### <sup>o</sup>Papa 1 ate 2 the 3 caviar 4 with 5 a 6 spoon 7

# **Our Usual Example Grammar**

```
ROOT \rightarrow S
S
          \rightarrow NP VP
                               NP \rightarrow Papa
                               N \rightarrow caviar
NP
          \rightarrow Det N
NP
          \rightarrow NP PP
                               N \rightarrow spoon
VP
          \rightarrow VP PP
                                V \rightarrow ate
                                P \rightarrow with
VP
          \rightarrow V NP
PP
          \rightarrow P NP
                                Det \rightarrow the
                                Det \rightarrow a
```

initialize 0 ROOT.S Remember this stands for  $(0, ROOT \rightarrow . S)$ 

0 ROOT.S 0S.NPVP

**predict** the kind of S we are looking for

Remember this stands for  $(0, S \rightarrow . NP VP)$ 

0 ROOT.S 0S.NPVP 0 NP . Det N 0 NP . NP PP 0 NP . Papa

predict the kind of NP we are looking for
(actually we'll look for 3 kinds: any of the 3 will do)

0
0 ROOT.S
0S.NPVP
0 NP . Det N
0 NP . NP PP
0 NP . Papa
0 Det . the
0 Det . a

predict the kind of Det we are looking for (2 kinds)

0 ROOT.S 0S.NPVP 0 NP . Det N 0 NP. NP PP 0 NP . Papa 0 Det . the 0 Det.a

#### predict the kind of NP we're looking for

but we were already looking for these so don't add duplicate goals! Note that this happened when we were processing a left-recursive rule.

0 Pa	pa 1
0 ROOT.S	0 NP Papa.
0 S . NP VP	
0 NP . Det N	
0 NP . NP PP	
0 NP . Papa	scan:
0 Det . the	
0 Det . a	
	1

0 Pa	pa 1
0 ROOT.S	0 NP Papa .
0 S . NP VP	
0 NP . Det N	
0 NP . NP PP	
0 NP . Papa	
0 Det . the	scan: f
0 Det . a	

0 Pa	pa 1
0 ROOT.S	0 NP Papa .
0 S . NP VP	
0 NP . Det N	
0 NP . NP PP	
0 NP . Papa	
0 Det . the	
0 Det . a	scan: f

0 Papa 1		
0 ROOT.S	0 NP Papa.	
0S.NPVP	0SNP.VP	
0 NP . Det N	0 NP NP . PP	
0 NP . NP PP		
0 NP . Papa		
0 Det . the		
0 Det . a		

attach the newly created NP (which starts at 0) to its customers (incomplete constituents that *end* at 0 and have NP after the dot)

0 Papa 1		
0 ROOT . S	0 NP Papa .	
0 S . NP VP	0 S NP. VP	
0 NP . Det N	0 NP NP . PP	
0 NP . NP PP	1 VP . V NP	
0 NP . Papa	1 VP . VP PP	
0 Det . the		
0 Det . a		

0 Pa	pa 1
0 ROOT.S	0 NP Papa .
0 S . NP VP	0SNP.VP
0 NP . Det N	0 NP NP . PP
0 NP . NP PP	1 VP . V NP
0 NP . Papa	1 VP . VP PP
0 Det . the	1 PP . P NP
0 Det . a	

0 Pa	pa 1
0 ROOT . S	0 NP Papa .
0 S . NP VP	0SNP.VP
0 NP . Det N	0 NP NP . PP
0 NP . NP PP	1 VP . V NP
0 NP . Papa	1 VP . VP PP
0 Det . the	1 PP . P NP
0 Det . a	1 V . ate

0 Pa	pa 1
0 ROOT . S	0 NP Papa .
0 S . NP VP	0SNP.VP
0 NP . Det N	0 NP NP . PP
0 NP . NP PP	1 VP . V NP
0 NP . Papa	1 VP . VP PP
0 Det . the	1 PP . P NP
0 Det . a	1 V . ate

0 Pa	pa 1
0 ROOT . S	0 NP Papa .
0 S . NP VP	0SNP.VP
0 NP . Det N	0 NP NP . PP
0 NP . NP PP	1 VP . V NP
0 NP . Papa	1 VP . VP PP
0 Det . the	1 PP . P NP
0 Det . a	1 V . ate
	1 P . with

0 Pa	pa 1 ate	2	
0 ROOT.S	0 NP Papa .	1 V ate.	
0 S . NP VP	0SNP.VP		
0 NP . Det N	0 NP NP . PP		
0 NP . NP PP	1 VP . V NP		
0 NP . Papa	1 VP . VP PP		
0 Det . the	1 PP . P NP		
0 Det . a	1 V . ate	scan: su	ccess!
	1P. with		

0 Pa	pa <mark>1</mark> ate	2	
0 ROOT.S	0 NP Papa .	1 V ate .	
0 S . NP VP	0SNP.VP		
0 NP . Det N	0 NP NP . PP		
0 NP . NP PP	1 VP . V NP		
0 NP . Papa	1 VP . VP PP		
0 Det . the	1 PP . P NP		
0 Det . a	1 V . ate		
	1 P . with	scan: failu	ıre

0 Pa	pa 1 ate	2
0 ROOT.S	0 NP Papa .	1 V ate.
0 S . NP VP	0SNP.VP	1 VP V . NP
0 NP . Det N	0 NP NP . PP	
0 NP . NP PP	1 VP . V NP	
0 NP . Papa	1 VP . VP PP	
0 Det . the	1 PP . P NP	
0 Det . a	1 V . ate	
	1P.with	
		_

## attach

0 Pa	pa 1 ate	2
0 ROOT.S	0 NP Papa .	1 V ate .
0 S . NP VP	0SNP.VP	1 VP V . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa
0 Det . the	1 PP . P NP	
0 Det . a	1 V . ate	
	1P. with	

0 Pa	pa 1 ate	2
0 ROOT.S	0 NP Papa .	1 V ate .
0 S . NP VP	0SNP.VP	1 VP V . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the
0 Det . a	1 V . ate	2 Det . a
	1P. with	

predict (these next few steps
should look familiar)

0 Pa	pa 1 ate	2
0 ROOT.S	0 NP Papa .	1 V ate .
0 S . NP VP	0SNP.VP	1 VP V . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the
0 Det . a	1 V . ate	2 Det . a
	1P. with	

0 Pa	pa 1 ate	2
0 ROOT.S	0 NP Papa .	1 V ate .
0 S . NP VP	0SNP.VP	1 VP V . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the
0 Det . a	1 V . ate	2 Det . a
	1P. with	

scan (this time we fail since Papa is not the next word)

	0 D.	4 .1.		0
	0 Pa	apa 1 ate	e 2 the	3
	ROOT.S	0 NP Papa .	1 V ate .	2 Det the .
	S.NPVP	0 S NP . VP	1 VP V . NP	
	NP . Det N	0 NP NP . PP	2 NP . Det N	
	NP.NPP	1 VP . V NP	2 NP . NP PP	
(	NP . Papa	1 VP . VP PP	2 NP . Papa	
	Det . the	1 PP . P NP	2 Det . the	scan: su
(	Det . a	1 V . ate	2 Det . a	
		1 P . with		

0 Pa	pa 1 ate	2 the	3
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .
0 S . NP VP	0SNP.VP	1 VP V . NP	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa	
0 Det . the	1 PP . P NP	2 Det . the	
0 Det . a	1 V . ate	2 Det . a	
	1 P . with		

0 Pa	pa 1 ate	2 the	3
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N
0 NP . Det N	0 NP NP . PP	2 NP . Det N	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa	
0 Det . the	1 PP . P NP	2 Det . the	
0 Det . a	1 V . ate	2 Det . a	
	1 P . with		

0 Papa 1 ate 2 the 3					
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .		
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N		
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar		
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon		
0 NP . Papa	1 VP . VP PP	2 NP . Papa			
0 Det . the	1 PP . P NP	2 Det . the			
0 Det . a	1 V . ate	2 Det . a			
	1 P . with				

0 Papa 1 ate 2 the 3 caviar 4				
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar.
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		
0 Det . the	1 PP . P NP	2 Det . the		
0 Det . a	1 V . ate	2 Det . a		
	1 P . with			

0 Pa	pa 1 ate	2 the	3 cav	viar 4
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		
0 Det . the	1 PP . P NP	2 Det . the		
0 Det . a	1 V . ate	2 Det . a		
	1 P . with			

#### 0 Papa 2 the 3 caviar 4 ate 0 ROOT.S 0 NP Papa. 1 V ate. 2 Det the. 3 N caviar. 0S.NPVP 0SNP.VP 1 VP V . NP 2 NP Det . N 2 NP Det N. 0 NP . Det N 0 NP NP . PP 2 NP . Det N 3 N. caviar 0 NP . NP PP 1 VP . V NP 2 NP. NP PP 3 N. spoon 0 NP . Papa 1 VP . VP PP 2 NP . Papa 0 Det . the 1 PP . P NP 2 Det . the 0 Det.a 1 V . ate 2 Det.a 1 P. with

#### attach

0 Pa	pa 1 ate	2 the	3 cav	viar 4
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		
0 Det . the	1 PP . P NP	2 Det . the		
0 Det . a	1 V . ate	2 Det . a		
	1 P . with			

attach (again!)

0 Pa	pa 1 ate	2 the	3 cav	viar 4
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		OSNPVP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		
	1 P . with			

attach (again!)

0 Papa 1 ate 2 the 3 caviar 4				
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP
	1P. with			

0 Pa	pa 1 ate	2 the	3 cav	viar 4
0 ROOT.S	0 NP Papa .	1 V ate.	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		OSNPVP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP
	1P. with			0 ROOTS.

attach (again!)

0 Papa 1 ate 2 the 3 caviar 4				
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP
	1P. with			0 ROOTS.

0 Papa 1 ate 2 the 3 caviar 4				
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP
	1P. with			0 ROOTS.
				4 P . with

0 Pa	pa 1 ate	2 the	3 cav	viar 4
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP
	1P. with			0 ROOTS.
				4 P. with

0 Pa	pa 1 ate	2 the	3 cav	viar <mark>4</mark> wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	
	1 P . with			0 ROOTS.	
				4 P. with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N. spoon	2 NP NP . PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.	
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	
	1 P . with			0 ROOTS.	
				4 P . with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate.	2 Det the .	3 N caviar .	4 P with .
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N. spoon	2 NP NP . PP	5 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.	5 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	
	1P. with			0 ROOTS.	
				4 P . with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	5 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	5 Det . the
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	5 Det . a
	1P. with			0 ROOTS.	
				4 P . with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	5 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	5 Det . the
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	5 Det . a
	1P. with			0 ROOTS.	
				4 P. with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	5 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	5 Det . the
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	5 Det . a
	1P. with			0 ROOTS.	
				4 P. with	

0 Pa	pa 1 ate	2 the	3 cav	viar 4 wit	h 5
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	4 P with .
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	5 NP . Papa
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	5 Det . the
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	5 Det . a
	1P. with			0 ROOTS.	
				4 P . with	

ate	2 the	3 cav	viar 4 wit	h 5 a	a 6
	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .
0	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	
ъР	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N	
)	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	
ъР	2 NP . Papa		0SNPVP.	5 NP . Papa	
)	2 Det . the		1 VP VP . PP	5 Det . the	
	2 Det . a		4 PP . P NP	5 Det . a	
			0 ROOTS.		
			4 P . with		

ate	2 the	3 cav	viar 4 wit	h 5	a 6
•	1 V ate .	2 Det the .	3 N caviar.	4 P with .	5 Det a.
C	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	5 NP Det . N
ъР	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N	
)	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	
ъР	2 NP . Papa		0 S NP VP.	5 NP . Papa	
)	2 Det . the		1 VP VP . PP	5 Det . the	
	2 Det . a		4 PP . P NP	5 Det . a	
			0 ROOTS.		
			4 P . with		

ate	2 the	e 3 cav	∕iar 4 wit	h 5	a 6
•	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .
)	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	5 NP Det . N
эP	2 NP . Det N	3 N . caviar	1 VP V NP.	5 NP . Det N	6 N . caviar
כ	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	6 N . spoon
γP	2 NP . Papa		0SNPVP.	5 NP . Papa	
כ	2 Det . the		1 VP VP . PP	5 Det . the	
	2 Det . a		4 PP . P NP	5 Det . a	
			0 ROOTS.		
			4 P . with		

ate	2 the	e 3 cav	/iar 4 wit	h 5 a	a 6
•	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .
)	1 VP V . NP	2 NP Det . N	2 NP Det N .	4 PP P . NP	5 NP Det . N
эР	2 NP . Det N	3 N . caviar	1 VP V NP.	5 NP . Det N	6 N . caviar
כ	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	6 N . spoon
ъР	2 NP . Papa		0SNPVP.	5 NP . Papa	
כ	2 Det . the		1 VP VP . PP	5 Det . the	
	2 Det . a		4 PP . P NP	5 Det . a	
			0 ROOTS.		
			4 P. with		

ate	2 the	3 cav	viar 4 wit	h 5 a	a 6 spo	oon 7
	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .	6 N spoon.
)	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	5 NP Det . N	
эÞ	2 NP . Det N	3 N . caviar	1 VP V NP.	5 NP . Det N	6 N . caviar	
)	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	6 N . spoon	
ъР	2 NP . Papa		0 S NP VP.	5 NP . Papa		
)	2 Det . the		1 VP VP . PP	5 Det . the		
	2 Det . a		4 PP . P NP	5 Det . a		
			0 ROOTS.			
			4 P . with			

ate	ate 2 the 3 caviar 4 with 5 a 6 spoon 7						
	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .	6 N spoon.	
)	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	5 NP Det . N	5 NP Det N.	
эР	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N	6 N . caviar		
)	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	6 N . spoon		
γP	2 NP . Papa		0 S NP VP.	5 NP . Papa			
)	2 Det . the		1 VP VP . PP	5 Det . the			
	2 Det . a		4 PP . P NP	5 Det . a			
			0 ROOTS.				
			4 P . with				

ate	ate 2 the 3 caviar 4 with 5 a 6 spoon 7							
	1 V ate .	2 Det the .	3 N caviar .	4 P with .	5 Det a .	6 N spoon.		
)	1 VP V . NP	2 NP Det . N	2 NP Det N.	4 PP P . NP	5 NP Det . N	5 NP Det N.		
эÞ	2 NP . Det N	3 N . caviar	1 VP V NP .	5 NP . Det N	6 N . caviar	4 PP P NP.		
)	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP . NP PP	6 N . spoon	5 NP NP . PP		
ъР	2 NP . Papa		0 S NP VP.	5 NP . Papa				
)	2 Det . the		1 VP VP . PP	5 Det . the				
	2 Det . a		4 PP . P NP	5 Det . a				
			0 ROOTS.					
			4 P . with					

0 Pa	0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7							
0 ROOT.S	0 NP Papa .	1 V ate.	2 Det the .	3 N caviar .	<b></b>	6 N spoon.		
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP Det N.		
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .		4 PP P NP.		
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP . PP		
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NP PP.		
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.		
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP				
	1 P . with			0 ROOTS.				
				4 P . with				

0 Pa	0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7							
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar.		6 N spoon.		
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP Det N.		
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P NP .		
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP . PP		
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NP PP .		
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.		
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP		
	1P. with			0 ROOTS.				
				4 P . with				

0 Pa	0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7								
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar.	•••	6 N spoon.			
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP Det N.			
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P NP .			
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP . PP			
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.		2 NP NP PP.			
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.			
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP			
	1P. with			0 ROOTS.		1 VP V NP.			
				4 P . with		2 NP NP . PP			

0 Pa	0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7								
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	<b></b>	6 N spoon.			
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP Det N.			
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P NP .			
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP . PP			
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.		2 NP NP PP .			
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.			
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP			
	1P. with			0 ROOTS.		1 VP V NP .			
				4 P . with		2 NP NP . PP			
						0SNPVP.			
						1 VP VP . PP			

0 Pa	pa 1 ate	2 the	3 cav	iar 4 with	a s	poon 7
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .		6 N spoo
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP De
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NP
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P
	1 P . with			0 ROOTS.		1 VP V N
				4 P . with		2 NP NP
						0 S NP \
						1 VP VP
						7P.with

100011
6 N spoon.
5 NP Det N.
4 PP P NP.
5 NP NP . PP
2 NP NP PP.
1 VP VP PP.
7 PP . P NP
1 VP V NP .
2 NP NP . PP
0SNPVP.
1 VP VP . PP
7 P . with

0 Pa	0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7								
0 ROOT.S	0 NP Papa .	1 V ate.	2 Det the .	3 N caviar .	<b> </b>	6 N spoon.			
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP Det N.			
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .		4 PP P NP .			
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP . PP			
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.		2 NP NP PP .			
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.			
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP			
	1P. with			0 ROOTS.		1 VP V NP.			
				4 P . with		2 NP NP . PP			
						0 S NP VP.			
						1 VP VP . PP			
						7 P . with			

0 Pa	pa 1 ate	2 the	3 cav	iar 4 with	a s
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar.	][
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.	
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	
	1 P . with			0 ROOTS.	
				4 P . with	

spoon 7
. 6 N spoon .
5 NP Det N.
4 PP P NP.
5 NP NP . PP
2 NP NP PP .
1 VP VP PP.
7 PP . P NP
1 VP V NP.
2 NP NP . PP
0SNPVP.
1 VP VP . PP
7 P. with

0 Pa	pa 1 ate	2 the	3 cav	iar 4 with	a s	poon 7
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	<b>]</b>	6 N spoo
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP De
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .		4 PP P N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NF
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P
	1 P . with			0 ROOTS.		1 VP V N
				4 P. with		2 NP NF
						0 S NP \
						1 VP VP
						7 P . with
						0 ROOT

√ spoon . NP Det N. PPPNP. NP NP . PP NP NP PP. VP VP PP . PP.PNP VP V NP. NP NP . PP S NP VP. VP VP . PP ⊃ . with ROOTS.

0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7							
0 ROOT.S	0 NP Papa .	1 V ate.	2 Det the .	3 N caviar .		6 N spoon .	
0S.NPVP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N . 5 N		5 NP Det N.	
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP . 4 PP P		4 PP P NP .	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP 5 NP NF		5 NP NP . PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NP PP .	
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP	
	1 P . with			0 ROOTS.		1 VP V NP .	
				4 P . with		2 NP NP . PP	
						0SNPVP.	
						1 VP VP . PP	
						7 P . with	
						0 ROOTS.	

0 Pa	pa 1 ate	2 the	3 cav	iar 4 with	a s	spoon 7
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	]	6 N spoo
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.		5 NP De
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP		5 NP NP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.		2 NP NP
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P
	1 P . with			0 ROOTS.		1 VP V N
				4 P . with		2 NP NP
						0 S NP \
						1 VP VP
						7P. with
						0 ROOT

6 N spoon.
5 NP Det N.
4 PP P NP .
5 NP NP . PP
2 NP NP PP .
1 VP VP PP.
7 PP . P NP
1 VP V NP .
2 NP NP . PP
0 S NP VP.
1 VP VP . PP
7 P . with
0 ROOTS.

0 Papa 1 ate 2 the 3 caviar 4 with a spoon 7							
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar .	]	6 N spoon .	
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	IP Det N . 5 N		
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP.		4 PP P NP .	
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP 5 NP N		5 NP NP . PP	
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0SNPVP.		2 NP NP PP .	
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP		1 VP VP PP.	
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP		7 PP . P NP	
	1P. with			0 ROOTS.		1 VP V NP.	
				4 P . with		2 NP NP . PP	
						0SNPVP.	
						1 VP VP . PP	
						7 P . with	
						0 ROOTS.	

0 Pa	pa 1 ate	2 the	3 cav	iar 4 with	a spoon 7
0 ROOT.S	0 NP Papa .	1 V ate .	2 Det the .	3 N caviar.	6 N spoo
0 S . NP VP	0SNP.VP	1 VP V . NP	2 NP Det . N	2 NP Det N.	5 NP De
0 NP . Det N	0 NP NP . PP	2 NP . Det N	3 N . caviar	1 VP V NP .	4 PP P N
0 NP . NP PP	1 VP . V NP	2 NP . NP PP	3 N . spoon	2 NP NP . PP	5 NP NP
0 NP . Papa	1 VP . VP PP	2 NP . Papa		0 S NP VP.	2 NP NP
0 Det . the	1 PP . P NP	2 Det . the		1 VP VP . PP	1 VP VP
0 Det . a	1 V . ate	2 Det . a		4 PP . P NP	7 PP . P
	1 P . with			0 ROOTS.	1 VP V N
				4 P. with	2 NP NP
					0 S NP V
					1 VP VP
					7 P . with
					0 ROOT

. 6 N spoon .
5 NP Det N.
4 PP P NP.
5 NP NP . PP
2 NP NP PP.
1 VP VP PP.
7 PP . P NP
1 VP V NP.
2 NP NP . PP
0 S NP VP.
1 VP VP . PP
7 P . with
0 ROOTS.