

CKY example

Based on [these slides](#) by [Dávid Nemeskey](#)

The input sentence

The dog bit John

The grammar

S → NP VP
 | ProperNoun VP
 | NP Verb
 | ProperNoun Verb

NP → Det Nominal
 | Det Noun

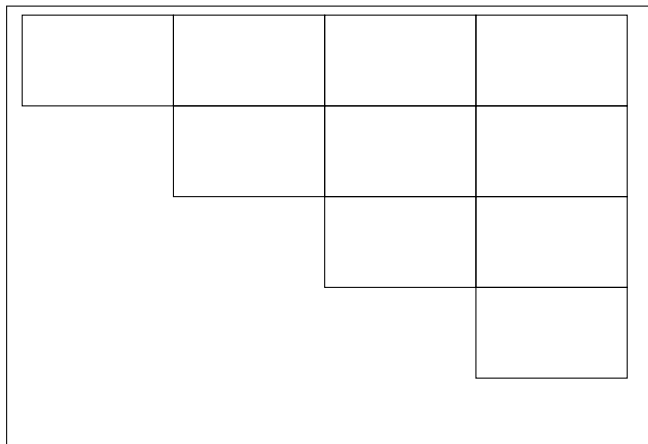
Nominal → Nominal Noun
 | Noun Noun

VP → Verb NP
 | Verb ProperNoun

Example: CKY – The dog bit John.

Now we can apply the CKY algorithm...

Example: CKY – The dog bit John.



First, we start by drawing the upper triangular matrix

Example: CKY – The dog bit John.

<i>the</i>			
	<i>dog</i>		
		<i>bit</i>	
			<i>John</i>

Each column is assigned to a word in the sentence

Example: CKY – The dog bit John.

[1]	[1-2]	[1-3]	[1-4]
<i>the</i>	[2]	[2-3]	[2-4]
	<i>dog</i>	[3]	[3-4]
		<i>bit</i>	[4]
			<i>John</i>

We note the word indices each cell corresponds to

Example: CKY – The dog bit John.

[1] Det	[1-2]	[1-3]	[1-4]
<i>the</i>	[2] Noun	[2-3]	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4]
		<i>bit</i>	[4] ProperNoun
			<i>John</i>

The diagonal records the terminal production rules (POS). Ambiguity: *bit* can also be a noun

Example: CKY – The dog bit John.

[1] Det <i>the</i>	[1-2] Noun	[1-3] Noun Verb	[1-4] ProperNoun
	[2] <i>dog</i>	[2-3]	[2-4]
		[3] <i>bit</i>	[3-4]
			[4] <i>John</i>

There is not much else to do in the first column

Example: CKY – The dog bit John.

[1]	Det	[1-2]	[1-3]	[1-4]
<i>the</i>		Noun	[2-3]	[2-4]
		<i>dog</i>	Noun Verb	[3-4]
			<i>bit</i>	ProperNoun [4]
				<i>John</i>

On to the second column...

Example: CKY – The dog bit John.

[1]	Det [1-2]	[1-3]	[1-4]
<i>the</i>	Noun [2]	[2-3]	[2-4]
	<i>dog</i>	Noun Verb [3]	[3-4]
		<i>bit</i>	ProperNoun [4]
			<i>John</i>

Non-leaf cells correspond to binary rules:

- the first constituent on the right side of the rule is to the *left*
- the second one is *down*

Example: CKY – The dog bit John.

[1] Det	← NP [1-2]	[1-3]	[1-4]
<i>the</i>	[2] Noun	[2-3]	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4]
		<i>bit</i>	ProperNoun [4]
			<i>John</i>

The first rule application: $NP \rightarrow Det \ Noun$

Example: CKY – The dog bit John.

[1]	Det	NP		
	<i>the</i>			
		Noun		
		<i>dog</i>		
			Noun Verb	
			<i>bit</i>	ProperNoun
				<i>John</i>

On to the third column...

Example: CKY – The dog bit John.

[1]	Det	NP		
	[1-2]	[1-3]	[1-4]	
<i>the</i>		Noun		
	[2]	← Nominal		
		[2-3]	[2-4]	
	<i>dog</i>	Noun		
		Verb		
		[3]	[3-4]	
		<i>bit</i>	ProperNoun	
			[4]	
			<i>John</i>	

Rule application: Nominal \rightarrow Noun Noun

Example: CKY – The dog bit John.

[1] Det	[1-2] NP	[1-3]	[1-4]
<i>the</i>	[2] Noun	[2-3] Nominal	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4]
		<i>bit</i>	[4] ProperNoun
			<i>John</i>

In general, non-leaf cells with N words can be split into two in $N - 1$ ways.

Example: CKY – The dog bit John.

[1]	Det	← NP	NP
	[1-2]	[1-3]	[1-4]
<i>the</i>	Noun	Nominal	
	[2]	[2-3]	[2-4]
<i>dog</i>	Noun	Verb	
	[3]	[3-4]	
<i>bit</i>	ProperNoun		
	[4]		
<i>John</i>			

In general, non-leaf cells with N words can be split into two in $N - 1$ ways. When $N = 3$:

- 2 to the left, 1 down: rule application $NP \rightarrow Det \text{ Nominal}$

Example: CKY – The dog bit John.

[1]	Det	[1-2]	NP	[1-3]	NP	[1-4]
<i>the</i>					S	
		[2]	Noun	[2-3]	Nominal	[2-4]
		<i>dog</i>				
				[3]	Noun Verb	[3-4]
				<i>bit</i>		
					ProperNoun	[4]
					<i>John</i>	

In general, non-leaf cells with N words can be split into two in $N - 1$ ways. When $N = 3$:

- 2 to the left, 1 down: rule application $NP \rightarrow Det \text{ Nominal}$
- 1 to the left, 2 down: rule application $S \rightarrow NP \text{ Verb}$

Example: CKY – The dog bit John.

[1] Det	[1-2] NP	[1-3] NP S	[1-4]
<i>the</i>	[2] Noun	[2-3] Nominal	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4]
		<i>bit</i>	ProperNoun [4]
			<i>John</i>

Here we found an S. However, it is not at the top right cell, so we are not done yet.

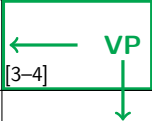
Example: CKY – The dog bit John.

[1] Det	[1-2] NP	[1-3] NP S	[1-4]
<i>the</i>	[2] Noun	[2-3] Nominal	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4]
		<i>bit</i>	ProperNoun [4]
			<i>John</i>

On to the fourth column...

Example: CKY – The dog bit John.

[1]	Det	[1-2]	NP	[1-3]	NP S	[1-4]
<i>the</i>			Noun	[2-3]	Nominal	[2-4]
		[2]				
		<i>dog</i>		[3]	Noun Verb	[3-4]
				<i>bit</i>		ProperNoun [4]
						<i>John</i>



Rule application: $VP \rightarrow \text{Verb ProperNoun}$

Example: CKY – The dog bit John.

[1]	Det	[1-2]	NP	[1-3]	NP S	[1-4]
<i>the</i>			Noun	← Nominal		
		[2]		[2-3]		[2-4]
			<i>dog</i>		Noun Verb	VP
				[3]		[3-4]
					<i>bit</i>	ProperNoun
						[4]
						<i>John</i>

No applicable rules

Example: CKY – The dog bit John.

[1]	Det	[1-2]	NP	[1-3]	NP S	[1-4]
<i>the</i>						
		[2]	Noun	[2-3]	Nominal	[2-4]
		<i>dog</i>				
			[3]	Noun Verb	[3-4]	VP
			<i>bit</i>			
						ProperNoun
						[4]
						<i>John</i>

No applicable rules

Example: CKY – The dog bit John.

	Det	NP	NP	
[1]	[1-2]	[1-3]	S	[1-4]
<i>the</i>	Noun	Nominal		
	[2]	[2-3]	[2-4]	
	<i>dog</i>	Noun	VP	
		[3]	Verb	[3-4]
		<i>bit</i>	ProperNoun	
			[4]	
				<i>John</i>

The top right cell represents the whole sentence.

Example: CKY – The dog bit John.

	Det	NP	NP	S
[1]	[1-2]	[1-3]	[1-3]	[1-4]
<i>the</i>	Noun	Nominal		
	[2]	[2-3]	[2-4]	
	<i>dog</i>	Noun		VP
		[3]	[3-4]	
		<i>bit</i>	ProperNoun	
			[4]	
			<i>John</i>	

Rule application: $S \rightarrow NP \ VP$

Example: CKY – The dog bit John.

[1]	Det	[1-2]	NP	[1-3]	NP S	[1-4]	S
<i>the</i>		[2]	Noun	[2-3]	Nominal	[2-4]	
	<i>dog</i>			[3]	Noun Verb	[3-4]	VP
			<i>bit</i>				ProperNoun
						[4]	<i>John</i>

Example: CKY – The dog bit John.

[1] Det	[1-2] NP	[1-3] NP S	[1-4] S
<i>the</i>	[2] Noun	[2-3] Nominal	[2-4]
	<i>dog</i>	[3] Noun Verb	[3-4] VP
		<i>bit</i>	[4] ProperNoun
			<i>John</i>

S in the top right cell: sentence accepted.

Example: CKY – The dog bit John.

	Det		NP	
[1]		[1-2]	S	[1-4]
<i>the</i>	Noun	Nominal		
	[2]	[2-3]	[2-4]	
	<i>dog</i>	Noun		
		Verb		
		[3]	[3-4]	
		<i>bit</i>	ProperNoun	
			[4]	
			<i>John</i>	

The diagram illustrates the CKY parsing process for the sentence "The dog bit John". The parse tree is represented as a grid of cells. The root node is S, which is highlighted with a green border. A green arrow points from the S node to its child NP. Another green arrow points from the S node to its child VP. The NP node is also highlighted with a green border. The VP node is highlighted with a green border. The terminal nodes are "the", "dog", "bit", and "John". The nonterminal nodes are Det, Noun, Nominal, Noun, Verb, and ProperNoun. The grid cells contain the index ranges for each node: [1] for Det, [1-2] for Noun, [1-3] for Nominal, [1-4] for S, [2] for Noun, [2-3] for Nominal, [2-4] for Noun, [3] for Verb, [3-4] for ProperNoun, and [4] for ProperNoun.

Each nonterminal maintains backpointers to its children (here: NP and VP)

Example: CKY – The dog bit John.

<div>Det</div> <div>[1]</div>	<div>← NP</div> <div>[1-2]</div>	<div>← NP</div> <div>[1-3]</div>	<div>S</div> <div>[1-4]</div>
<div>the</div>	<div>Noun</div> <div>[2]</div>	<div>Nominal</div> <div>[2-3]</div>	
	<div>dog</div>	<div>Noun</div> <div>[3]</div>	<div>← VP</div> <div>[3-4]</div>
		<div>bit</div>	<div>ProperNoun</div> <div>[4]</div>
<div>John</div>			

The backpointers define the syntax tree.