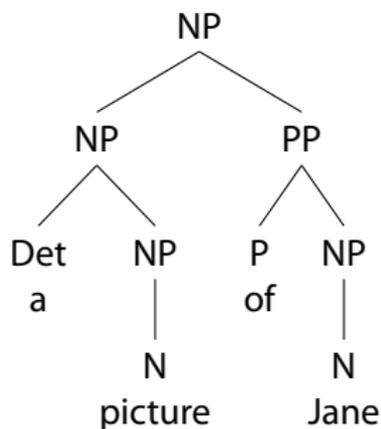
$NP \rightarrow \text{Det NP}$

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$PP \rightarrow P NP$

$NP \rightarrow NP PP$

a picture of Jane



Phrase Structure Rules

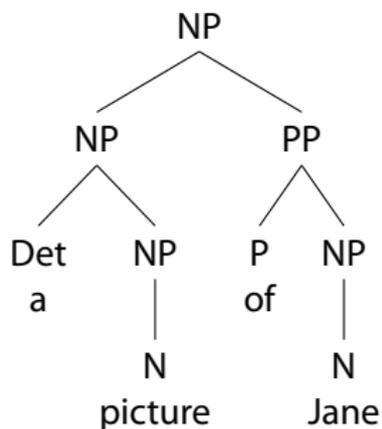
$NP \rightarrow \text{Det } NP$

$NP \rightarrow N$

$PP \rightarrow P \ NP$

$NP \rightarrow NP \ PP$

a picture of Jane



Phrase Structure Rules

$NP \rightarrow Det\ NP$

$NP \rightarrow N$

$PP \rightarrow P\ NP$

$NP \rightarrow NP\ PP$

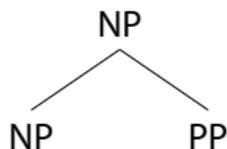
pictures of a friend

NP

Phrase Structure Rules

NP \rightarrow Det NP NP \rightarrow N
PP \rightarrow P NP NP \rightarrow NP PP

pictures of a friend



Phrase Structure Rules

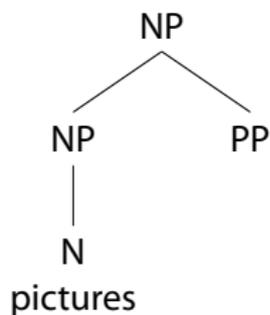
$NP \rightarrow \text{Det NP}$

$NP \rightarrow N$

$PP \rightarrow P NP$

$NP \rightarrow NP PP$

pictures of a friend



Phrase Structure Rules

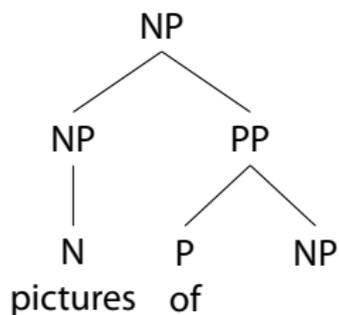
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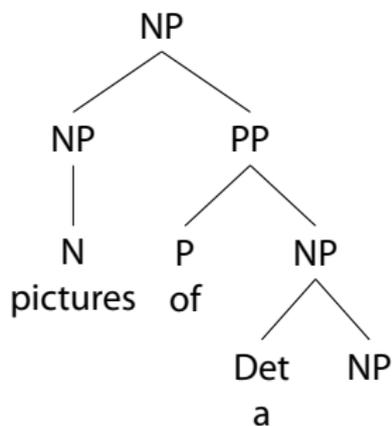
pictures of a friend



Phrase Structure Rules

$NP \rightarrow \text{Det NP}$ $NP \rightarrow N$
 $PP \rightarrow P NP$ $NP \rightarrow NP PP$

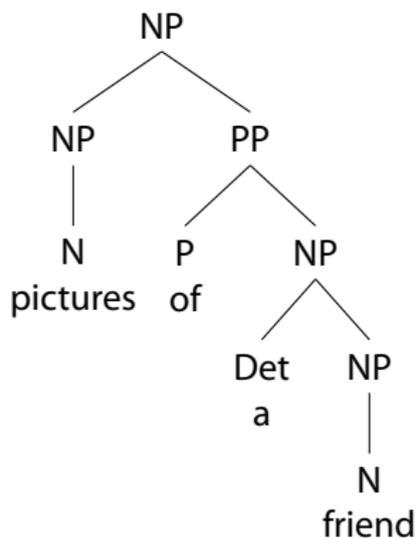
pictures of a friend



Phrase Structure Rules

$NP \rightarrow Det\ NP$ $NP \rightarrow N$
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pictures of a friend



Phrase Structure Rules

$NP \rightarrow Det\ NP$

$NP \rightarrow N$

$PP \rightarrow P\ NP$

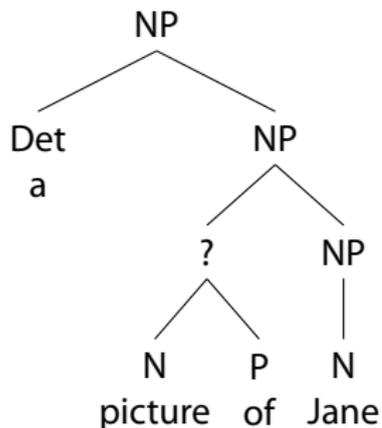
$NP \rightarrow NP\ PP$

Constituency

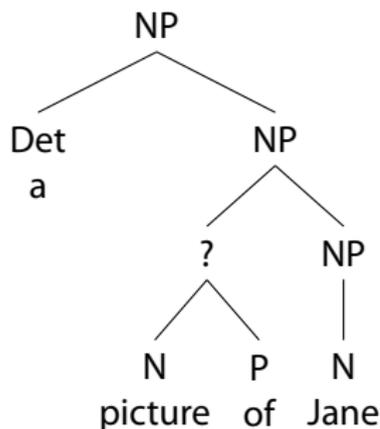
- But wait, how do we know that these are the right structures?

Constituency

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- Why couldn't it be like this:



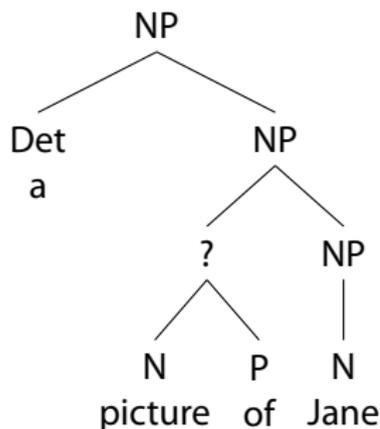
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- This structure predicts that *picture* and *of* should share a tighter syntactic connection than *a* and *picture* (because they form a constituent).

Constituency

- But wait, how do we know that these are the right structures?
- Why couldn't it be like this:



- This structure predicts that *picture* and *of* should share a tighter syntactic connection than *a* and *picture* (because they form a constituent).
- We can use **constituency tests** to argue for one structure over another.

Assumption

Syntactic processes can only affect phrasal constituents.

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Some constituency tests:

- Displacement

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Some constituency tests:

- Displacement
- Replacement

Assumption

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Some constituency tests:

- Displacement
- Replacement
- Deletion

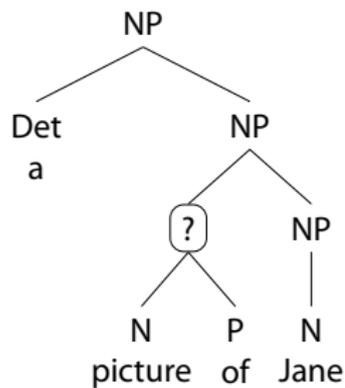
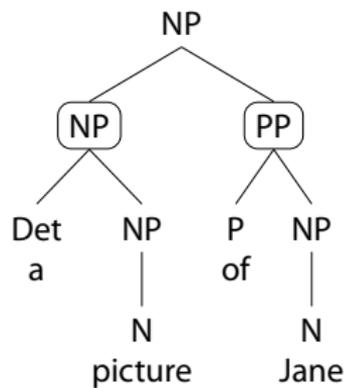
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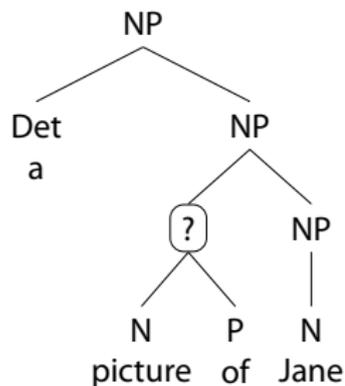
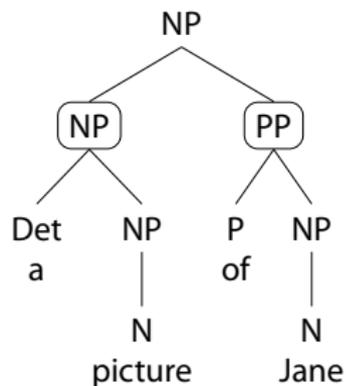
Some constituency tests:

- Displacement
- Replacement
- Deletion
- Coordination

Displacement



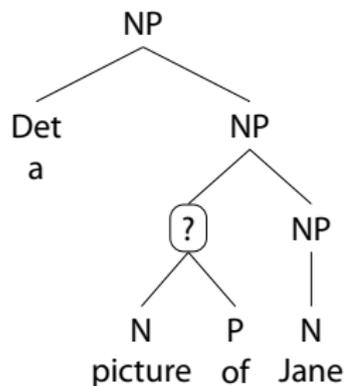
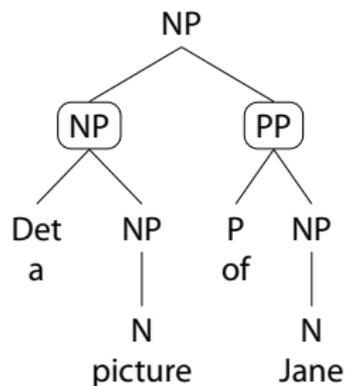
Displacement



Displacement

Only constituents can be displaced

Displacement

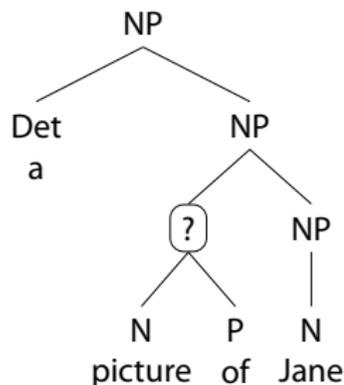
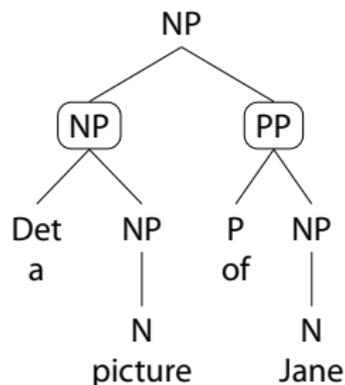


Displacement

Only constituents can be displaced

- (1) a. I saw a picture of Jane

Displacement

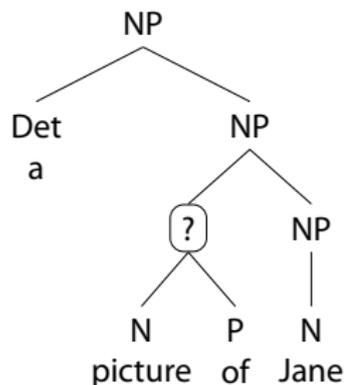
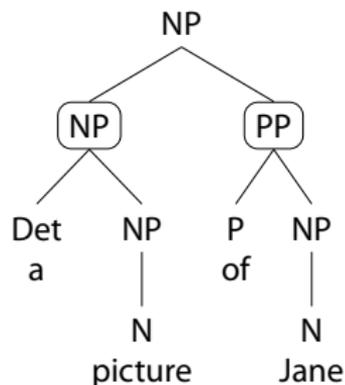


Displacement

Only constituents can be displaced

- (1) a. I saw a picture of Jane
b. It was **a picture** that I saw ___ of Jane (not a video)

Displacement

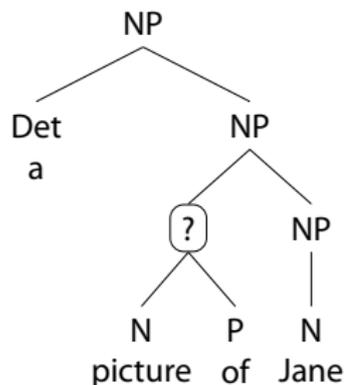
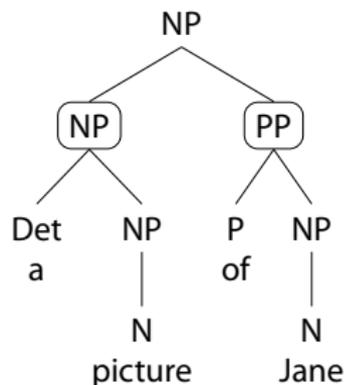


Displacement

Only constituents can be displaced

- (1)
- I saw a picture of Jane
 - It was **a picture** that I saw ___ of Jane (not a video)
 - It was **of Jane** that I saw a picture ___ (not of James)

Displacement

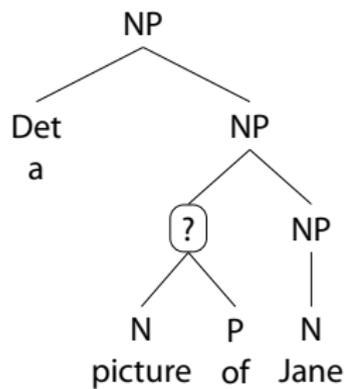
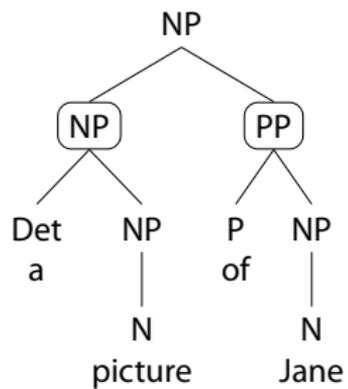


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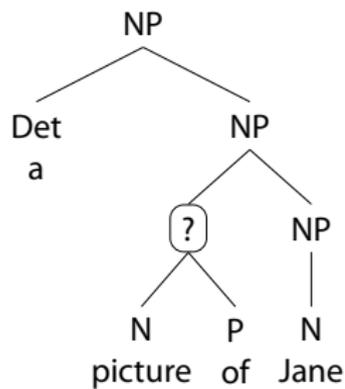
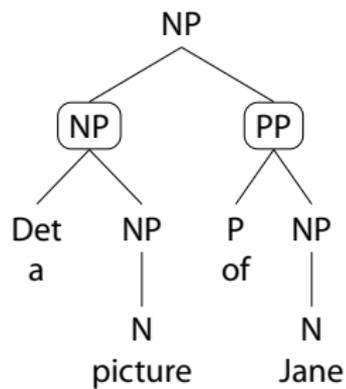
Only constituents can be displaced

- (1)
- I saw a picture of Jane
 - It was **a picture** that I saw ___ of Jane (not a video)
 - It was **of Jane** that I saw a picture ___ (not of James)
 - *It was **picture of**, I saw a ___ Jane (not video of)

Replacement



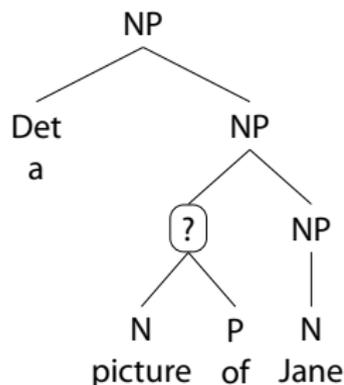
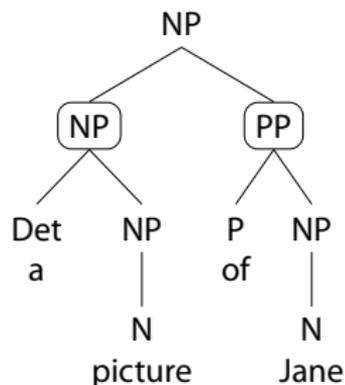
Replacement



Replacement

Only constituents can be replaced with a pronoun

Replacement

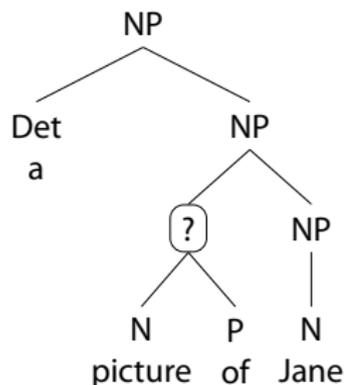
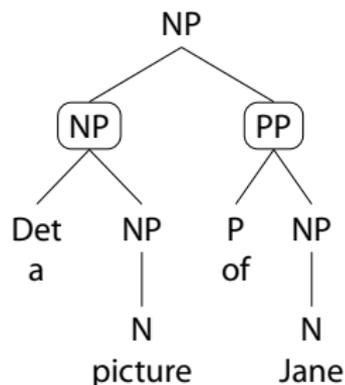


Replacement

Only constituents can be replaced with a pronoun

- (2) a. You saw a picture of Steve and I saw a picture of Jane

Replacement

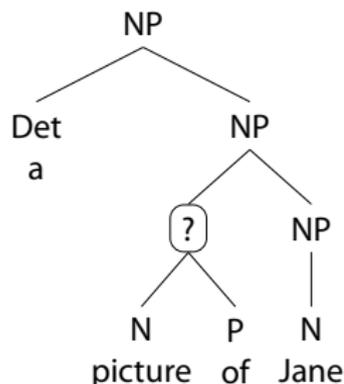
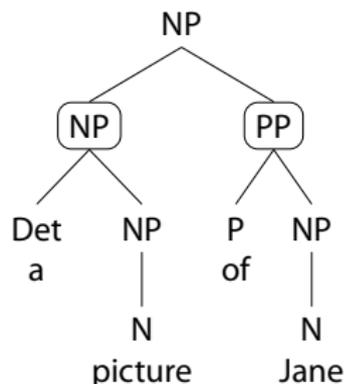


Replacement

Only constituents can be replaced with a pronoun

- (2) a. You saw a picture of Steve and I saw a picture of Jane
b. You saw a picture of Steve and I saw **one** of Jane

Replacement

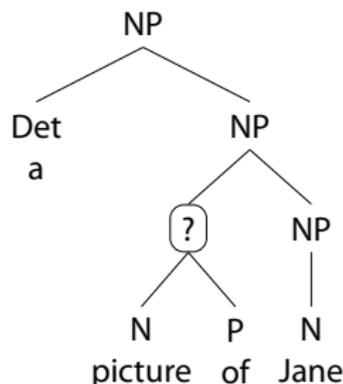
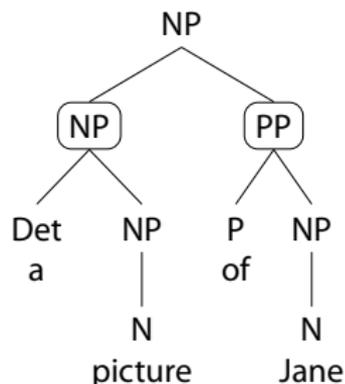


Replacement

Only constituents can be replaced with a pronoun

- (2) a. You saw a picture of Steve and I saw a picture of Jane
- b. You saw a picture of Steve and I saw **one** of Jane
- c. *You saw a picture of Steve and I saw a picture **thereof**

Replacement

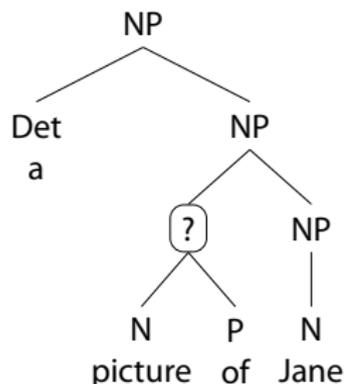
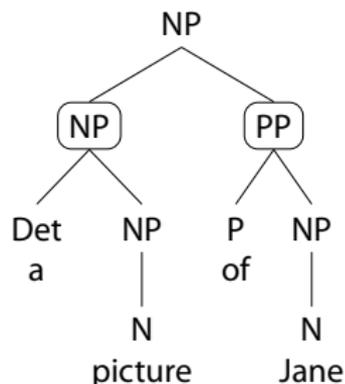


Replacement

Only constituents can be replaced with a pronoun

- (2)
- a. You saw a picture of Steve and I saw a picture of Jane
 - b. You saw a picture of Steve and I saw **one** of Jane
 - c. *You saw a picture of Steve and I saw a picture **thereof**
- But: (the identification of **a problem** and the discussion **thereof**)

Replacement

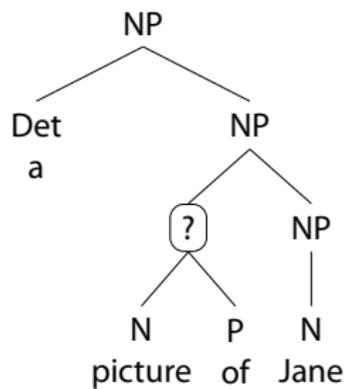
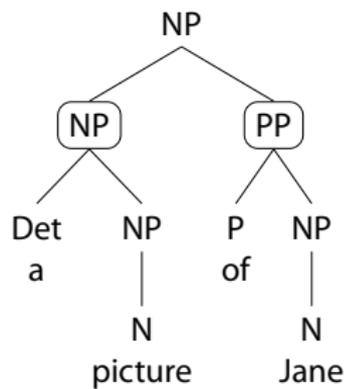


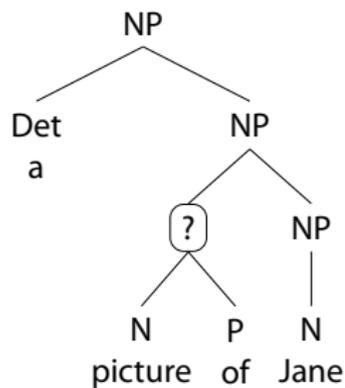
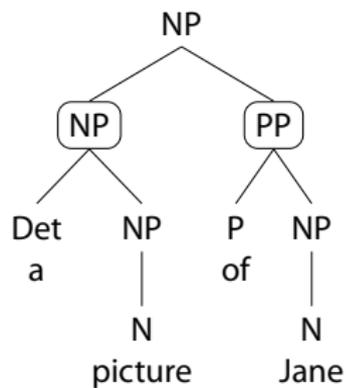
Replacement

Only constituents can be replaced with a pronoun

- (2)
- You saw a picture of Steve and I saw a picture of Jane
 - You saw a picture of Steve and I saw **one** of Jane
 - *You saw a picture of Steve and I saw a picture **thereof**
But: (the identification of **a problem** and the discussion **thereof**)
 - *You saw a picture of Steve and I saw a **one/thereof** Jane

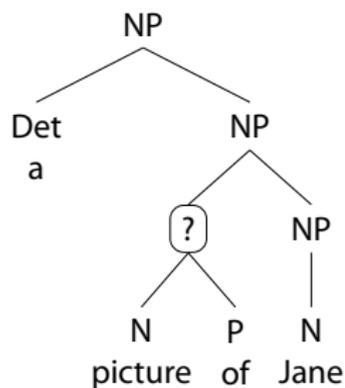
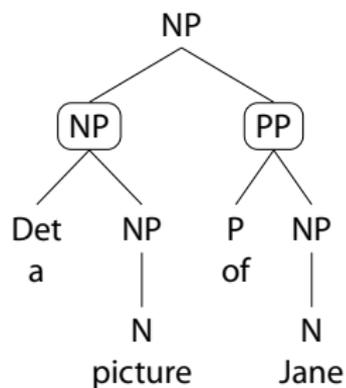
Deletion





Deletion

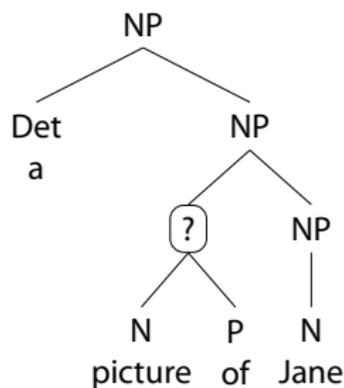
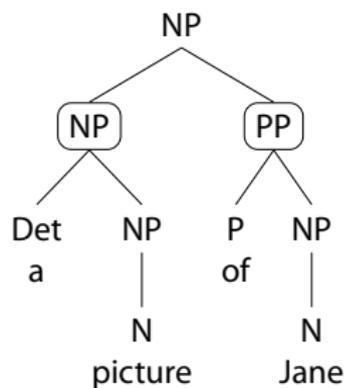
Only constituents can be deleted



Deletion

Only constituents can be deleted

- (3) a. I saw a picture of Jane

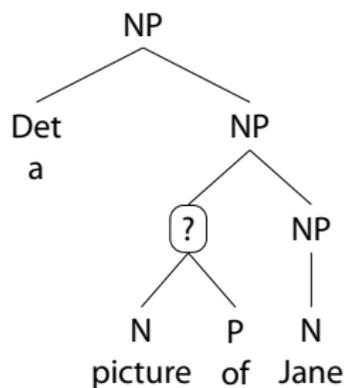
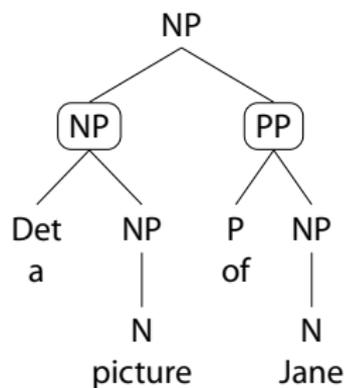


Deletion

Only constituents can be deleted

- (3) a. I saw a picture of Jane
b. *I saw ~~a picture~~ of Jane

(might fail for other reasons!)

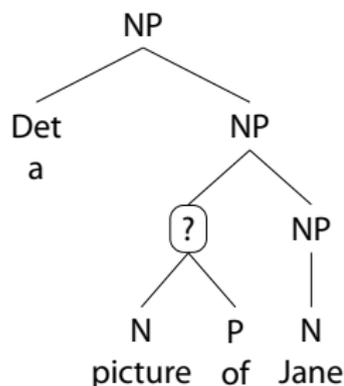
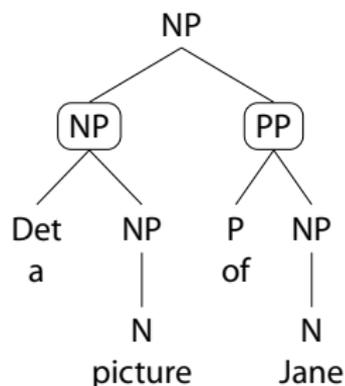


Deletion

Only constituents can be deleted

- (3) a. I saw a picture of Jane
b. *I saw ~~a picture~~ of Jane
c. I saw a picture ~~of Jane~~

(might fail for other reasons!)



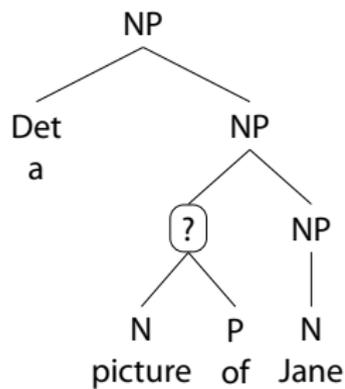
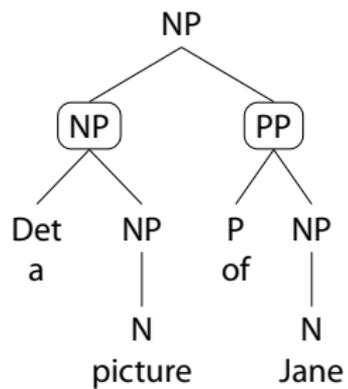
Deletion

Only constituents can be deleted

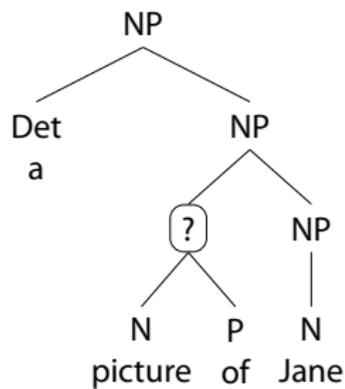
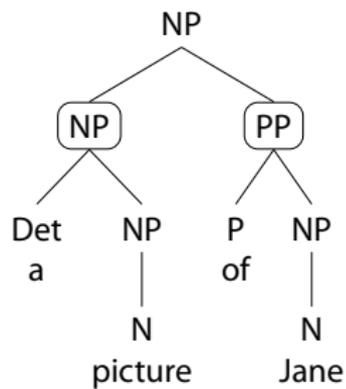
- (3)
- a. I saw a picture of Jane
 - b. *I saw ~~a picture~~ of Jane
 - c. I saw a picture ~~of Jane~~
 - d. *I saw a ~~picture of~~ Jane

(might fail for other reasons!)

Coordination

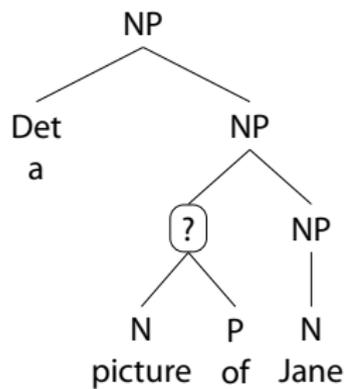
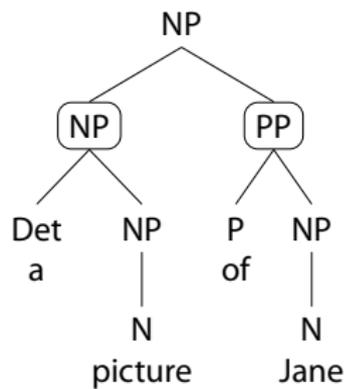


Coordination



Coordination

Only constituents can be connected with coordinators (*and, or*).

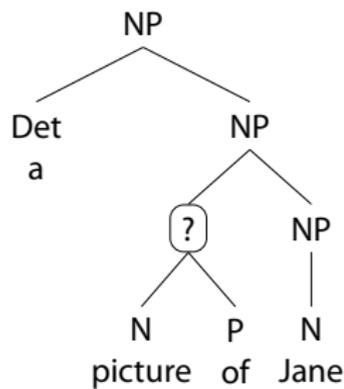
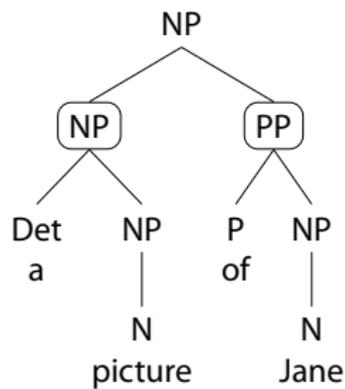


Coordination

Only constituents can be connected with coordinators (*and, or*).

- (4) a. I saw a picture of Jane

Coordination

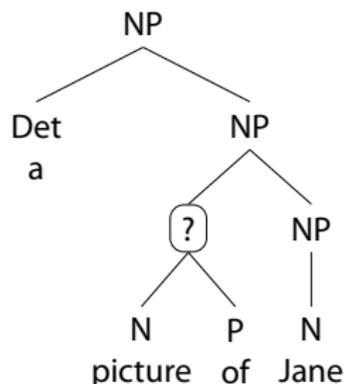
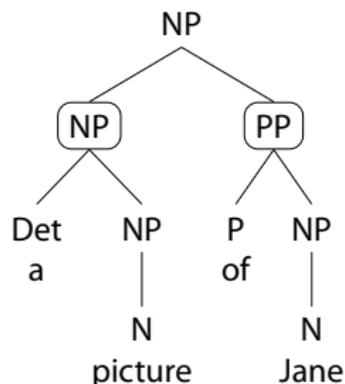


Coordination

Only constituents can be connected with coordinators (*and, or*).

- (4) a. I saw a picture of Jane
b. I saw **a picture** and **a video** of Jane

Coordination

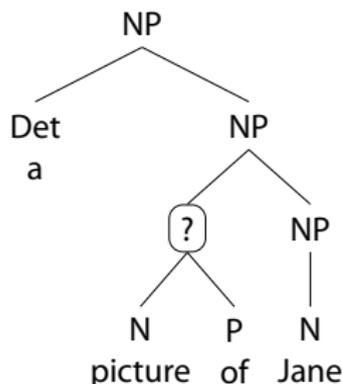
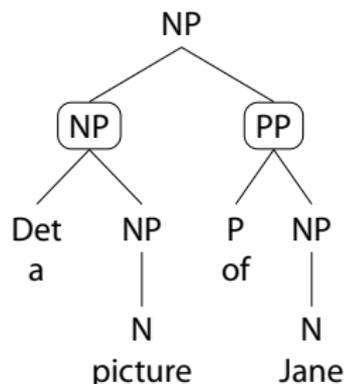


Coordination

Only constituents can be connected with coordinators (*and, or*).

- (4)
- I saw a picture of Jane
 - I saw **a picture** and **a video** of Jane
 - I saw a picture **of Jane** and **of Sean**

Coordination

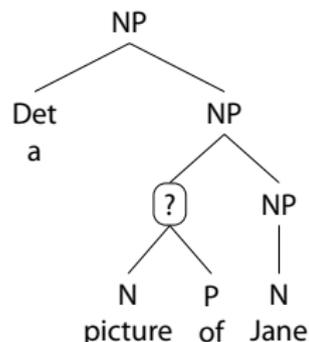
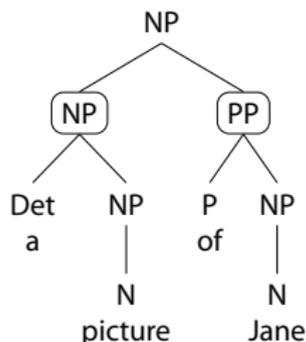


Coordination

Only constituents can be connected with coordinators (*and, or*).

- (4)
- a. I saw a picture of Jane
 - b. I saw **a picture** and **a video** of Jane
 - c. I saw a picture **of Jane** and **of Sean**
 - d. ?I saw a **picture of** and **video of** Jane
(could actually be: **picture of ~~the~~** and **video of** Jane)

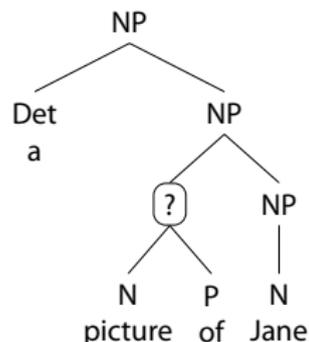
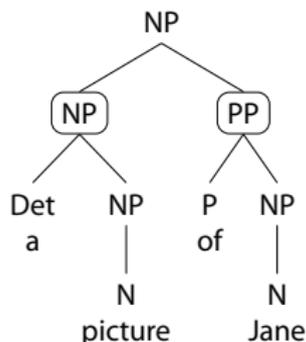
Constituency tests: Summary



	Displacement	Replacement	Deletion	Coordination
a picture	✓	✓	✗	✓
of Jane	✓	(✗)	✓	✓
picture of	✗	✗	✗	(✓)

- Constituent tests are not a perfect diagnostic, but can be useful when multiple tests converge on a similar result.

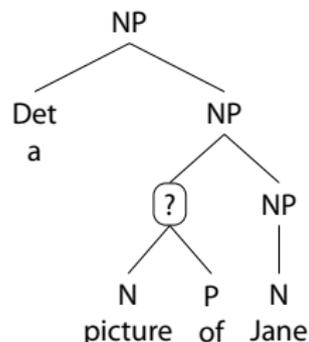
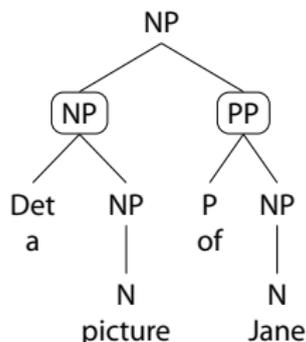
Constituency tests: Summary



	Displacement	Replacement	Deletion	Coordination
a picture	✓	✓	✗	✓
of Jane	✓	(✗)	✓	✓
picture of	✗	✗	✗	(✓)

- Constituent tests are not a perfect diagnostic, but can be useful when multiple tests converge on a similar result.
- Based on our tests, we can conclude:

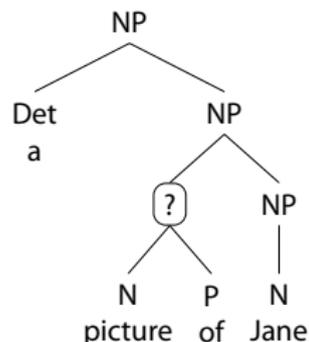
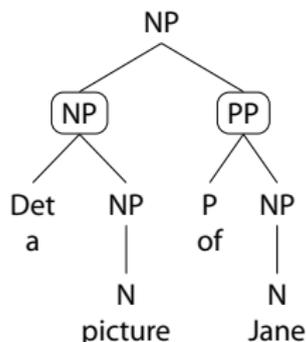
Constituency tests: Summary



	Displacement	Replacement	Deletion	Coordination
a picture	✓	✓	✗	✓
of Jane	✓	(✗)	✓	✓
picture of	✗	✗	✗	(✓)

- Constituency tests are not a perfect diagnostic, but can be useful when multiple tests converge on a similar result.
- Based on our tests, we can conclude:
 - ★ **a picture** is most likely a constituent

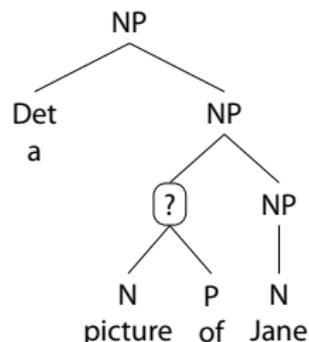
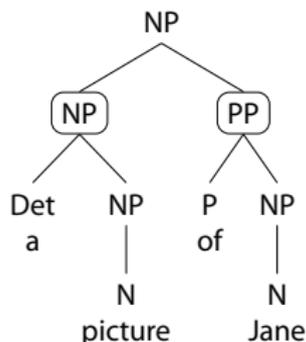
Constituency tests: Summary



	Displacement	Replacement	Deletion	Coordination
a picture	✓	✓	✗	✓
of Jane	✓	(✗)	✓	✓
picture of	✗	✗	✗	(✓)

- Constituency tests are not a perfect diagnostic, but can be useful when multiple tests converge on a similar result.
- Based on our tests, we can conclude:
 - ★ **a picture** is most likely a constituent
 - ★ **of Jane** is a most likely constituent

Constituency tests: Summary

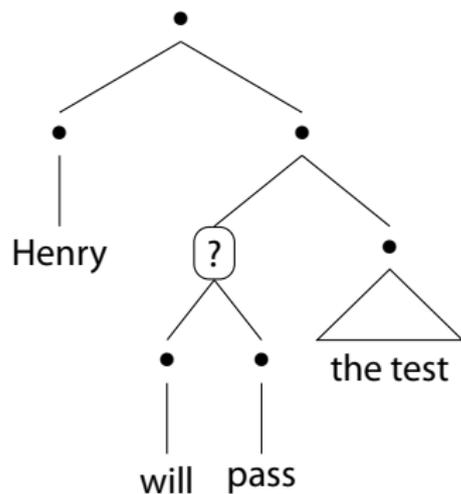
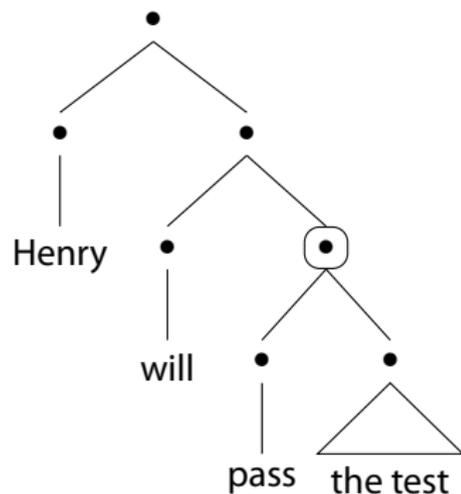


	Displacement	Replacement	Deletion	Coordination
a picture	✓	✓	✗	✓
of Jane	✓	(✗)	✓	✓
picture of	✗	✗	✗	(✓)

- Constituency tests are not a perfect diagnostic, but can be useful when multiple tests converge on a similar result.
- Based on our tests, we can conclude:
 - ★ **a picture** is most likely a constituent
 - ★ **of Jane** is a most likely constituent
 - ★ **picture of** is most likely not a constituent

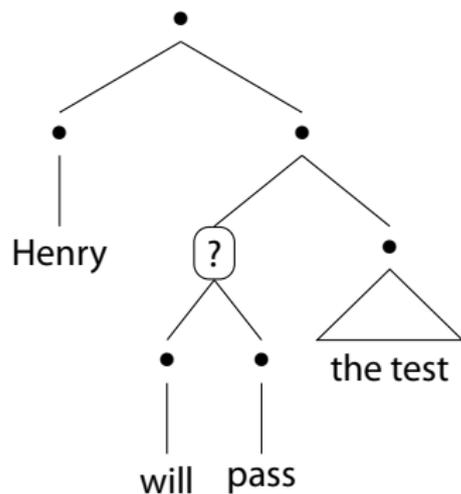
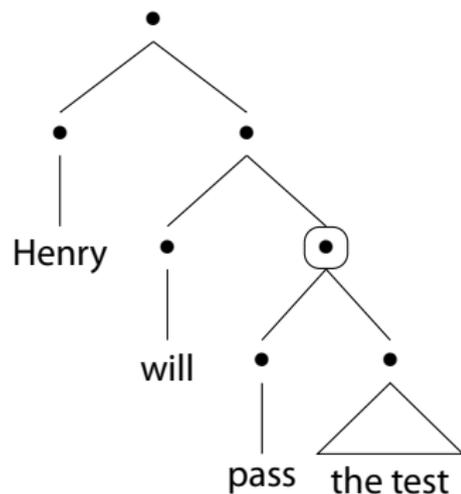
More constituency: Sentences

What is the right structure here based on constituency tests?



More constituency: Sentences

What is the right structure here based on constituency tests?

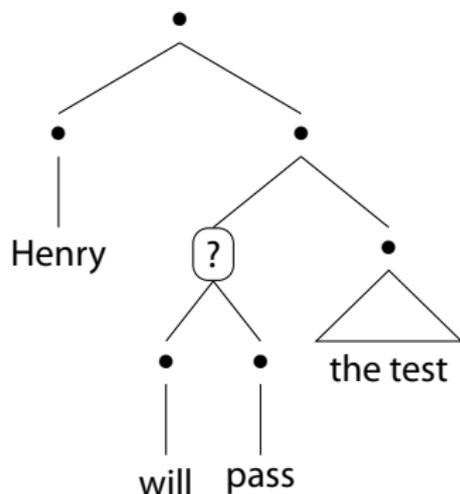
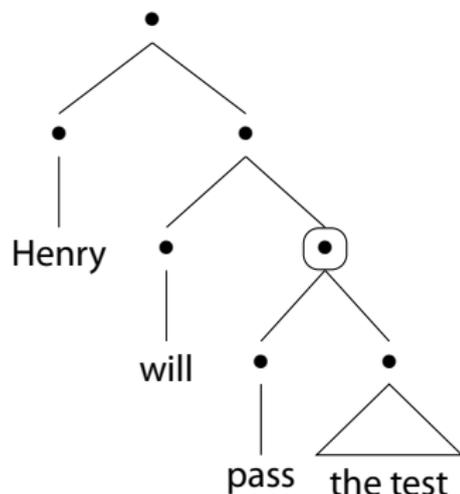


Displacement:

Pass the test though Henry will ___ / ***Will pass** though Henry ___ the test,
he will still fail the class.

More constituency: Sentences

What is the right structure here based on constituency tests?



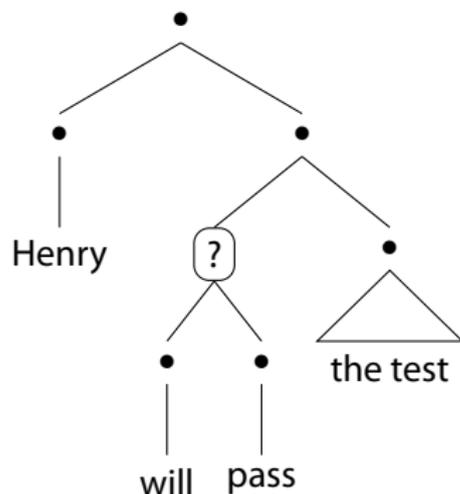
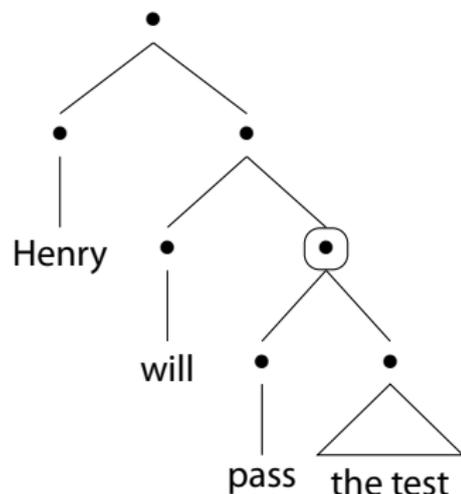
Replacement:

Mary will **pass the test**, but Henry will **do so**, too.

*Mary **will pass** the test, but Henry **do so** the test, too.

More constituency: Sentences

What is the right structure here based on constituency tests?



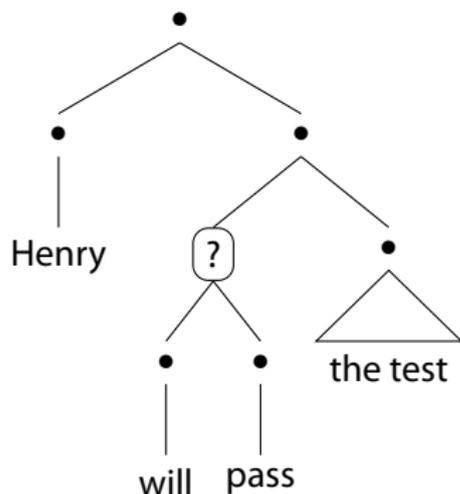
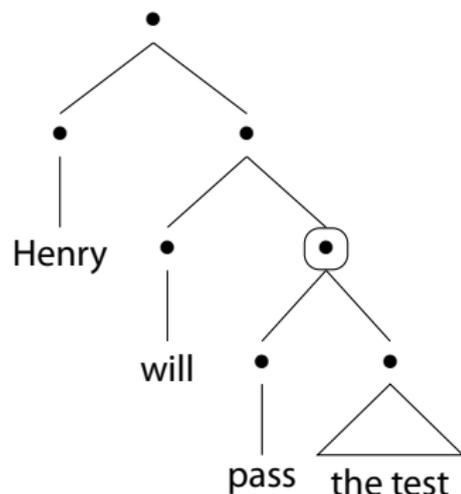
Deletion:

Mary will **pass the test**, and Henry will ____, too.

*Mary **will pass** the test, and Henry __ the test, too.

More constituency: Sentences

What is the right structure here based on constituency tests?



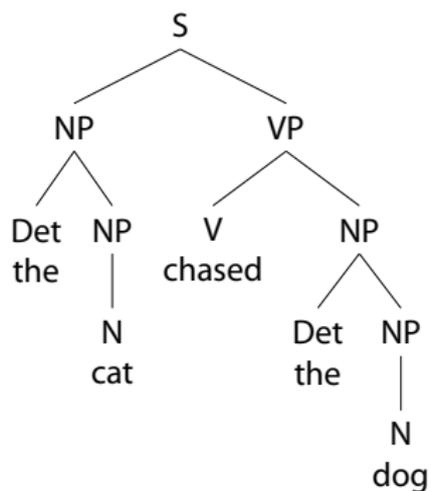
Coordination:

Henry will **take the test** and **pass the test**.

?Mary **will take** and **will pass** the test.

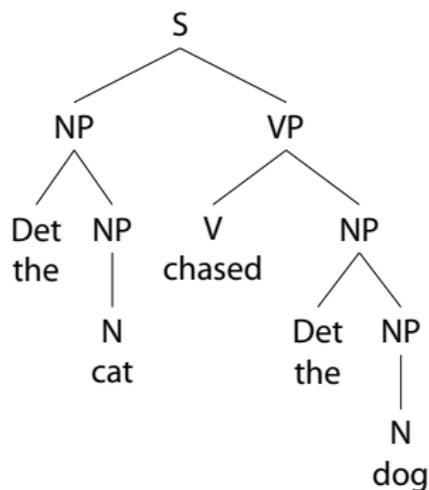
Sentences

What about full sentences like *The cat chased the dog*?



Sentences

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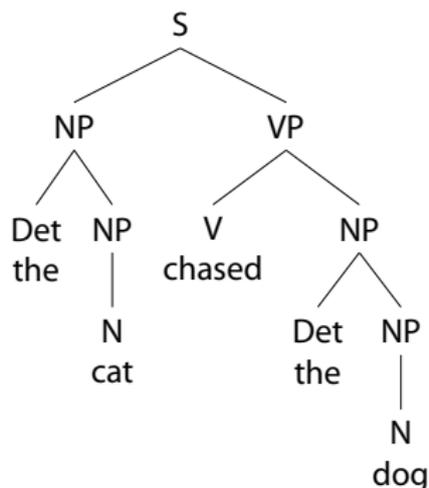
What additional rules do we need to describe this tree?

Phrase Structure Rules

$NP \rightarrow Det\ NP$ $NP \rightarrow N$
 $PP \rightarrow P\ NP$ $NP \rightarrow NP\ PP$

Sentences

What about full sentences like *The cat chased the dog*?



What additional rules do we need to describe this tree?

Phrase Structure Rules

$S \rightarrow NP VP$

$NP \rightarrow Det NP$

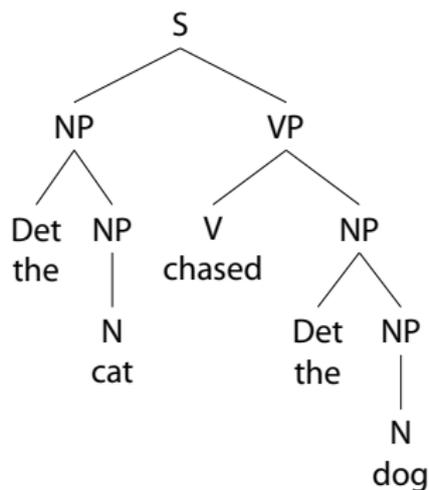
$NP \rightarrow N$

$PP \rightarrow P NP$

$NP \rightarrow NP PP$

Sentences

What about full sentences like *The cat chased the dog*?



What additional rules do we need to describe this tree?

Phrase Structure Rules

$S \rightarrow NP VP$	$VP \rightarrow V NP$
$NP \rightarrow Det NP$	$NP \rightarrow N$
$PP \rightarrow P NP$	$NP \rightarrow NP PP$

What about full sentences like *The cat chased the dog*?

S

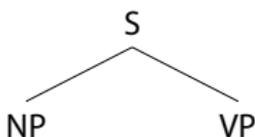
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$NP \rightarrow Det NP$	$NP \rightarrow N$
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Sentences

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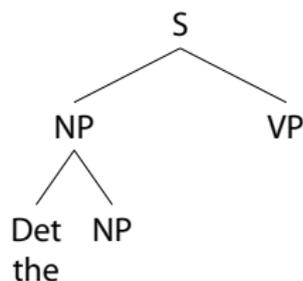
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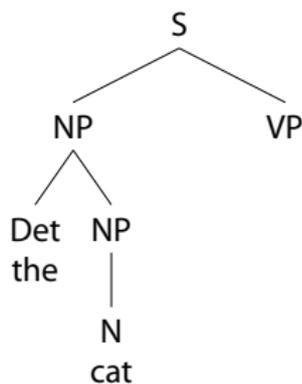
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Sentences

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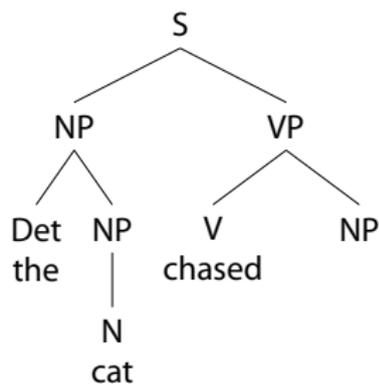
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Sentences

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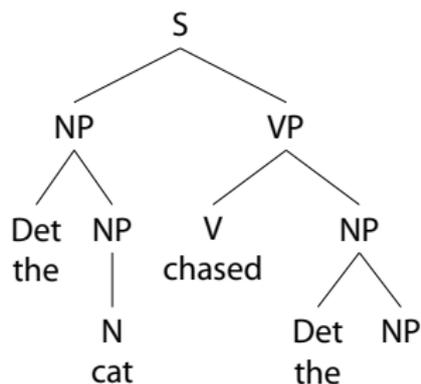
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Sentences

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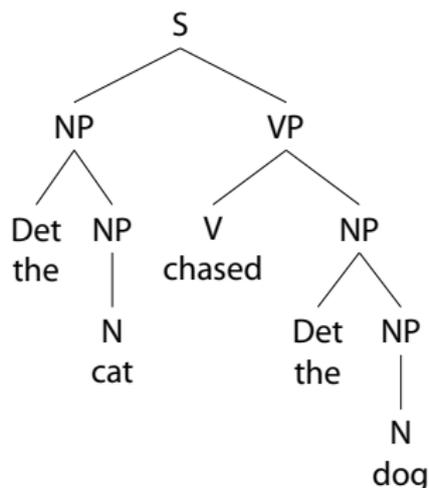
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Sentences

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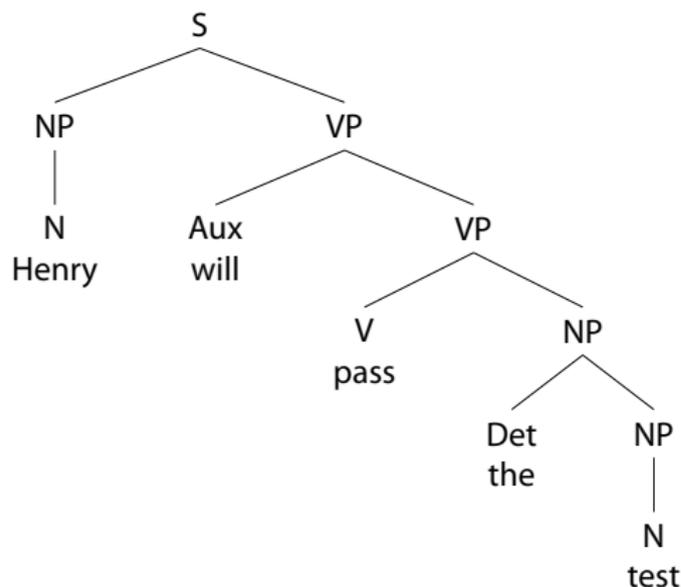


What additional rules do we need to describe this tree?

Phrase Structure Rules

$S \rightarrow NP VP$	$VP \rightarrow V NP$
$NP \rightarrow Det NP$	$NP \rightarrow N$
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What other rule do we need?



Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

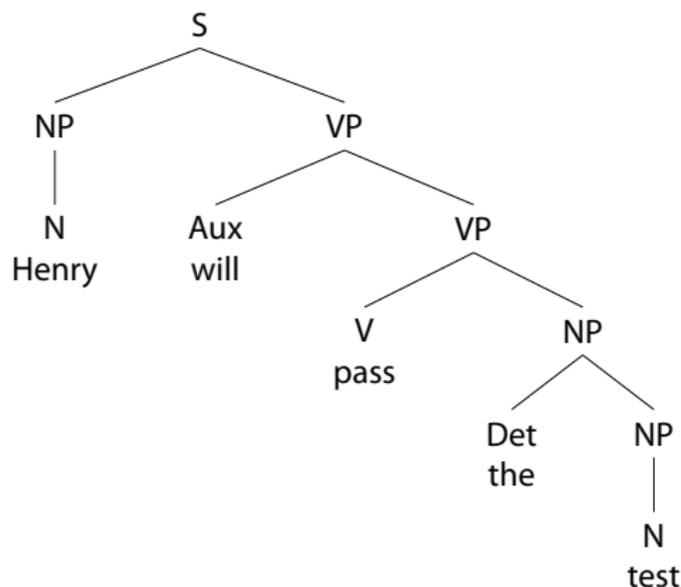
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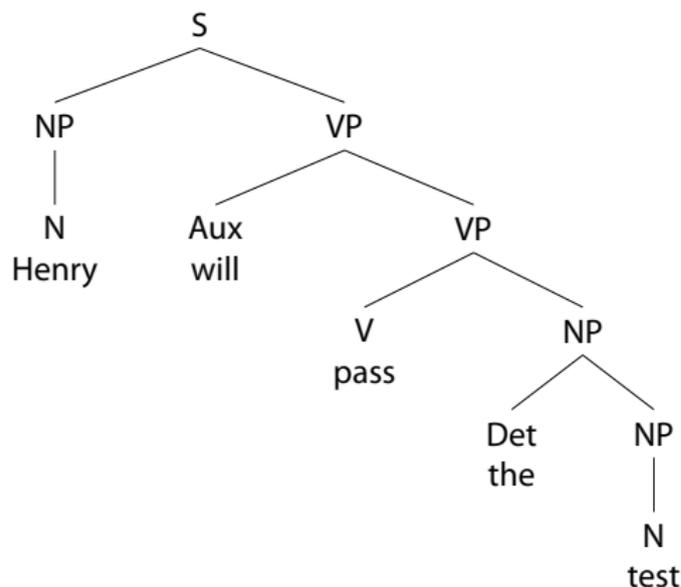
$NP \rightarrow Det NP$

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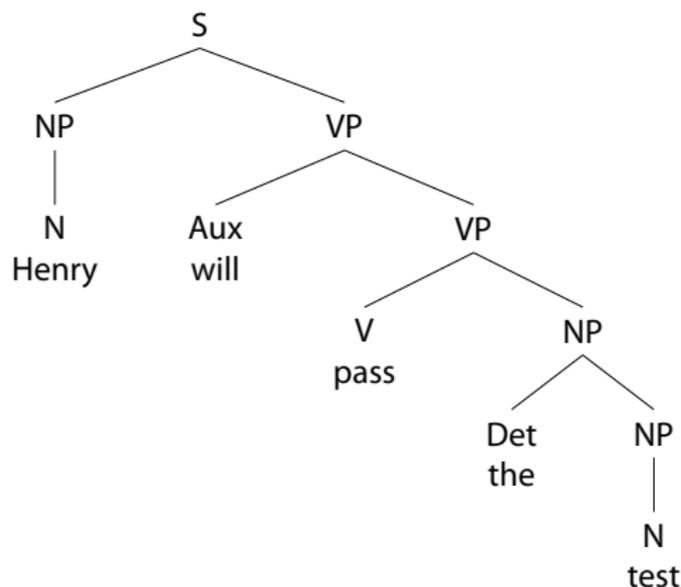
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Phrase Structure Rules

$S \rightarrow NP VP$	$VP \rightarrow V NP$
$VP \rightarrow Aux VP$	$NP \rightarrow Det NP$
$NP \rightarrow N$	$PP \rightarrow P NP$
$NP \rightarrow NP PP$	

What other rule do we need?



Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

$VP \rightarrow Aux VP$

$NP \rightarrow Det NP$

$NP \rightarrow N$

$PP \rightarrow P NP$

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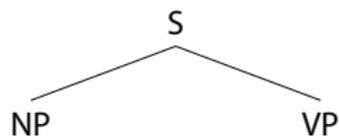
What other rule do we need?

S

Phrase Structure Rules

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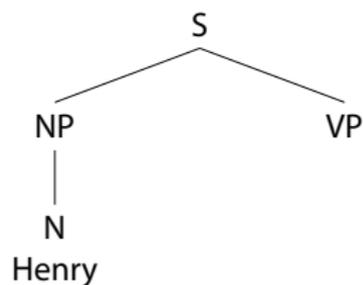
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$VP \rightarrow Aux VP$	$NP \rightarrow Det NP$
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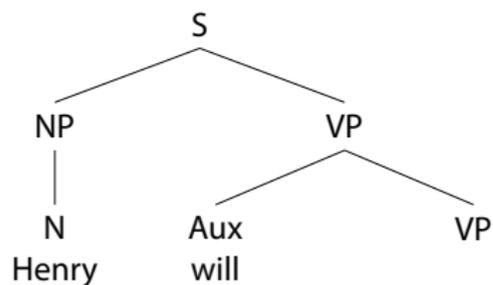
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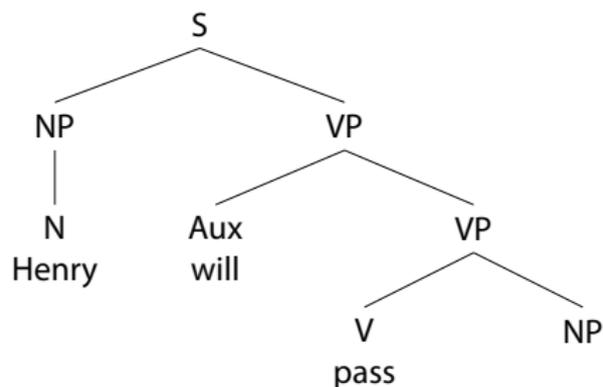
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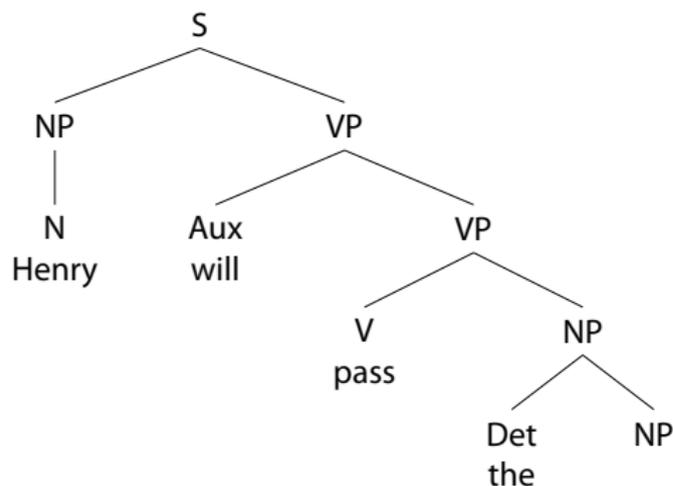
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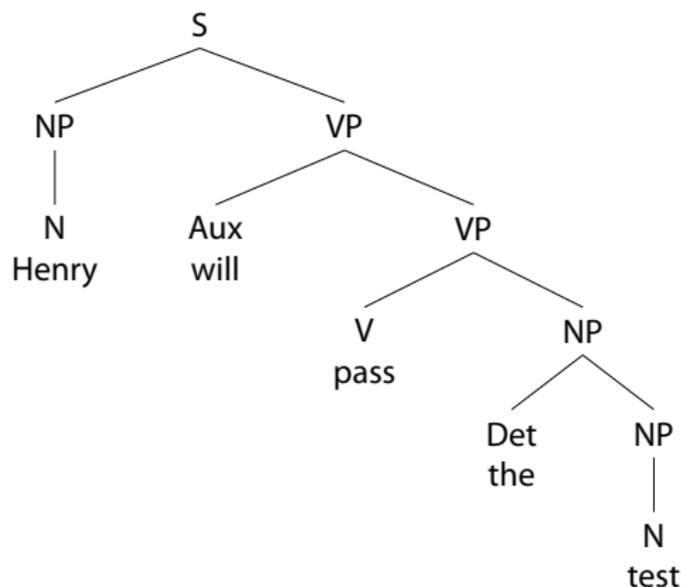
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- Right now, we have a set of rules that can describe sentences with a **transitive** verb like *chase*:

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

$NP \rightarrow Det NP$ $NP \rightarrow N$

$NP \rightarrow NP PP$ $PP \rightarrow P NP$

- Right now, we have a set of rules that can describe sentences with a **transitive** verb like *chase*:

The dog chased the cat

Subject + Verb + Object

transitive

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

$NP \rightarrow Det NP$ $NP \rightarrow N$

$NP \rightarrow NP PP$ $PP \rightarrow P NP$

- Right now, we have a set of rules that can describe sentences with a **transitive** verb like *chase*:

The dog chased the cat

The dog barked

Subject + Verb + Object

Subject + Verb

transitive

intransitive

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

$NP \rightarrow Det NP$ $NP \rightarrow N$
 $NP \rightarrow NP PP$ $PP \rightarrow P NP$

- Right now, we have a set of rules that can describe sentences with a **transitive** verb like *chase*:

The dog chased the cat

Subject + Verb + Object

transitive

The dog barked

Subject + Verb

intransitive

She gave the dog a treat

Subject + Verb + 2 Objects

ditransitive

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

$NP \rightarrow Det NP$ $NP \rightarrow N$

$NP \rightarrow NP PP$ $PP \rightarrow P NP$

- Right now, we have a set of rules that can describe sentences with a **transitive** verb like *chase*:

The dog chased the cat	Subject + Verb + Object	transitive
The dog barked	Subject + Verb	intransitive
She gave the dog a treat	Subject + Verb + 2 Objects	ditransitive
She gave a treat to the dog	Subject + Verb + 2 Objects	ditransitive

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

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She gave a treat to the dog	Subject + Verb + 2 Objects	ditransitive

- What rules do we need to add to account for these sentences?

Phrase Structure Rules

$S \rightarrow NP VP$ $VP \rightarrow V NP$

$VP \rightarrow V$

$NP \rightarrow Det NP$ $NP \rightarrow N$

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$NP \rightarrow N$

$PP \rightarrow P NP$

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She gave a treat to the dog	Subject + Verb + 2 Objects	ditransitive

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$S \rightarrow NP VP$	$VP \rightarrow V NP$
$VP \rightarrow V$	$VP \rightarrow V NP NP$
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$NP \rightarrow Det NP$	$NP \rightarrow N$
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The dog chased the cat	Subject + Verb + Object	transitive
The dog barked	Subject + Verb	intransitive
She gave the dog a treat	Subject + Verb + 2 Objects	ditransitive
She gave a treat to the dog	Subject + Verb + 2 Objects	ditransitive

- What rules do we need to add to account for these sentences?

The dog barked

S

Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

$VP \rightarrow V$

$VP \rightarrow V NP NP$

$VP \rightarrow V NP PP$

$NP \rightarrow Det NP$

$NP \rightarrow N$

$NP \rightarrow NP PP$

$PP \rightarrow P NP$

The dog barked

Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

$VP \rightarrow V$

$VP \rightarrow V NP NP$

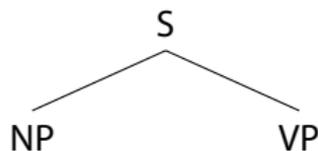
$VP \rightarrow V NP PP$

$NP \rightarrow Det NP$

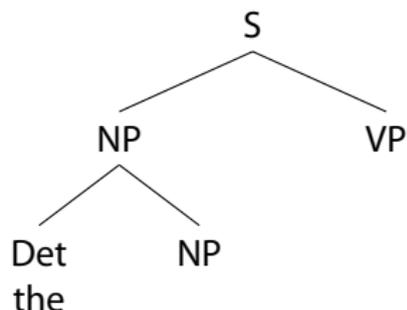
$NP \rightarrow N$

$NP \rightarrow NP PP$

$PP \rightarrow P NP$



The dog barked



Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

$VP \rightarrow V$

$VP \rightarrow V NP NP$

$VP \rightarrow V NP PP$

$NP \rightarrow Det NP$

$NP \rightarrow N$

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The dog barked

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$S \rightarrow NP VP$

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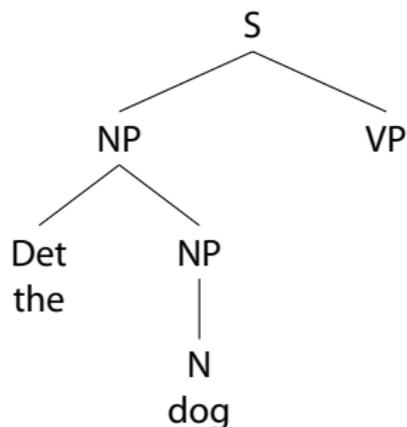
$VP \rightarrow V NP PP$

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$NP \rightarrow NP PP$

$PP \rightarrow P NP$



The dog barked

Phrase Structure Rules

$S \rightarrow NP VP$

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$VP \rightarrow V NP NP$

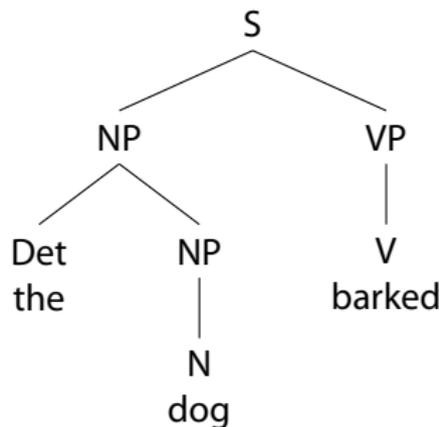
$VP \rightarrow V NP PP$

$NP \rightarrow Det NP$

$NP \rightarrow N$

$NP \rightarrow NP PP$

$PP \rightarrow P NP$



She gave the dog a treat

S

Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V$

$VP \rightarrow V NP PP$

$NP \rightarrow Det NP$

$NP \rightarrow NP PP$

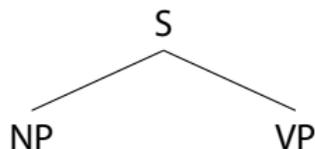
$VP \rightarrow V NP$

$VP \rightarrow V NP NP$

$NP \rightarrow N$

$PP \rightarrow P NP$

She gave the dog a treat



Phrase Structure Rules

$S \rightarrow NP VP$

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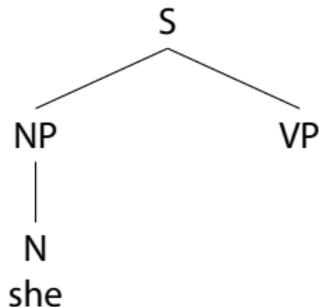
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She gave the dog a treat



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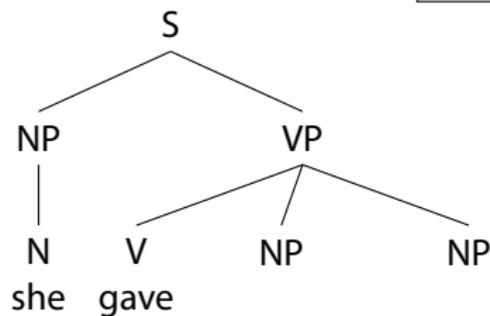
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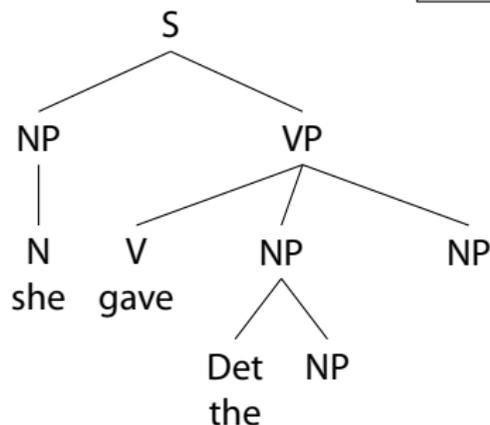
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Phrase Structure Rules

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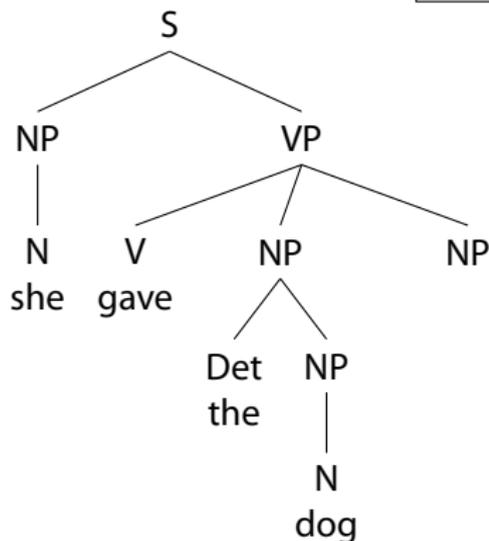
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Phrase Structure Rules

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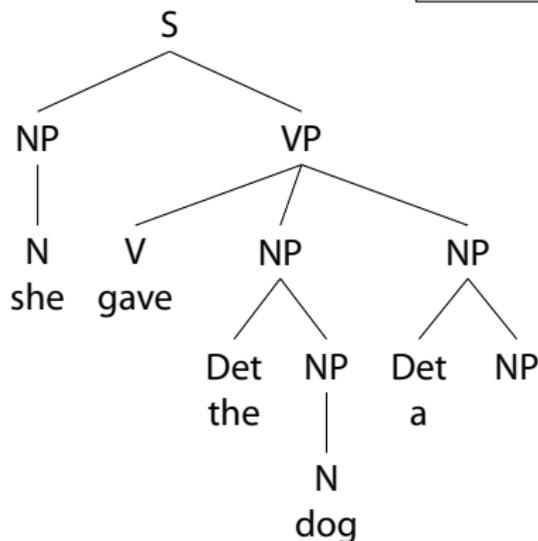
$NP \rightarrow Det NP$

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She gave the dog a treat



Phrase Structure Rules

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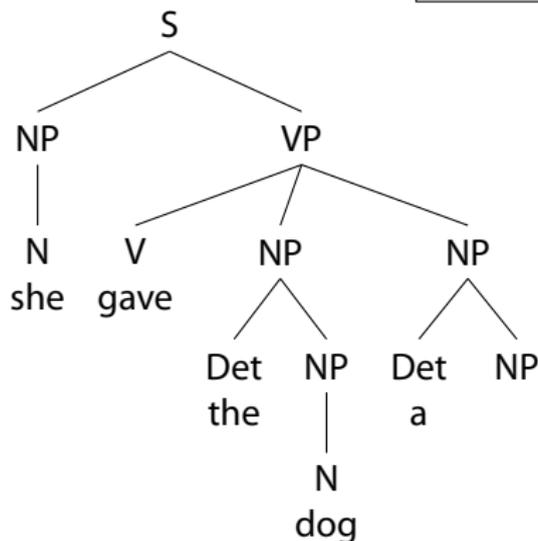
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She gave the dog a treat



Phrase Structure Rules

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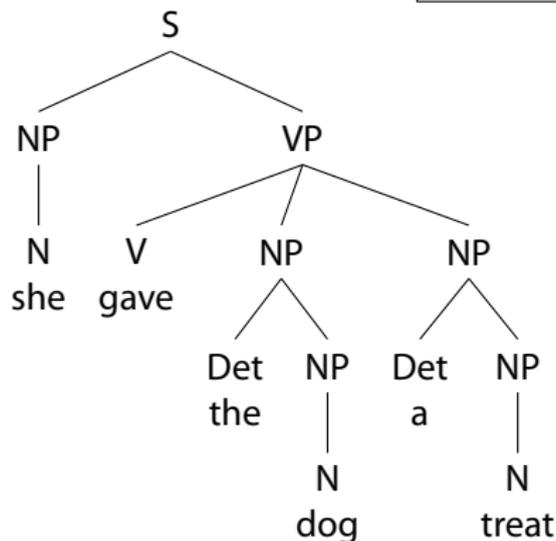
$NP \rightarrow Det NP$

$NP \rightarrow N$

$NP \rightarrow NP PP$

$PP \rightarrow P NP$

She gave the dog a treat



She gave a treat to the dog

S

Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

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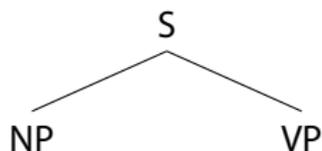
$NP \rightarrow Det NP$

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She gave a treat to the dog



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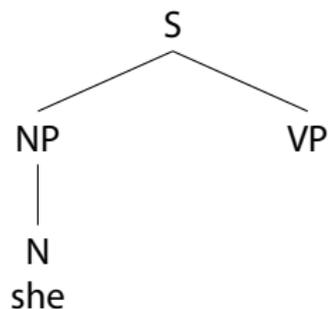
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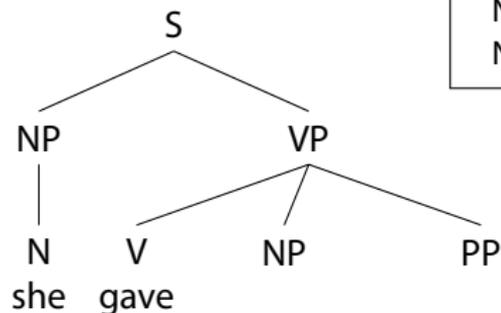
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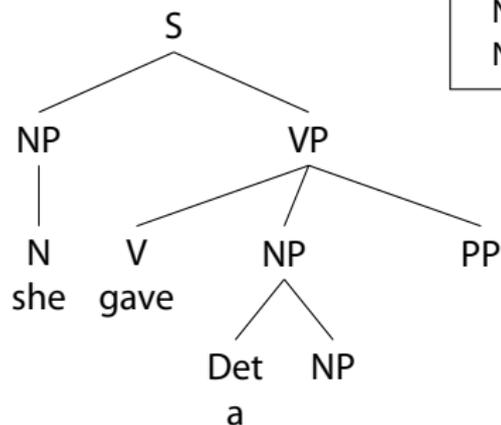
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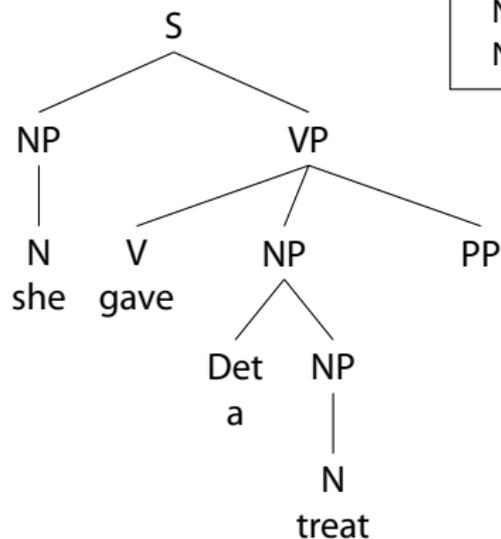
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$VP \rightarrow V NP NP$

$VP \rightarrow V NP PP$

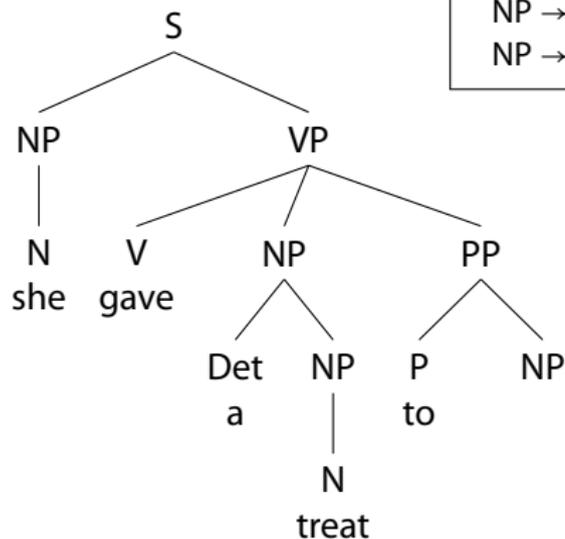
$NP \rightarrow Det NP$

$NP \rightarrow N$

$NP \rightarrow NP PP$

$PP \rightarrow P NP$

She gave a treat to the dog



Phrase Structure Rules

$S \rightarrow NP VP$

$VP \rightarrow V NP$

$VP \rightarrow V$

$VP \rightarrow V NP NP$

$VP \rightarrow V NP PP$

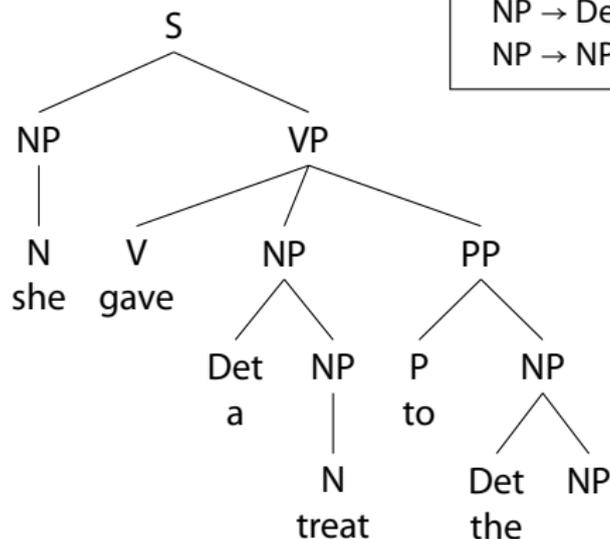
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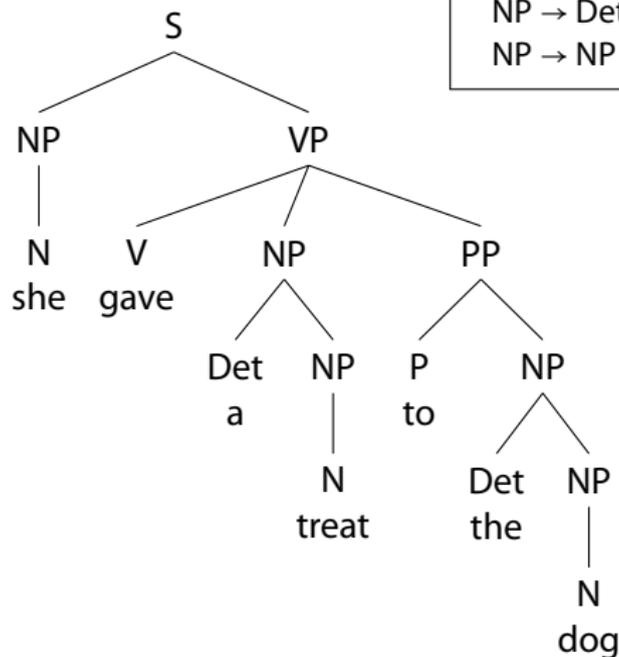
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