



# Dependency Parsing

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EXERCISE

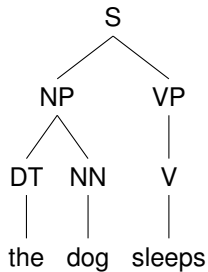
## A pcfg

Assume the following grammar

s	→	np	vp	1.0	v	→	sleeps	0.4
vp	→	v	np	0.7	v	→	saw	0.6
vp	→	vp	pp	0.2	nn	→	man	0.1
vp	→	v		0.1	nn	→	woman	0.1
np	→	dt	nn	0.2	nn	→	telescope	0.3
np	→	np	pp	0.8	nn	→	dog	0.5
pp	→	p	np	1.0	dt	→	the	1.0
					p	→	with	0.6
					p	→	in	0.4

## Evaluating the probability of a sentence

What is the probability of the parse



## Evaluating the probability of a sentence

$$\underbrace{1.0}_{\text{det} \rightarrow \text{the}} \cdot \underbrace{0.5}_{\text{n} \rightarrow \text{dog}} \cdot \underbrace{1.0}_{\text{v} \rightarrow \text{sleeps}} \cdot \underbrace{0.1}_{\text{vp} \rightarrow \text{v}} \cdot \underbrace{0.2}_{\text{np} \rightarrow \text{dt n}} \cdot \underbrace{1.0}_{\text{s} \rightarrow \text{np vp}} = 0.002$$

## Parsing Sentence

What's the best parse for the sentence

1      2      3      4      5      6      7      8  
the   man   saw   the   dog   with   a   telescope

### Under the grammar

s	→	np	vp	1.0	v	→	sleeps	0.4
vp	→	v	np	0.7	v	→	saw	0.6
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vp	→	v		0.1	nn	→	woman	0.1
np	→	dt	nn	0.2	nn	→	telescope	0.3
np	→	np	pp	0.8	nn	→	dog	0.5
pp	→	p	np	1.0	dt	→	the	1.0
					p	→	with	0.6
					p	→	in	0.4

First, do spans for single word (e.g.,  $C[8, 8, nn]$ ).

## Span 0

1.  $C[8, 8, \text{nn}] = \ln(0.3) = -1.2$
2.  $C[7, 7, \text{dt}] = \ln(1.0) = 0.0$
3.  $C[6, 6, \text{p}] = \ln(0.6) = -0.51$
4.  $C[5, 5, \text{nn}] = \ln(0.5) = -0.69$
5.  $C[4, 4, \text{dt}] = \ln(1.0) = 0.0$
6.  $C[3, 3, \text{v}] = \ln(0.6) = -.51$
7.  $C[3, 3, \text{vp}] = \ln(0.6) + \ln(0.1) = -2.8$
8.  $C[2, 2, \text{nn}] = \ln(0.1) = -2.3$
9.  $C[1, 1, \text{dt}] = \ln(1.0) = 0.0$

## Span 1

$$1. C[1,2,np] = \underbrace{0.0}_{C[1,1,DT]} + \ln(\underbrace{-2.3}_{C[2,2,NN]}) + \ln(\underbrace{0.2}_{np \rightarrow dt \ n}) = -2.3 + -1.6 = -3.9$$

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$$1. C[1,2,np] = \underbrace{0.0}_{C[1,1,DT]} + \ln(\underbrace{-2.3}_{C[2,2,NN]}) + \ln(\underbrace{0.2}_{np \rightarrow dt \ n}) = -2.3 + -1.6 = -3.9$$

$$2. C[4,5,np] = \underbrace{0.0}_{C[4,4,DT]} + \underbrace{-0.69}_{C[5,5,NN]} + \ln(\underbrace{0.2}_{np \rightarrow dt \ n}) = -0.69 + -1.6 = -2.3$$



## Span 1

$$1. C[1,2,np] = \underbrace{0.0}_{C[1,1,DT]} + \ln\left(\underbrace{-2.3}_{C[2,2,NN]}\right) + \ln\left(\underbrace{0.2}_{np \rightarrow dt \ n}\right) = -2.3 + -1.6 = -3.9$$

$$2. C[4,5,np] = \underbrace{0.0}_{C[4,4,DT]} + \underbrace{-0.69}_{C[5,5,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt \ n}\right) = -0.69 + -1.6 = -2.3$$

$$3. C[7,8,np] = \underbrace{0.0}_{C[7,7,DT]} + \underbrace{-1.2}_{C[8,8,NN]} + \ln\left(\underbrace{0.2}_{np \rightarrow dt \ n}\right) = -1.2 + -1.6 = -2.8$$

## Span 2

$$1. C[1,3,s] = \underbrace{-3.9}_{C[1,2,NP]} + \underbrace{-2.8}_{C[3,3,VP]} + \ln\left(\underbrace{1.0}_{s \rightarrow np \text{ } vp}\right) = -6.7$$

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$$2. C[3,5,vp] = \underbrace{-0.5}_{C[3,3,V]} + \underbrace{-2.3}_{C[4,5,NP]} + \ln\left(\underbrace{0.7}_{vp \rightarrow v \text{ } np}\right) = -2.8 - 0.36 = -3.2$$

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$$3. C[6,8,pp] = \underbrace{-0.51}_{C[6,6,P]} + \underbrace{-2.8}_{C[7,8,NP]} + \ln\left(\underbrace{1.0}_{pp \rightarrow p \text{ } np}\right) = -3.3 + -1.6 = -3.3$$

## Span 4

$$1. C[1,5,s] = \underbrace{-3.9}_{C[1,2,NP]} + \underbrace{-3.2}_{C[3,5,VP]} + \ln(\underbrace{1.0}_{s \rightarrow np \text{ } vp}) = -7.1$$

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$$2. C[4,8,np] = \underbrace{-2.3}_{C[4,5,NP]} + \underbrace{-3.3}_{C[6,8,PP]} + \ln\left(\underbrace{0.8}_{np \rightarrow np\ pp}\right) = -5.6 + -0.2 = -5.8$$

## Span 5

$$C[3, 8, vp] = \max( \quad ) \quad (1)$$

$$\underbrace{-3.2}_{C[3,5,VP]} + \underbrace{-3.3}_{C[6,8,PP]} + \underbrace{-1.6}_{vp \rightarrow vp\ pp}, \quad (2)$$

$$\underbrace{-0.5}_{C[3,3,V]} + \underbrace{-5.8}_{C[4,8,NP]} + \underbrace{-0.36}_{vp \rightarrow v\ np} ) \quad (3)$$

$$= \max(-8.1, -6.7) = -6.7 \quad (4)$$

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$$= \max(-8.1, -6.7) = -6.7 \quad (4)$$

Which is it? “Man through telescope” or “Man holding telescope”?



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$$\underbrace{-0.5}_{C[3,3,V]} + \underbrace{-5.8}_{C[4,8,NP]} + \underbrace{-0.36}_{vp \rightarrow v\ np} ) \quad (3)$$

$$= \max(-8.1, -6.7) = -6.7 \quad (4)$$

Which is it? “Man through telescope” or “Man holding telescope”?

## Span 7

$$1. C[1,8,s] = \underbrace{-3.9}_{C[1,2,NP]} + \underbrace{-6.7}_{C[3,8,VP]} = -10.6$$