CKY Parsing

LING 571 — Deep Processing Techniques for NLP
October 10, 2022
Shane Steinert-Threlkeld

Announcements: HW #2

- Due **Friday**, 11:59pm Pacific

  - No late penalty, but also no submissions later than Friday

- Grammar output format:

  - Terminals quoted (single or double)

  - One production per line

  - *Optionally*, RHS alternates with vertical bar/pipe character: |

  - Start symbol is first nonterminal encountered in file

- Execute the conversion rules in the order that they are on the slides.

- Unit productions: any *non-unit* RHS that can be reached by a sequence of units.

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

- The Lushootseed spelling [IPA] of Chief Seattle/Sealth/Si'ahl:

  - siʔaɫ [ˈsiʔaːɬ]

  - ɬ : voiceless alveolar lateral fricative

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

- The Lushootseed spelling [IPA] of Chief Seattle/Sealth/Si'ahl:

  - siʔaɬ [ˈsiʔaːɬ]

  - ɬ : voiceless alveolar lateral fricative

- Duwamish — Dxʷdəwʔabš [dxʷdɐwʔabʃ]

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

- The Lushootseed spelling [IPA] of Chief Seattle/Sealth/Si'ahl:

  - siʔaɬ [ˈsiʔaːɬ]

  - ɬ : voiceless alveolar lateral fricative

- Duwamish — Dxʷdəwʔabš [dxʷdɐwʔabʃ]

- Vi Hilbert (Skagit elder) recording:

  - Source, with more Lushootseed: https://historylink.org/File/8156

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

- The Lushootseed spelling [IPA] of Chief Seattle/Sealth/Si'ahl:

  - siʔaɬ [ˈsiʔaːɬ]

  - ɬ : voiceless alveolar lateral fricative

- Duwamish — Dxʷdəwʔabš [dxʷdɐwʔabʃ]

- Vi Hilbert (Skagit elder) recording:

  - Source, with more Lushootseed: https://historylink.org/File/8156

Indigenous Peoples' Day

- Seattle/Sealth/Si'ahl

- The Lushootseed spelling [IPA] of Chief Seattle/Sealth/Si'ahl:

  - siʔaɬ [ˈsiʔaːɬ]

  - ɬ : voiceless alveolar lateral fricative

- Duwamish — Dxʷdəwʔabš [dxʷdɐwʔabʃ]

- Vi Hilbert (Skagit elder) recording:

  - Source, with more Lushootseed: https://historylink.org/File/8156

- IPA resources:

  - https://en.wikipedia.org/wiki/International_Phonetic_Alphabet

  - http://web.mit.edu/6.mitx/www/24.900%20IPA/IPAapp.html

Indigenous Peoples' Day

- Studying non-English languages gives more holistic insight for NLP tasks
  - Many interesting phenomena in non-Indo-European languages

Indigenous Peoples' Day

- Studying non-English languages gives more holistic insight for NLP tasks
  - Many interesting phenomena in non-Indo-European languages
- Important that our technologies work for all languages of the world

Indigenous Peoples' Day

- Studying non-English languages gives more holistic insight for NLP tasks

  - Many interesting phenomena in non-Indo-European languages

- Important that our technologies work for all languages of the world

- Lushootseed exhibits debatable distinction between verbs and nouns [link to Glottolog page for more references]

  - **ʔuχ̌ʷ** ti   **sbiaw**
    goes that-which **is-a-coyote**
    "The/a coyote goes"

  - **sbiaw**   ti   **ʔuχ̌ʷ**
    is-a-coyote that-which **goes**
    "The one who goes is a coyote"

  - (Translation distinction provided for clarity — semantically equivalent)

Indigenous Peoples' Day

- Studying non-English languages gives more holistic insight for NLP tasks

  - Many interesting phenomena in non-Indo-European languages

- Important that our technologies work for all languages of the world

- <u>Lushootseed</u> exhibits debatable distinction between verbs and nouns [link to Glottolog page for more references]

  - **ʔux̌ʷ** ti   **sbiaw**
    goes that-which **is-a-coyote**
    "The/a coyote goes"

  - **sbiaw**   ti   **ʔux̌ʷ**
    is-a-coyote that-which **goes**
    "The one who goes is a coyote"

    via <u>Beck, 2013</u>

  - (Translation distinction provided for clarity — semantically equivalent)

- Lillooet Salish quantification has repercussions for e.g. English (<u>Matthewson 2001</u>)

W How many indigenous languages do you think there are in the US today?

< 10

11-100
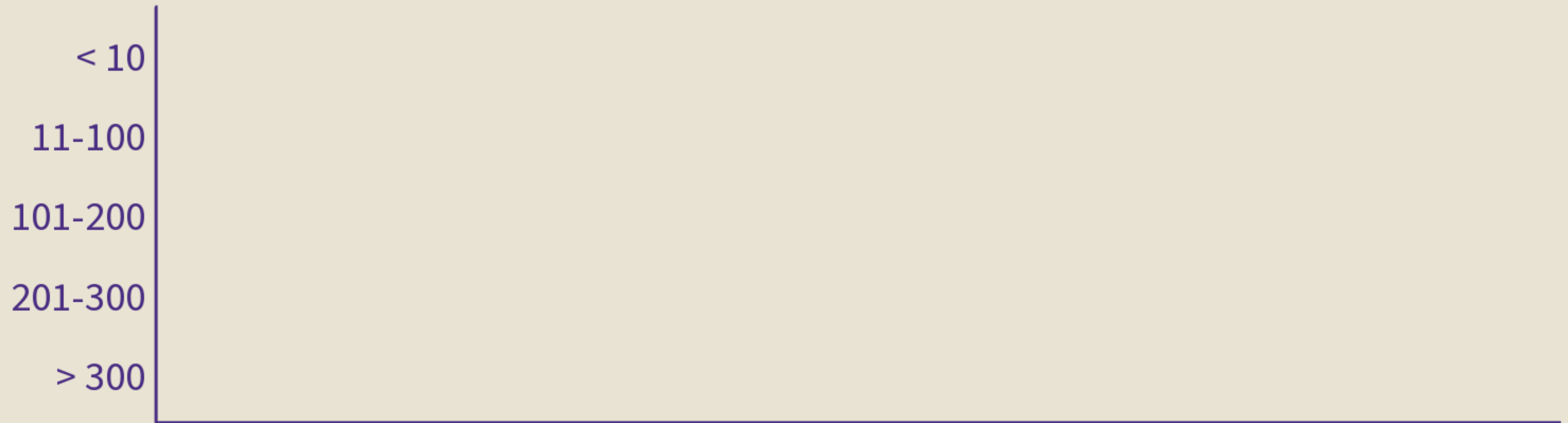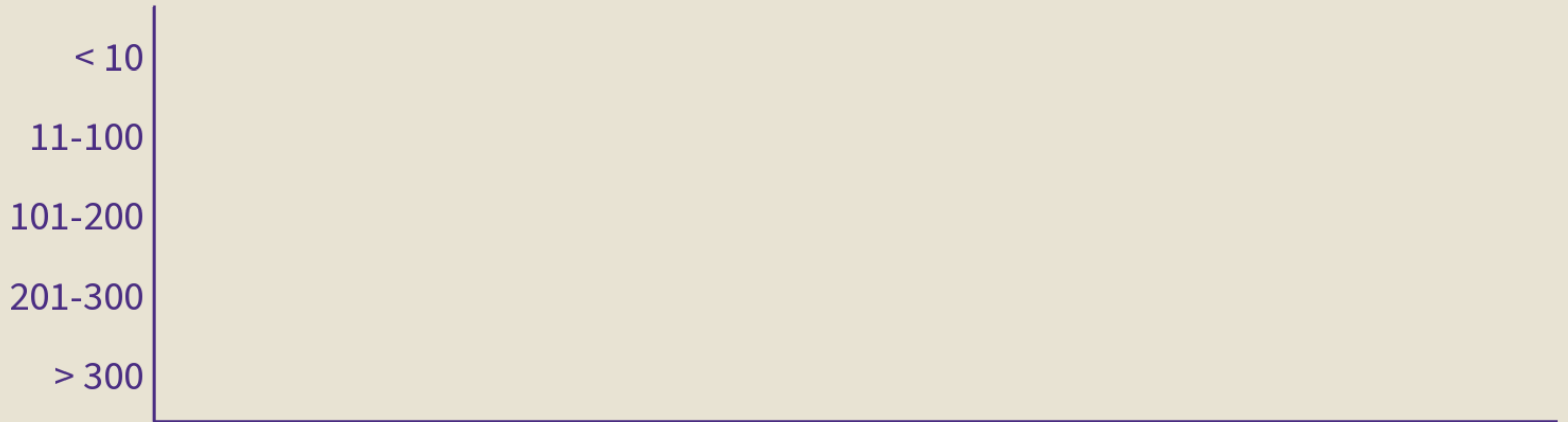
101-200

201-300

> 300

Total Results: 0

Powered by **Poll Everywhere**

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Languages in the U.S.

- Current estimate (Ethnologue): 238
  - 226 living, 12 extinct
  - 195 indigenous

- Navajo: ~170,000 speakers
  - Not in U.S. top 25 by pop size

- Many, many endangered; increased need for revitalization efforts
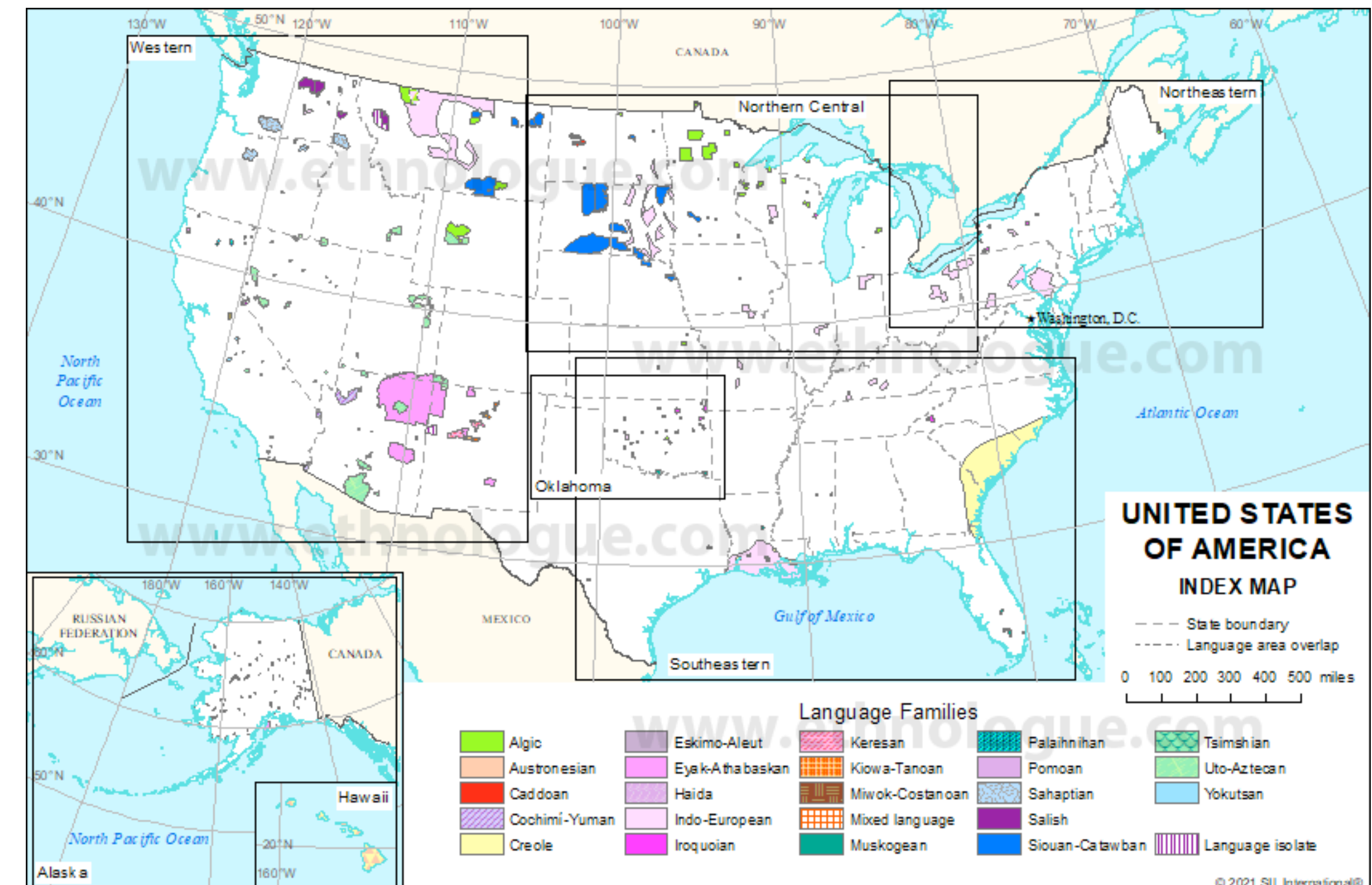
https://www.ethnologue.com/map/US_x_

Indigenous Peoples' Day: Resources

- UW American Indian Studies Courses
  - (Sometimes including language courses, e.g. Southern Lushootseed, Salish)
- Lushootseed resources: https://tulaliplushootseed.com/
- Computational Methods in the Study of Endangered Languages: https://computel-workshop.org/
- AmericasNLP: http://turing.iimas.unam.mx/americasnlp/index.html (currently broken)
  - 2021: https://aclanthology.org/volumes/2021.americasnlp-1/
  - 2022 shared task: https://github.com/AmericasNLP/americasnlp2022

Roadmap

- CKY Parsing Algorithm

  Dynamic programming structure

  Algorithm and example

  Analysis & Discussion

- Next time: Probabilistic CFGs

  Motivation: Ambiguity

  Augmenting CFGs with probabilities

CKY

- Given an input string S of length n

CKY

- Given an input string S of length n

- Build table $(n + 1) \times (n + 1)$

CKY

- Given an input string S of length n

- Build table $(n + 1) \times (n + 1)$

  - Indexes correspond to inter-word positions

  - $_0$ Book $_1$ that $_2$ flight $_3$

CKY

- Given an input string S of length n

- Build table $(n + 1) \times (n + 1)$

  - Indexes correspond to inter-word positions

  - $_0$ Book $_1$ that $_2$ flight $_3$

- Each cell $[\ i, j\ ]$ contains SETS $\{\ \}$ of non-terminals with derivations spanning i, j

CKY

- Given an input string S of length n

- Build table $(n + 1) \times (n + 1)$

  - Indexes correspond to inter-word positions

  - $_0$ Book $_1$ that $_2$ flight $_3$

- Each cell $[\, i, j \,]$ contains SETS $\{\ \}$ of non-terminals with derivations spanning i, j

 - $[\, j - 1, j \,]$ contains pre-terminals

CKY

- Given an input string S of length n

- Build table $(n + 1) \times (n + 1)$

  - Indexes correspond to inter-word positions

  - $_0$ Book $_1$ that $_2$ flight $_3$

- Each cell $[\, i, j \,]$ contains SETS $\{\ \}$ of non-terminals with derivations spanning i, j

  - $[\, j - 1, j \,]$ contains pre-terminals

  - if $[\, 0, n \,]$ contains the start symbol, the sentence is ***accepted***

CKY Matrix

Book	the	flight	through	Houston
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]
	[1,2]	[1,3]	[1,4]	[1,5]
		[2,3]	[2,4]	[2,5]
			[3,4]	[3,5]
				[4,5]

CKY Matrix

[0,1]	[0,2]	[0,3]	[0,4]	[0,5]
	[1,2]	[1,3]	[1,4]	[1,5]
		[2,3]	[2,4]	[2,5]
			[3,4]	[3,5]
				[4,5]

Book   *the*   *flight*   *through* *Houston*

0   1   2   3   4   5

CKY Matrix

Book   the   flight   through Houston
0   1   2   3   4   5

CKY Matrix

Book   the   flight   through   Houston

0   1   2   3   4   5

CKY Matrix

S (?)

NP

Det   Noun

Book   **the**   **flight**   **through** **Houston**
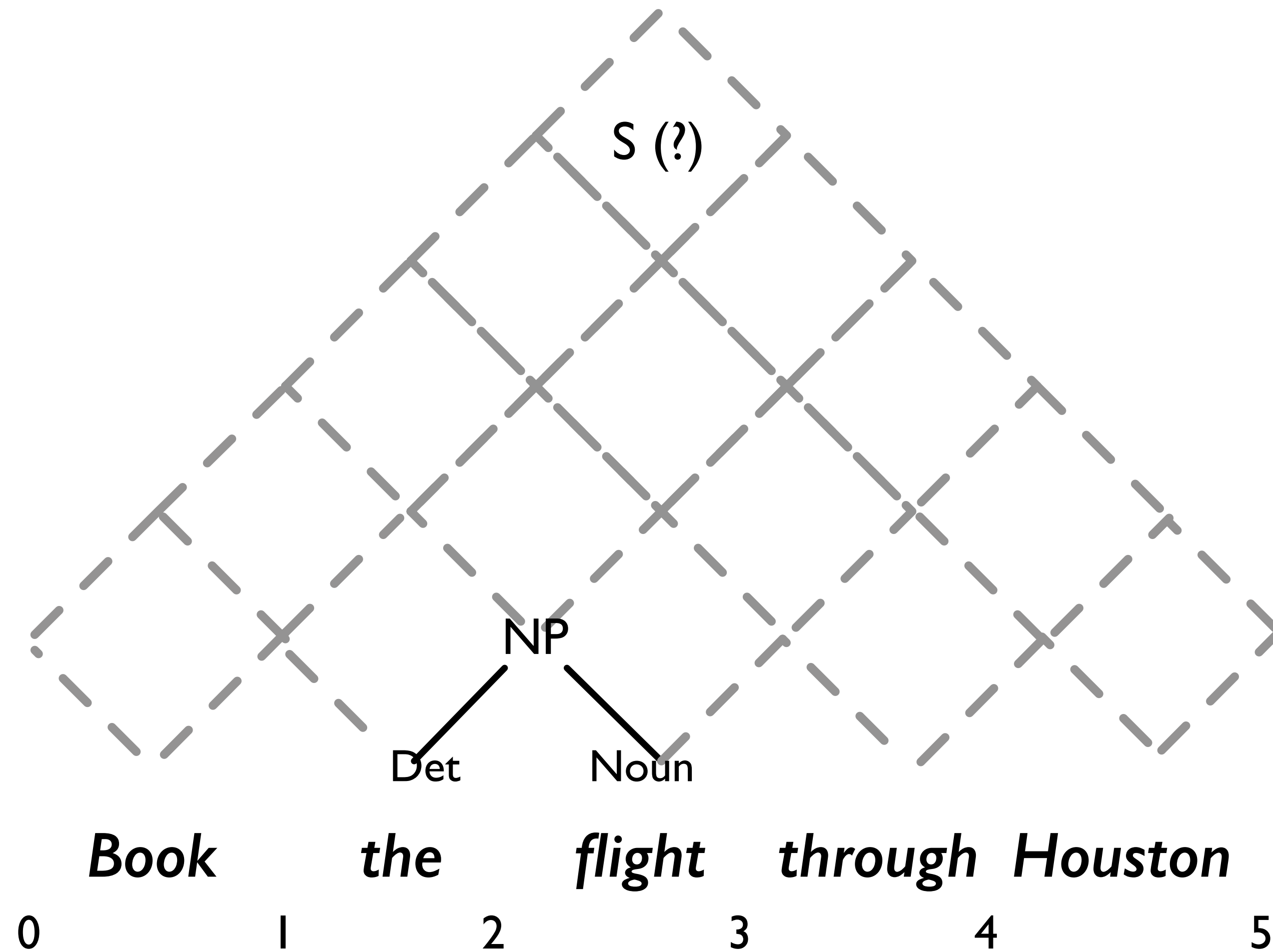
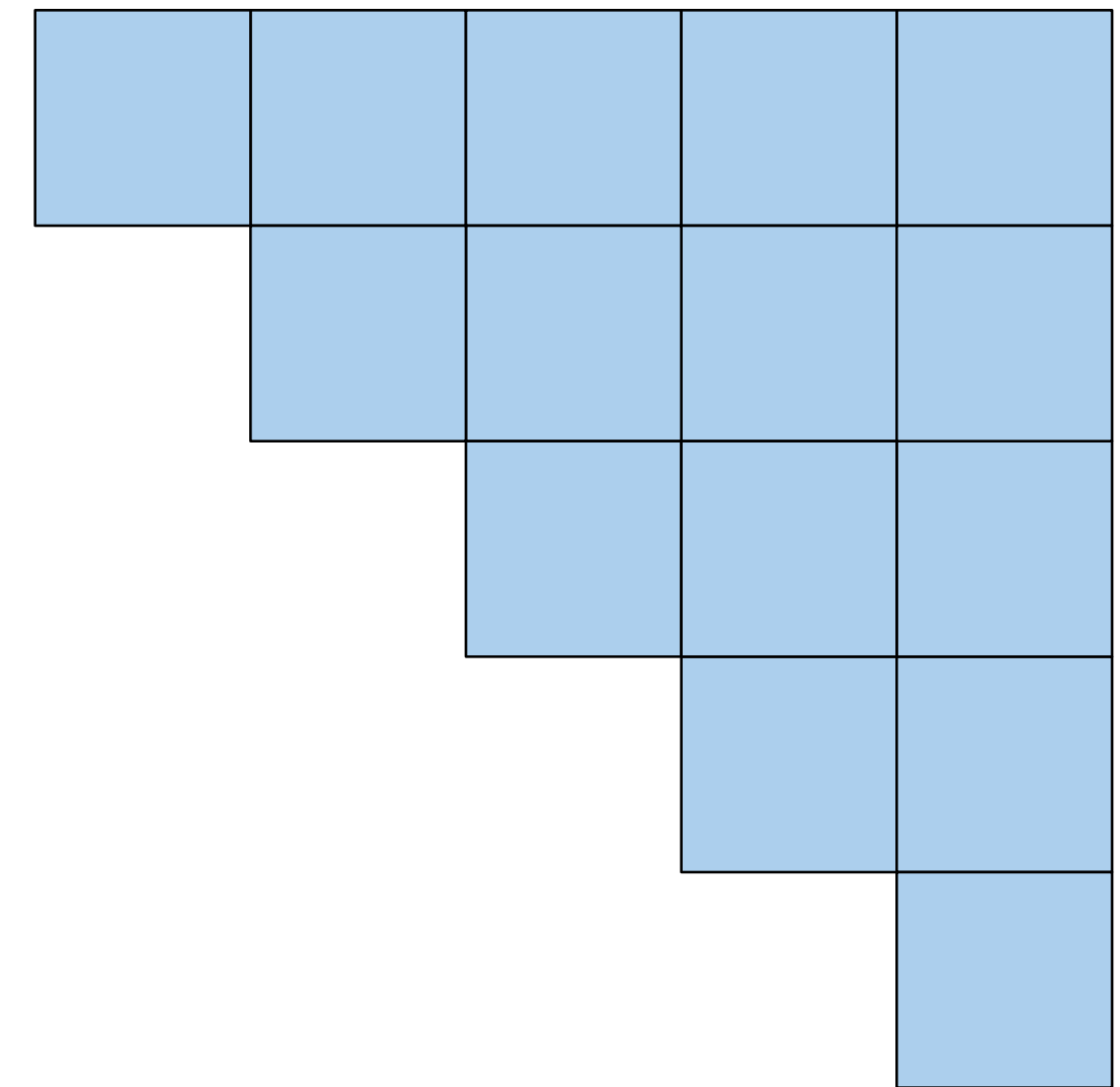0   1   2   3   4   5
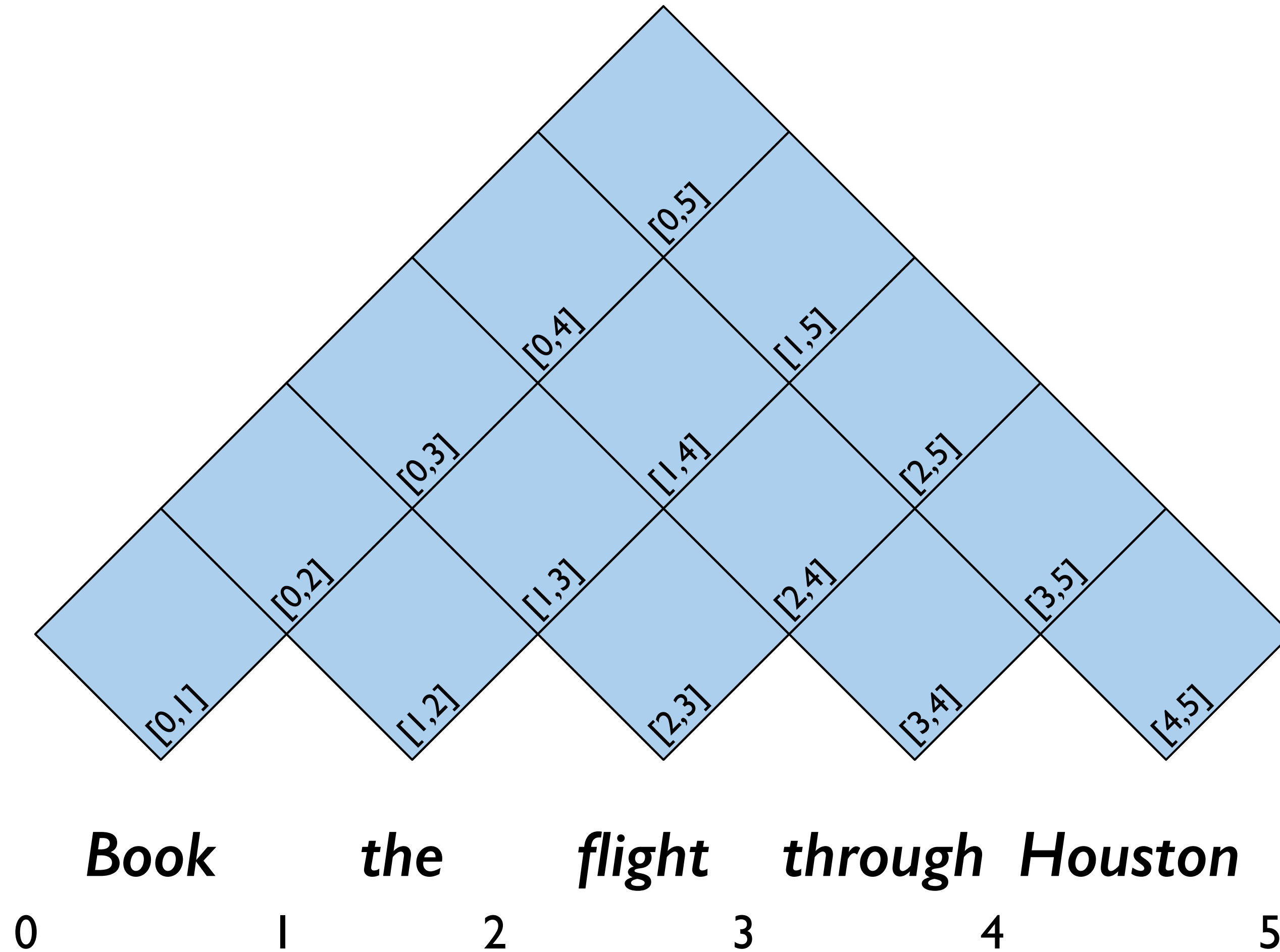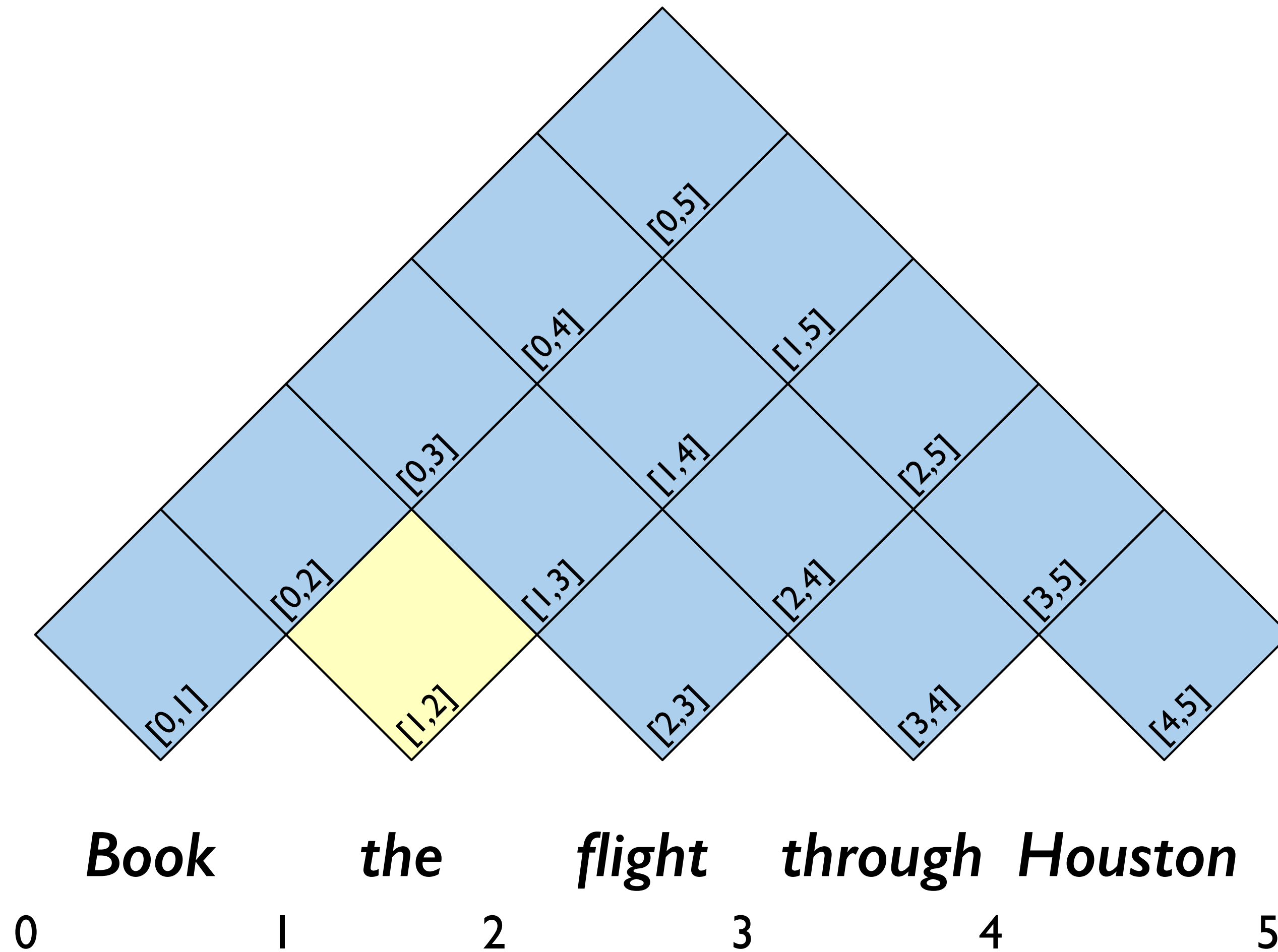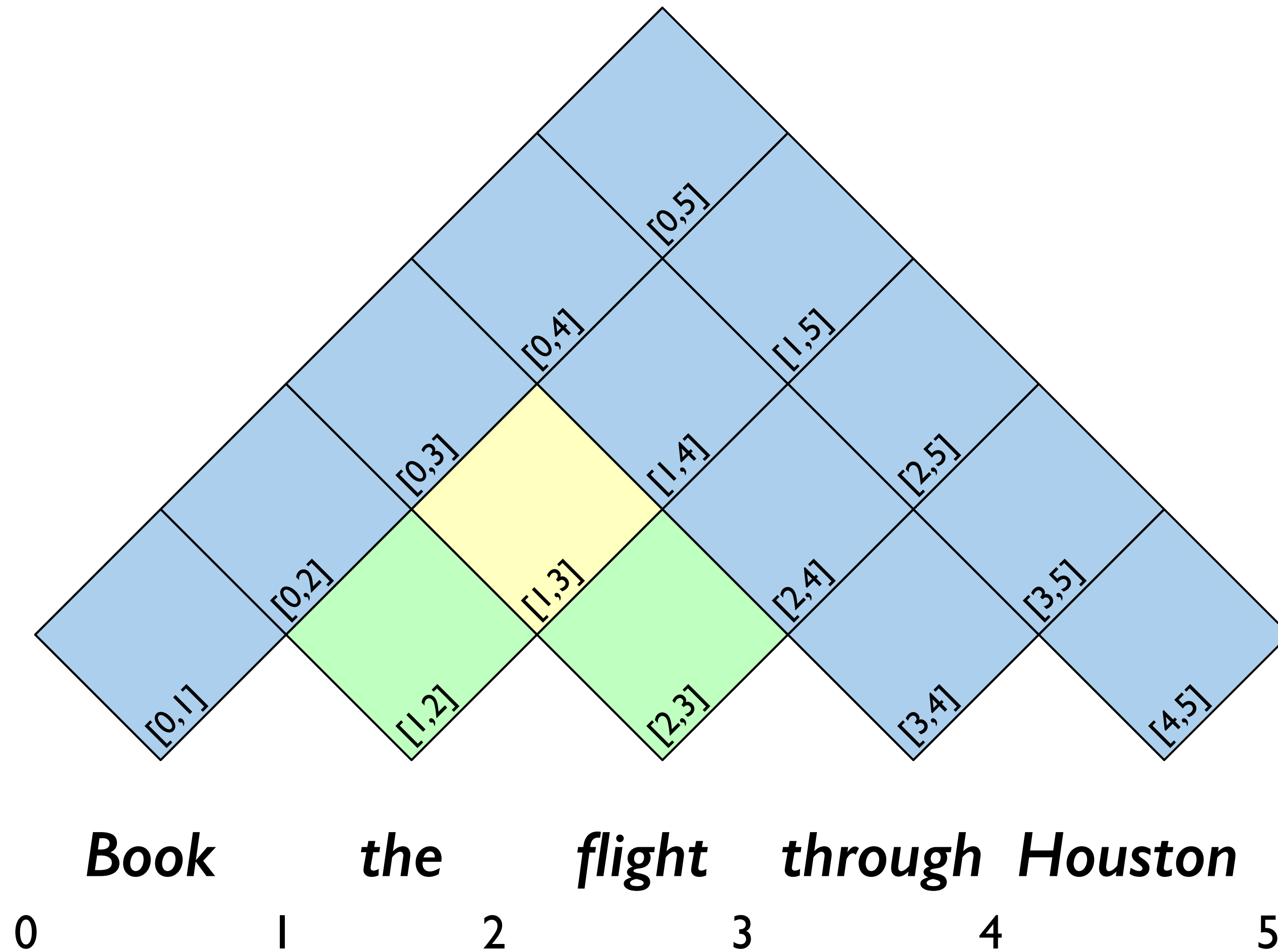
Dynamic Programming in CKY

- Key idea:

  - for $i < k < j$

  - …and a parse spanning substring $[\, i,\, j\,]$

  - There is a k such that there are parses spanning $[\, i,\, k\,]$ and $[\, k,\, j\,]$

  - We can construct parses for whole sentences by building from these partial parses

- So to have a rule $A \rightarrow B\ C$ in $[\, i,\, j\,]$

  - Must have B in $[\, i,\, k\,]$ and C in $[\, k,\, j\,]$ for some $i < k < j$

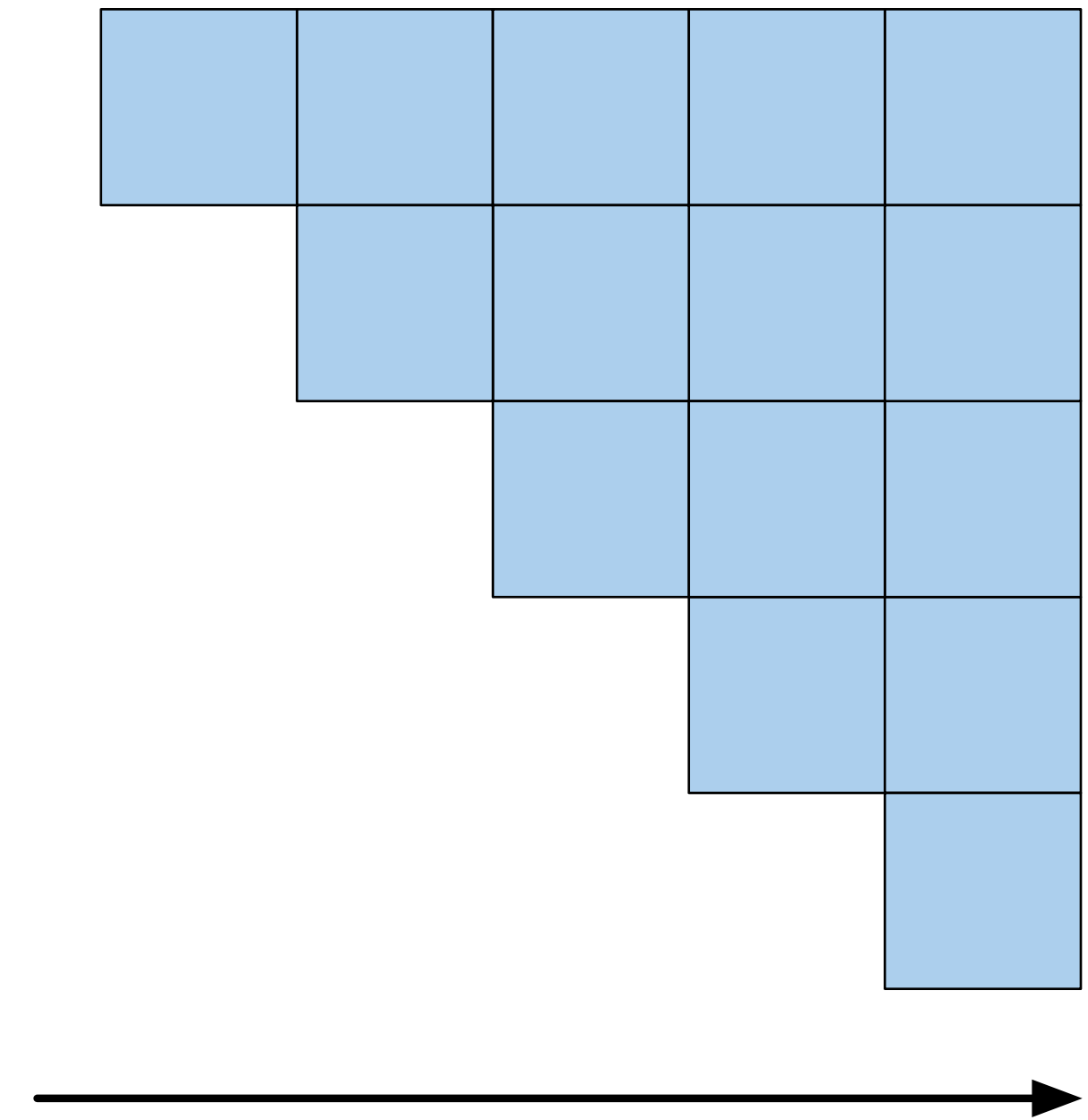 - CNF forces this for all $j > i + 1$
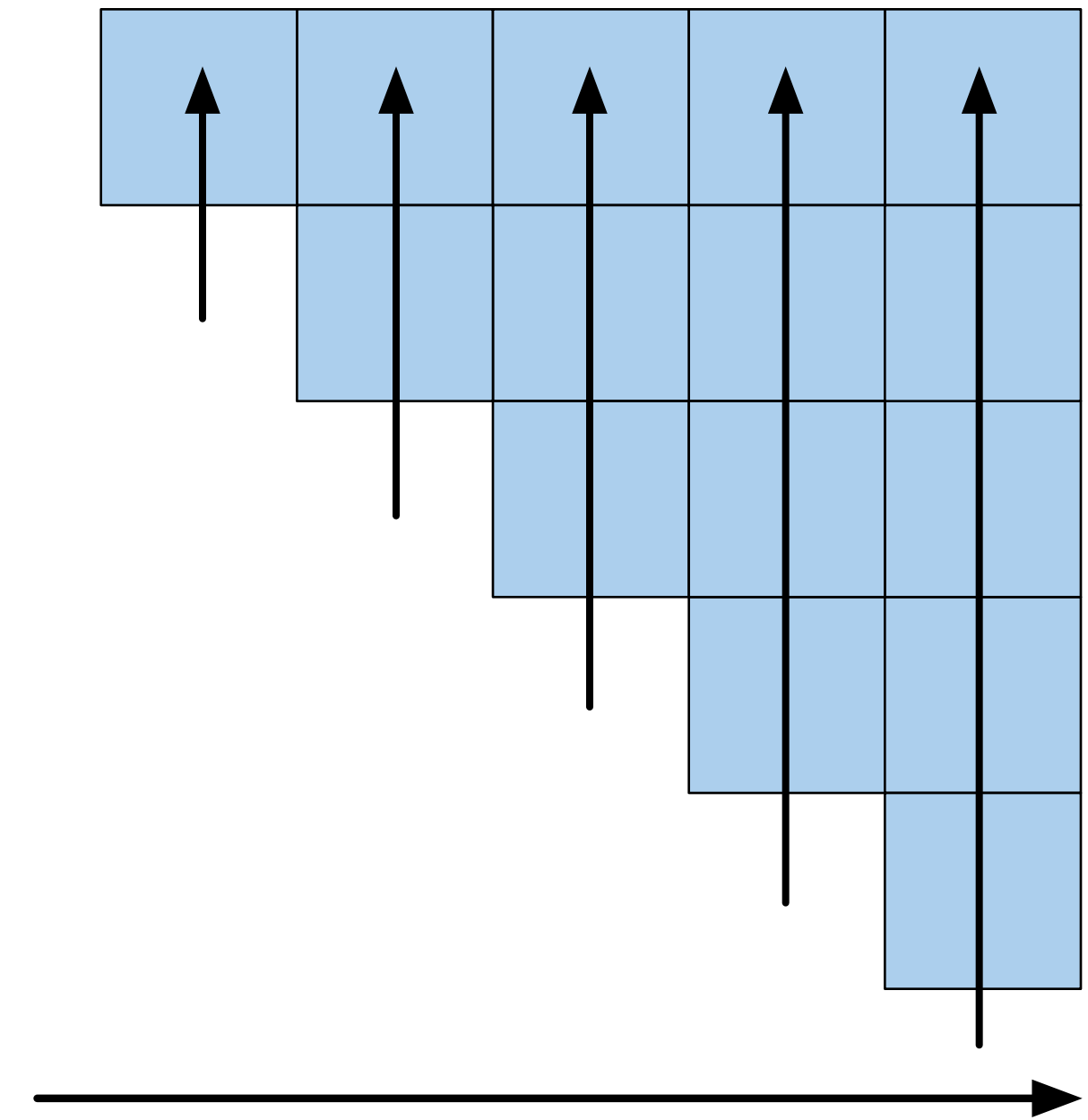
CKY

- Table fills:

CKY

- Table fills:
  - Column-by-column, left-to-right

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top
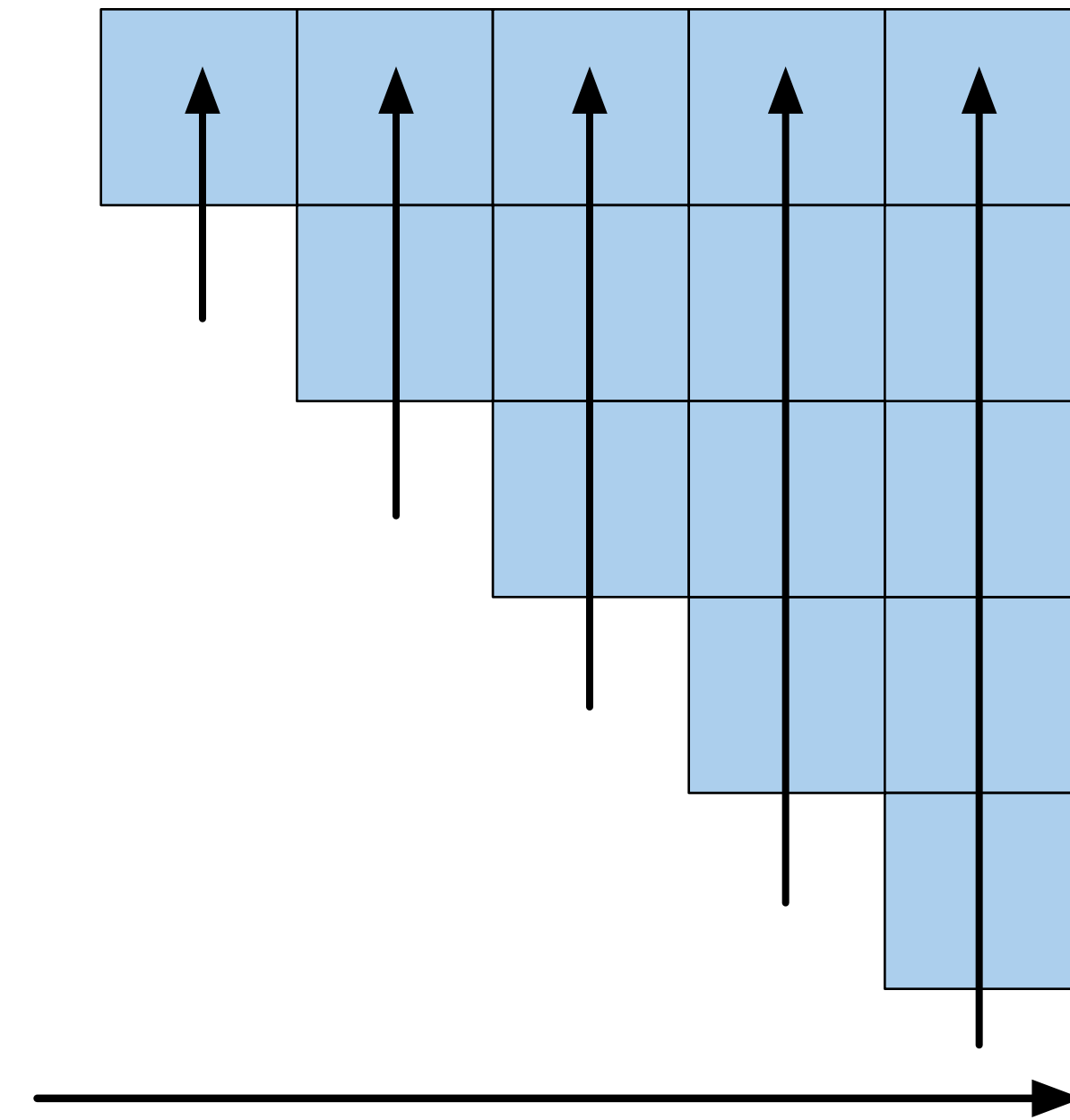
- Why?

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top

- Why?
  - To fill each cell, must have access to all sub-spans

CKY

- Table fills:

  - Column-by-column, left-to-right

  - bottom-to-top

- Why?
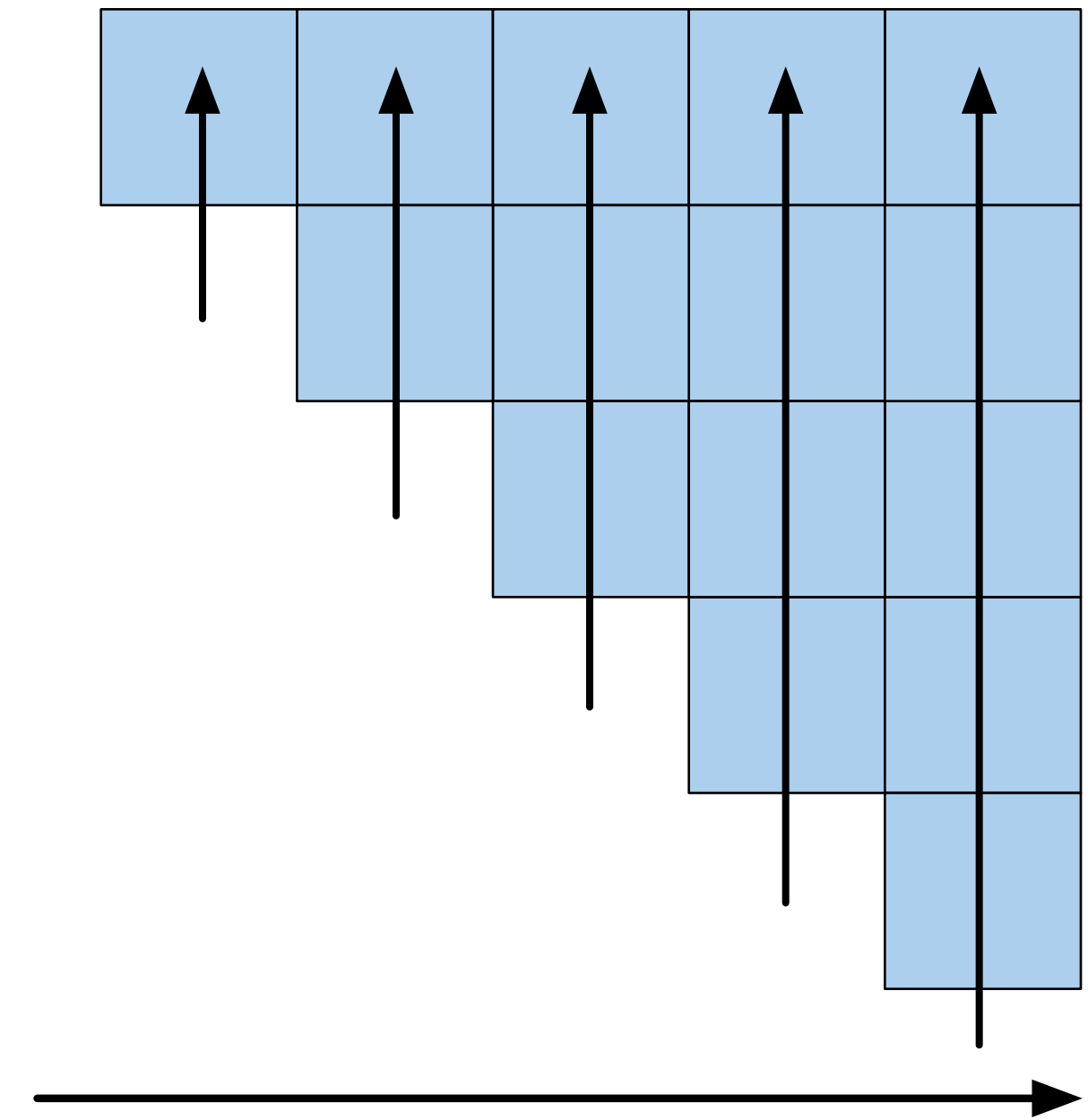
  - To fill each cell, must have access to all sub-spans

    - For cell $[\ i,\ j\ ]$, must be able to access all cells $[\ i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i < k < j$

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top

- Why?
  - To fill each cell, must have access to all sub-spans
    - For cell $[\,i, j\,]$, must be able to access all cells $[\,i, k\,]$ and $[\,k, j\,]$ where $i < k < j$
  - Allows online sentence analysis

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top

- Why?
  - To fill each cell, must have access to all sub-spans
    - For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$
  - Allows online sentence analysis
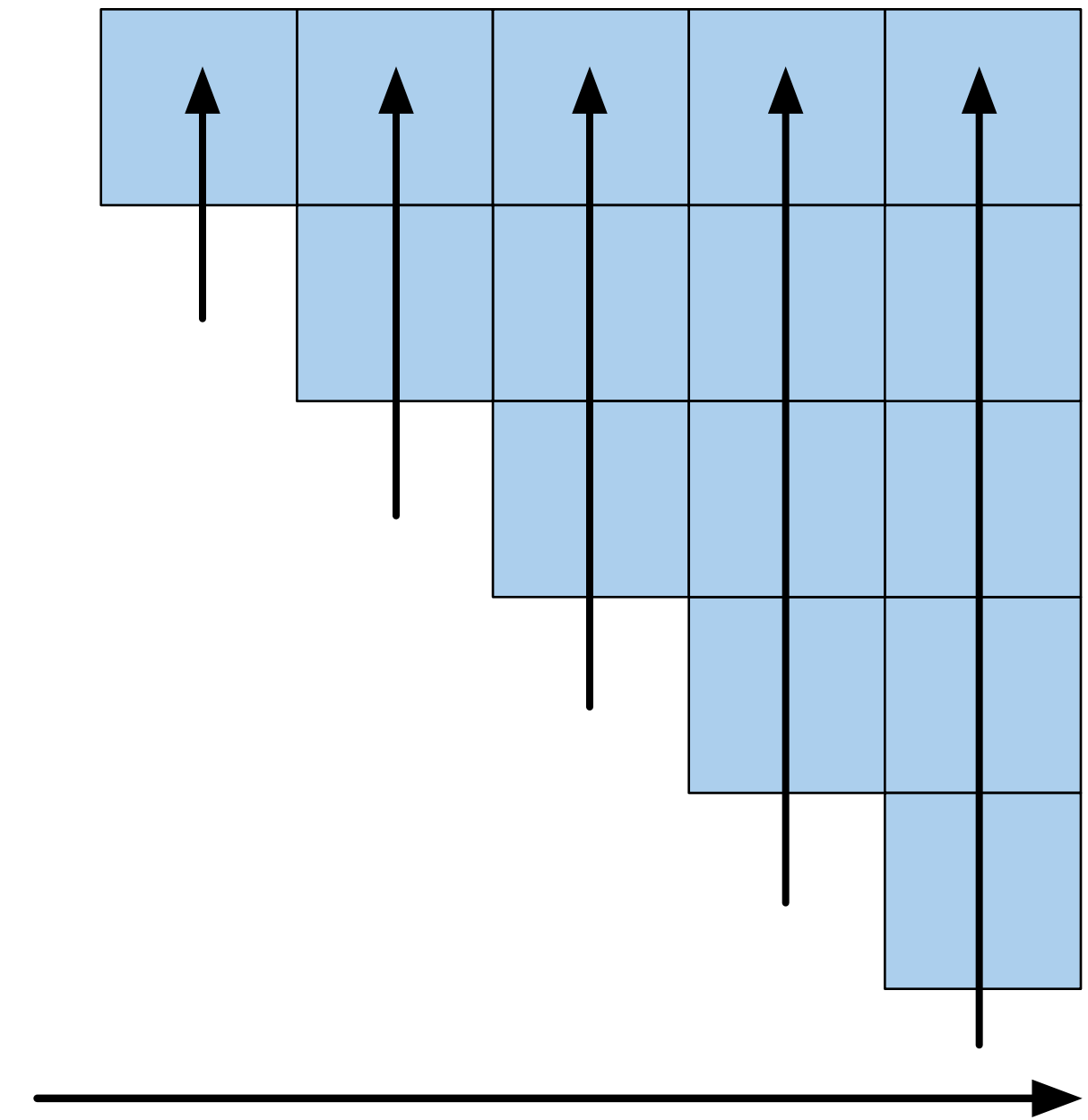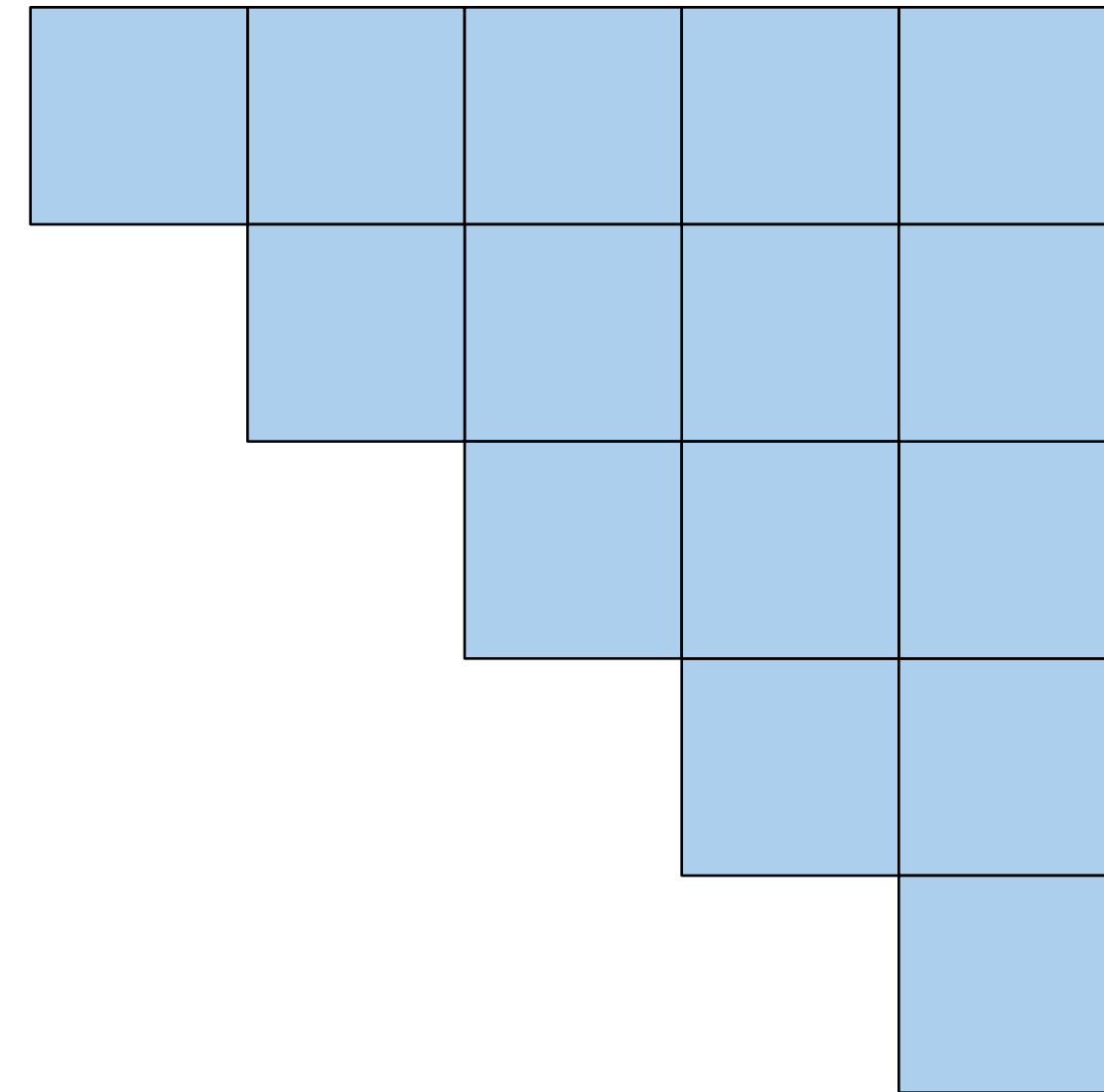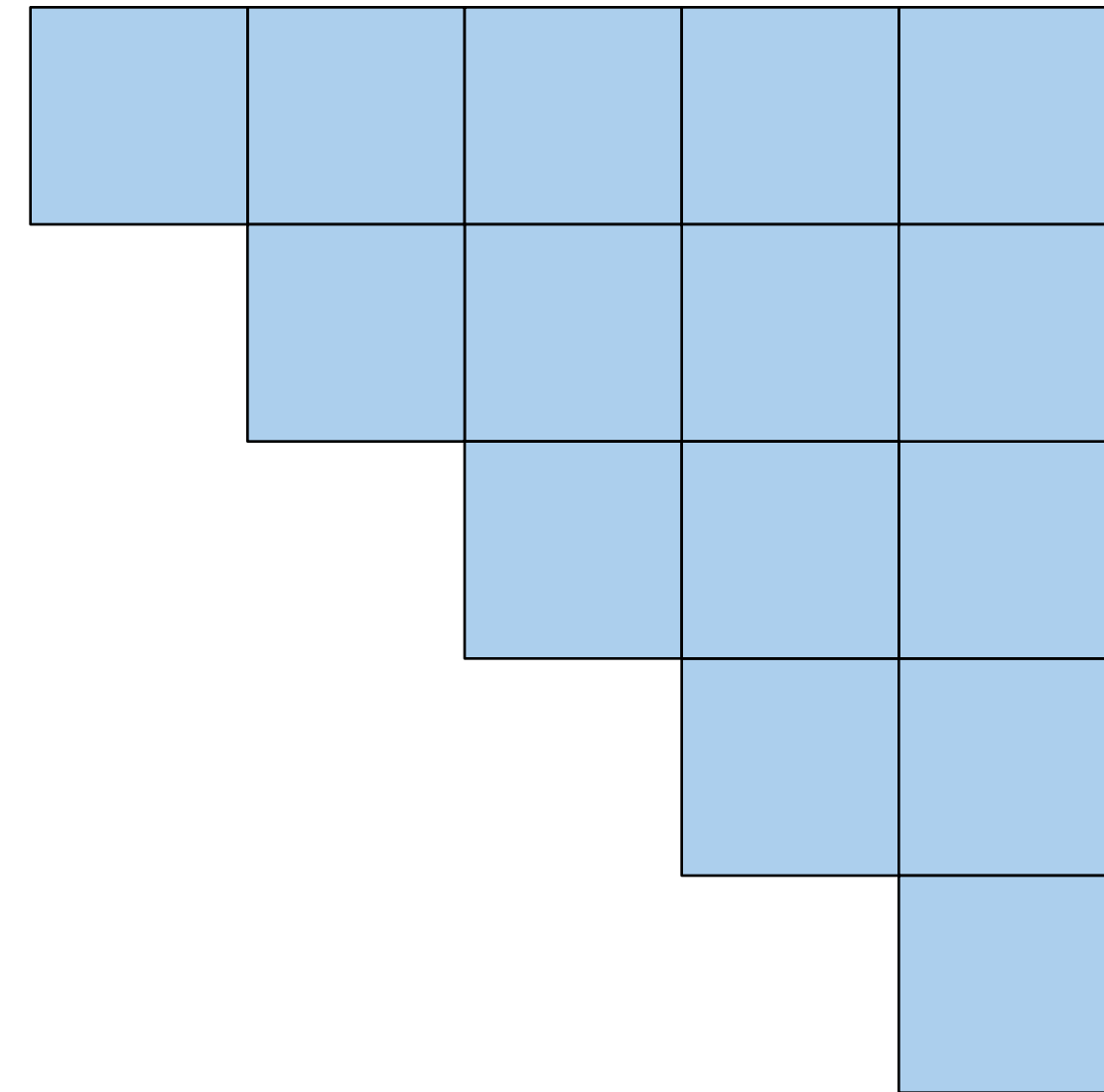   - Works across input string as it arrives

CKY

- Table fills:
  - Column-by-column, left-to-right
  - bottom-to-top
- Why?
  - To fill each cell, must have access to all sub-spans
    - For cell $[\ i,\ j\ ]$, must be able to access all cells $[i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i < k < j$
  - Allows online sentence analysis
    - Works across input string as it arrives
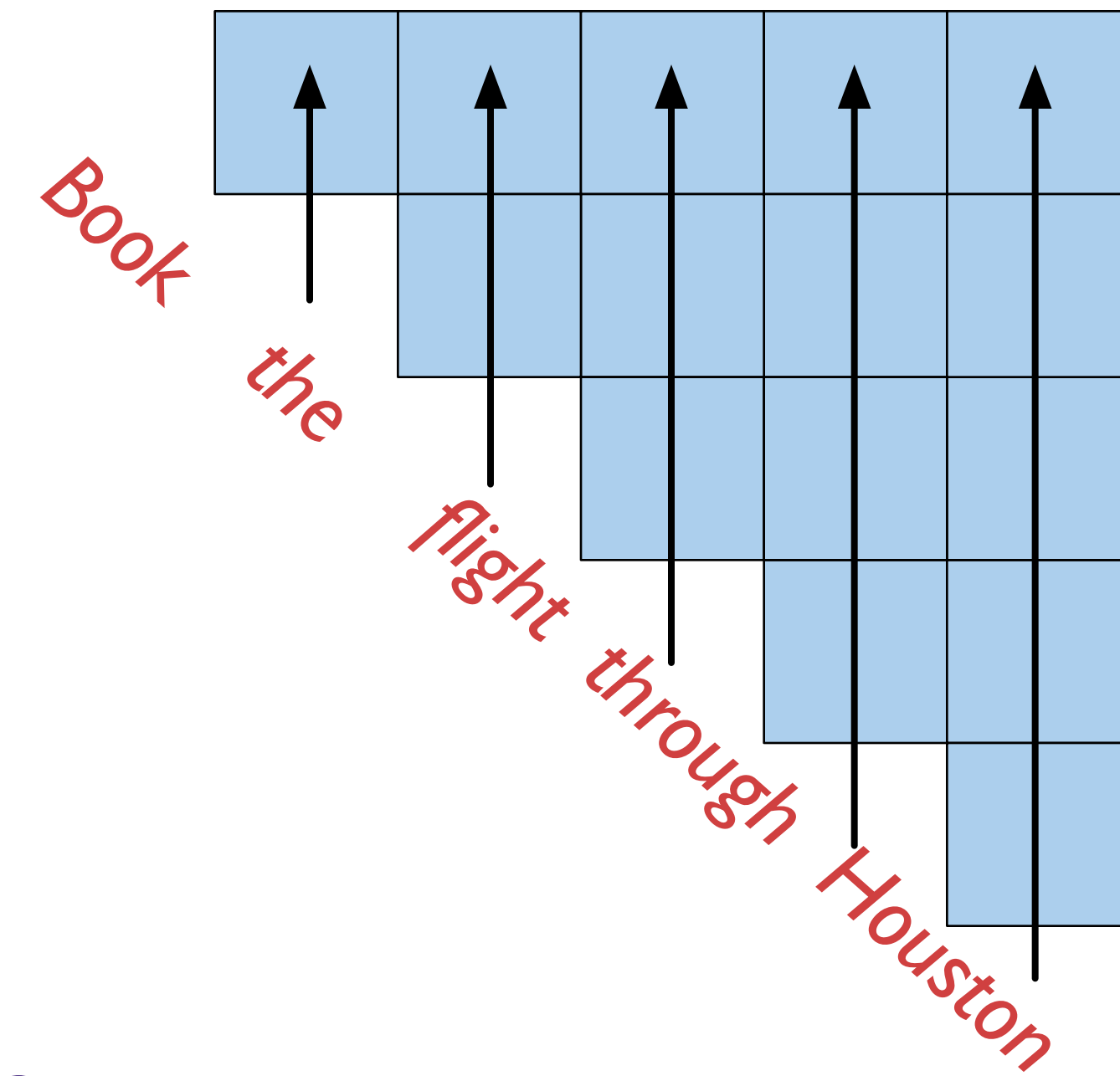
CKY Algorithm

function CKY-PARSE($words, grammar$) **returns** $table$
for j ← **from** 1 to LENGTH($words$) **do**
 $table[\ j - 1,\ j\ ]$ ← { $A\ |\ A$ → $words[\ j\ ]$ ∈ $grammar$ }
  for i ← **from** $j - 2$ **downto** 0 **do**
   for k ← $i + 1$ **to** $j - 1$ **do**
    $table[\ i,\ j\ ]$ ← $table[\ i,\ j\ ]$ ∪
     {$A\ |\ A$ → BC ∈ $grammar$
     B ∈ $table[\ i,\ k\ ]$,
     C ∈ $table[\ k,\ j\ ]$}

CKY Algorithm

function CKY-PARSE(*words, grammar*) **returns** *table*

for j ← **from** 1 to LENGTH(*words*) **do**

$table[\ j - 1, j\ ] \leftarrow \{\ A\ |\ A \rightarrow words[\ j\ ] \in grammar\ \}$

for $i \leftarrow$ **from** $j - 2$ **downto** 0 **do**

for $k \leftarrow i + 1$ **to** $j - 1$ **do**

$table[\ i, j\ ] \leftarrow table[\ i, j\ ]\ \cup$

$\{A\ |\ A \rightarrow BC \in grammar$

$B \in table[\ i, k\ ],$

$C \in table[\ k, j\ ]\}$

Left-to-right, bottom-to-top

CKY Algorithm

function CKY-PARSE(*words, grammar*) **returns** *table*
for j ← **from** 1 to LENGTH(*words*) **do**
    $table[\ j - 1, j\ ] \leftarrow \{\ A \mid A \rightarrow words[\ j\ ] \in grammar\ \}$
      for i ← **from** $j - 2$ **downto** 0 **do**
      for k ← $i + 1$ **to** $j - 1$ **do**
        $table[\ i, j\ ] \leftarrow table[\ i, j\ ] \cup$
          $\{A \mid A \rightarrow BC \in grammar$
           $B \in table[\ i, k\ ],$
           $C \in table[\ k, j\ ]\}$

Left-to-right, bottom-to-top
Sliding k as the pivot for child nodes

CKY Algorithm

function CKY-PARSE(*words, grammar*) **returns** *table*
for j ← **from** 1 to LENGTH(*words*) **do**
    $table[\ j - 1,\ j\ ] \leftarrow \{\ A\ |\ A \rightarrow words[\ j\ ] \in grammar\ \}$
    for i ← **from** $j - 2$ **downto** 0 **do**
      for $k \leftarrow i + 1$ **to** $j - 1$ **do**
        $table[\ i,\ j\ ] \leftarrow table[\ i,\ j\ ] \cup$
        $\{A\ |\ A \rightarrow BC \in grammar$
        $B \in table[\ i,\ k\ ],$
        $C \in table[\ k,\ j\ ]\}$

Left-to-right, bottom-to-top
Sliding k as the pivot for child nodes
Filling the cell with set of applicable rules

Filling Cell [i, j]

$[i,\ i{+}1]$	$[i,\ i{+}2]$		$[i,\ j{-}2]$	$[i,\ j{-}1]$	$[\ i,\ j\ ]$
					$[i{+}1,\ j\ ]$
					$[i{+}2,\ j\ ]$
				$[\ j{-}2,\ j\ ]$	
				$[\ j{-}1,\ j\ ]$	

For cell $[\ i,\ j\ ]$, find rule spanning cells $[i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i<\ k<\ j$

Filling Cell [i, j]

For cell $[\ i,\ j\ ]$, find rule spanning cells $[\ i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i < k < j$

Filling Cell [i, j]

$[i,\ i\text{+}1]$	$[i,\ i\text{+}2]$		$[i,\ j\text{-}2]$	$[i,\ j\text{-}1]$	$[\ i,\ j\ ]$
					$[i\text{+}1,\ j\ ]$
					$[i\text{+}2,\ j\ ]$
				$[\ j\text{-}2,\ j\ ]$	
					$[\ j\text{-}1,\ j\ ]$

For cell $[\ i,\ j\ ]$, find rule spanning cells $[i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i<\ k<\ j$

Filling Cell [i, j]

For cell $[\ i,\ j\ ]$, find rule spanning cells $[i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i < k < j$
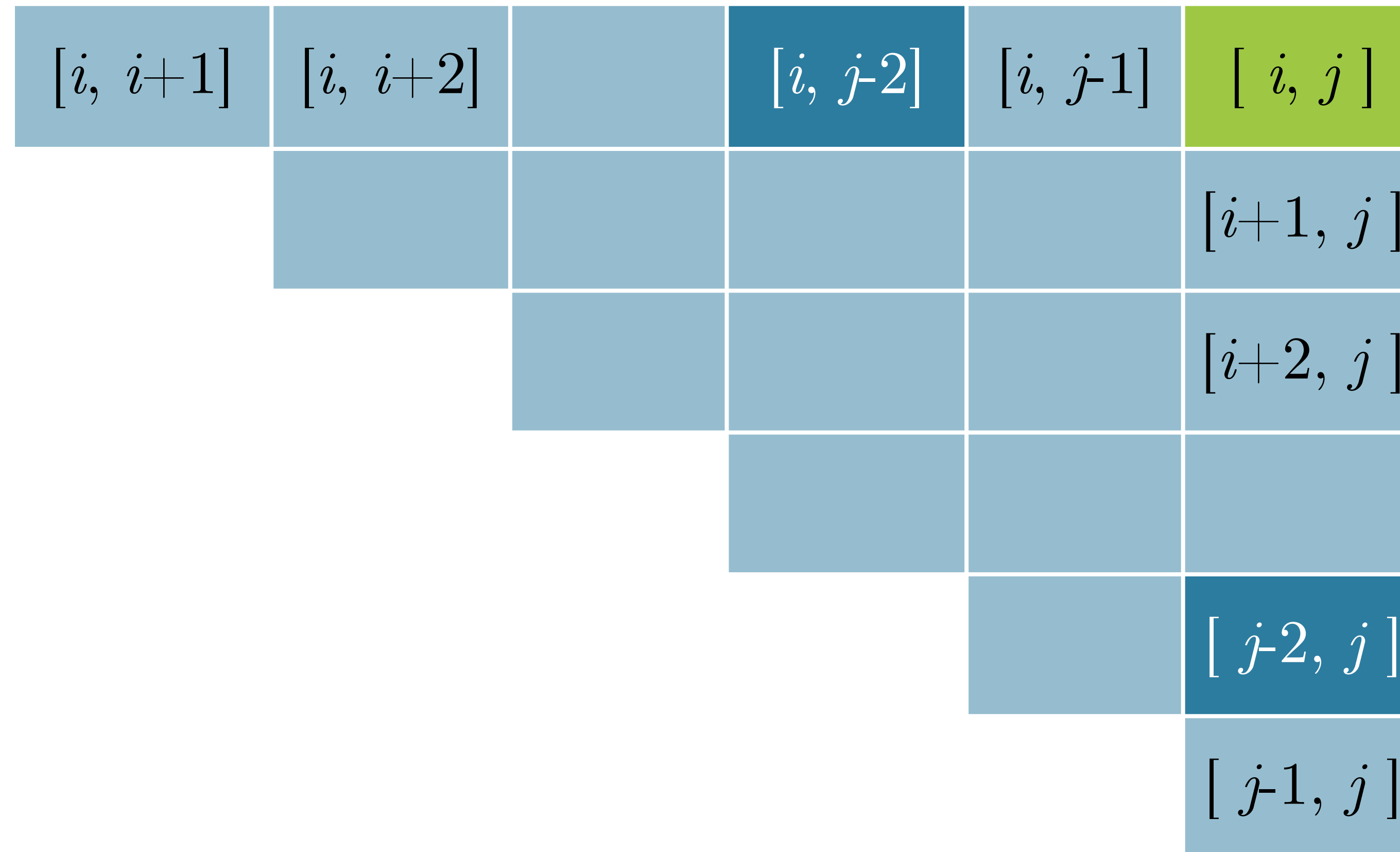
Filling Cell [i, j]

$[i,\ i{+}1]$	$[i,\ i{+}2]$		$[i,\ j{-}2]$	$[i,\ j{-}1]$	$[\ i,\ j\ ]$
					$[i{+}1,\ j\ ]$
					$[i{+}2,\ j\ ]$
					$[\ j{-}2,\ j\ ]$
					$[\ j{-}1,\ j\ ]$

For cell $[\ i,\ j\ ]$, find rule spanning cells $[i,\ k\ ]$ and $[\ k,\ j\ ]$ where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

0   1   2   3   4   5

Why fill cells this way?

- For cell $[\,i,\,j\,]$, must be able to access all cells $[\,i,\,k\,]$ and $[\,k,\,j\,]$ where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$
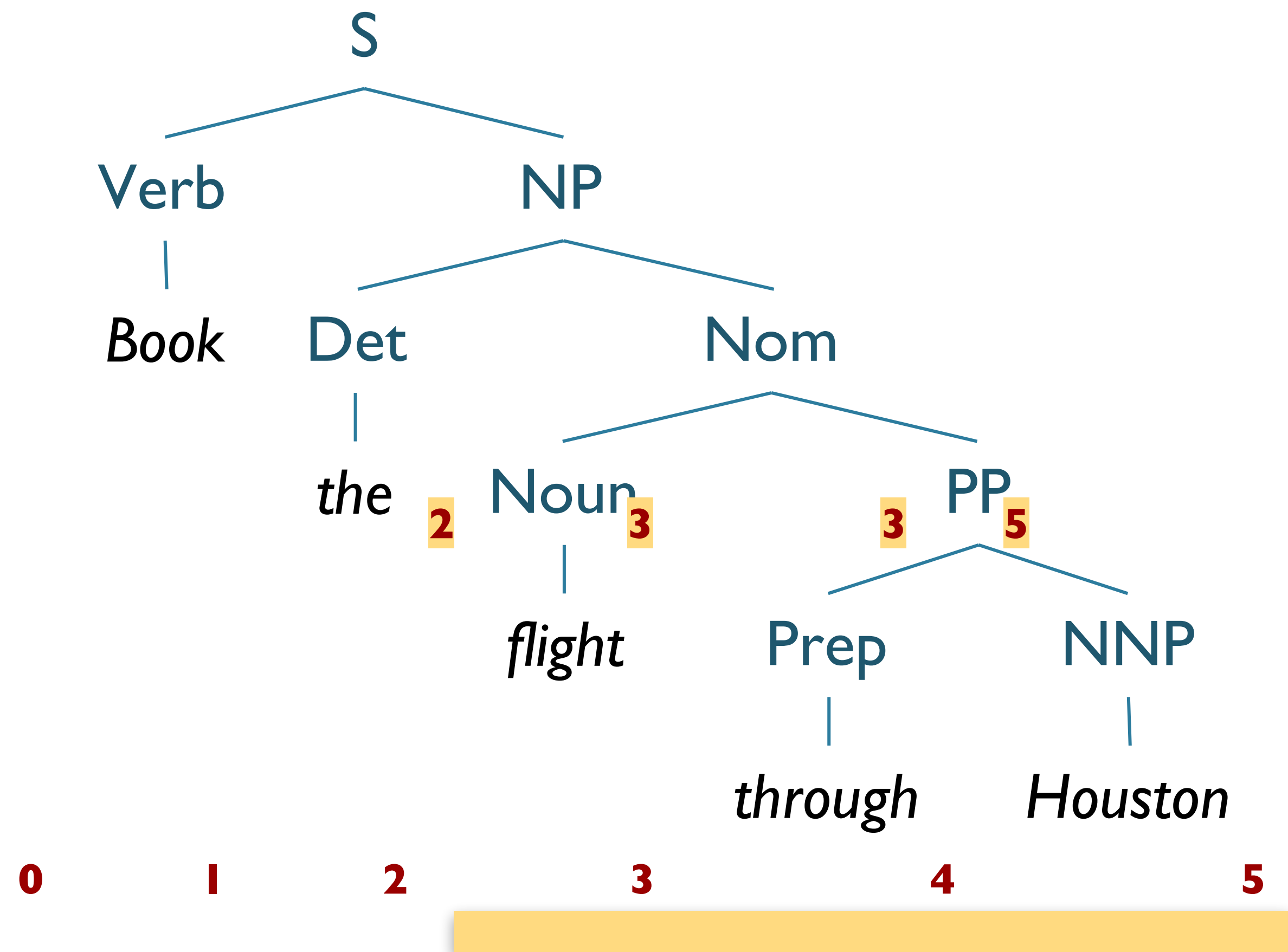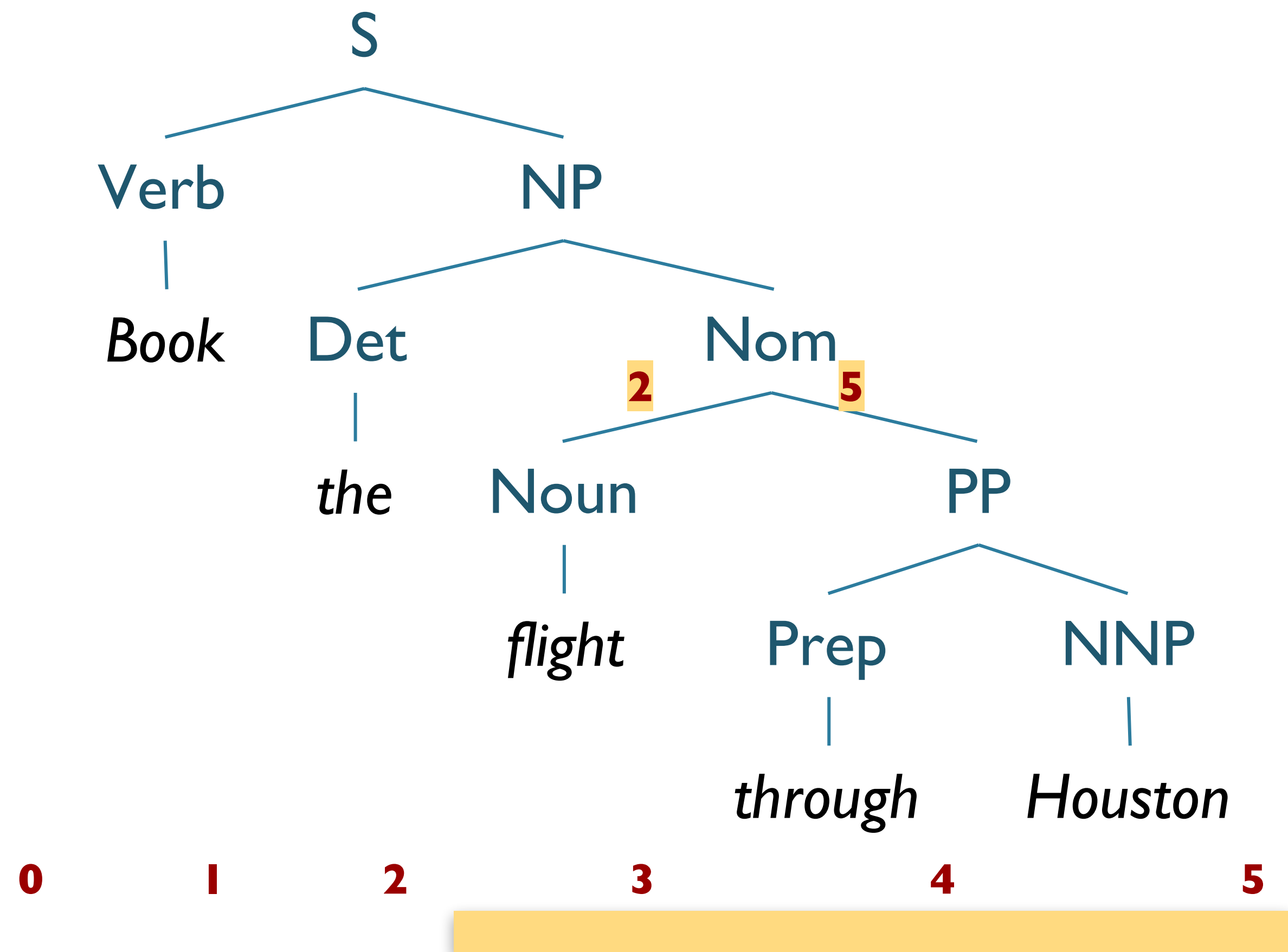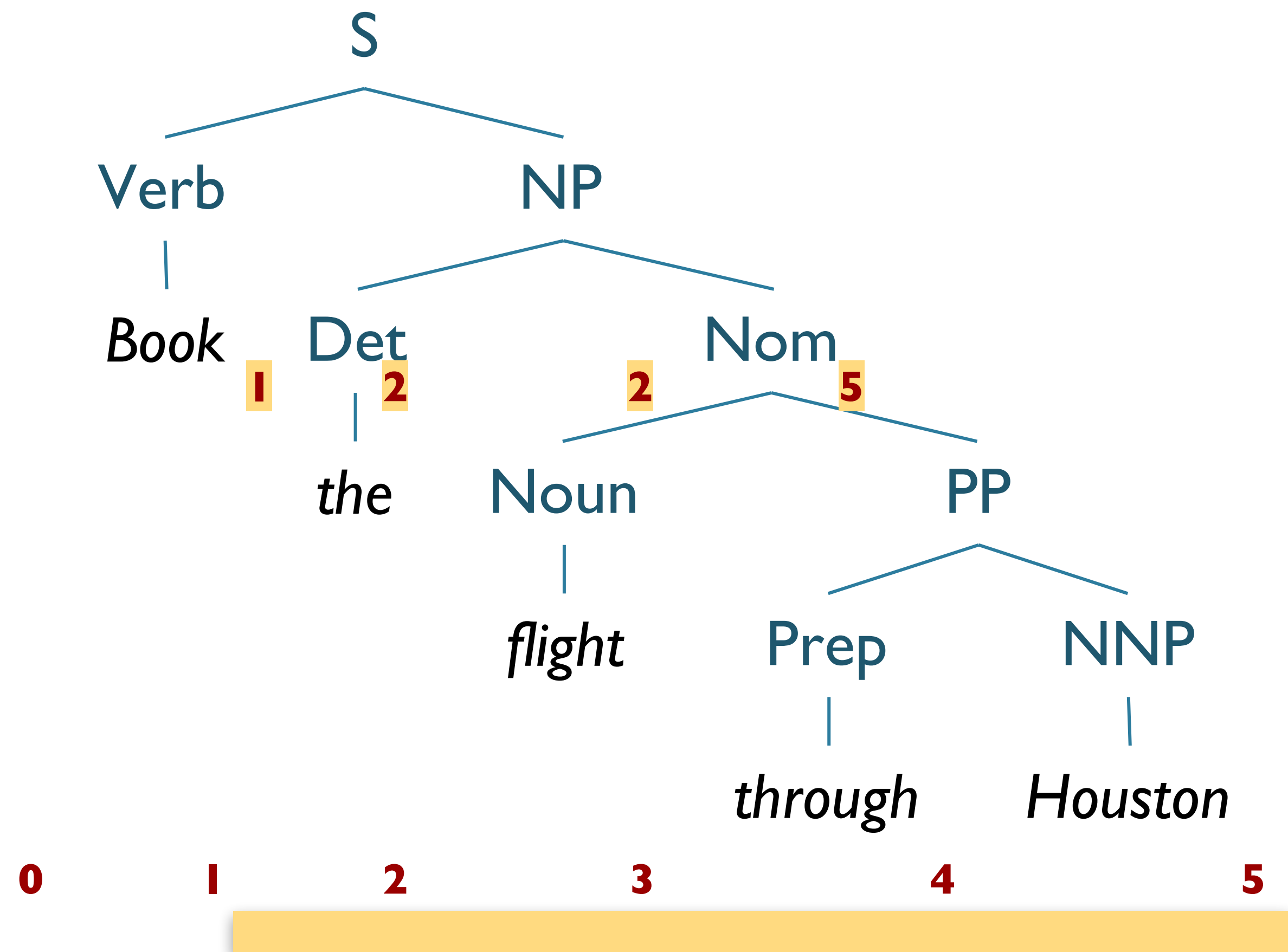
Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

Why fill cells this way?

- For cell [i, j], must be able to access all cells [i, k] and [k, j] where $i < k < j$

S

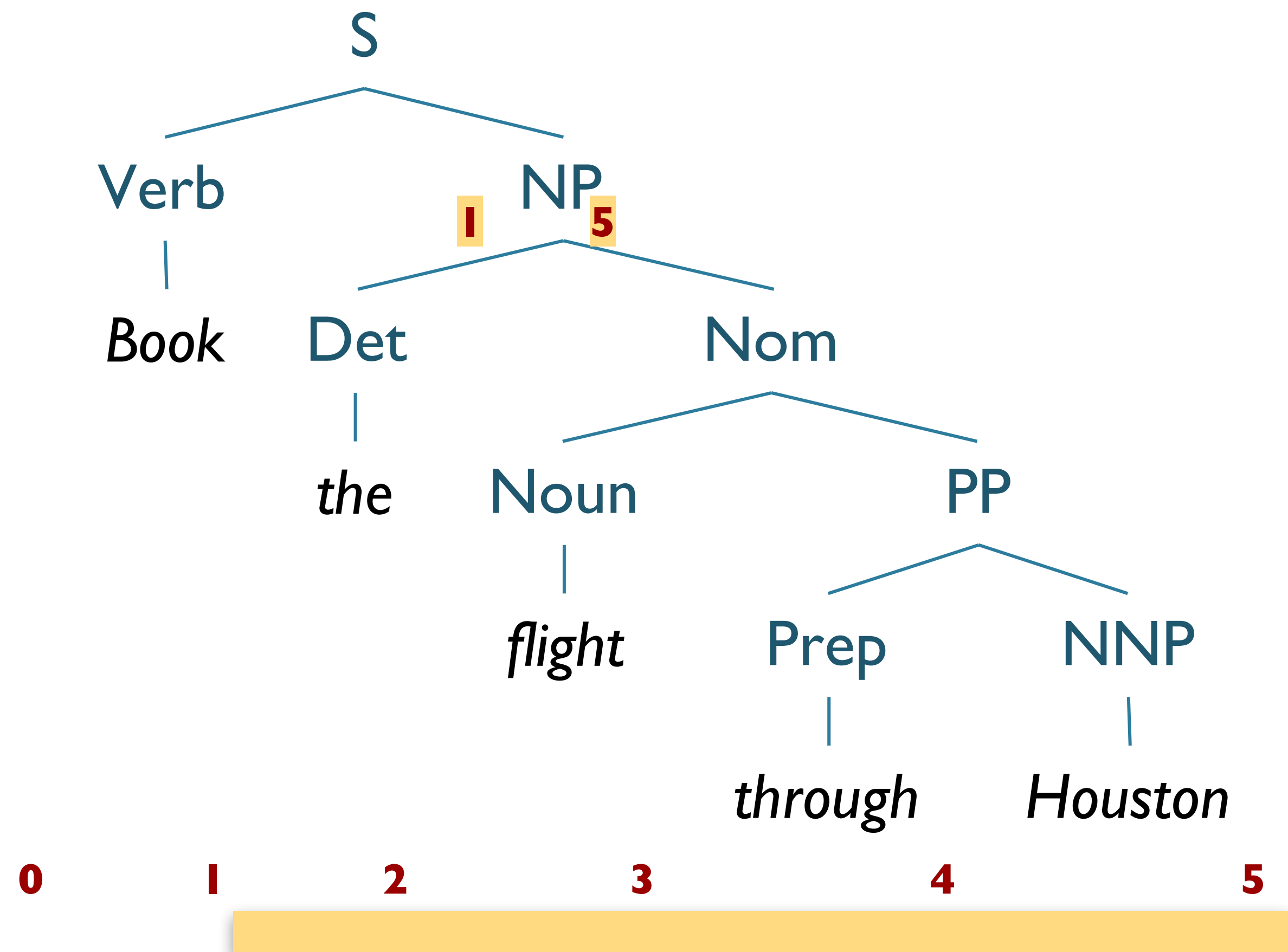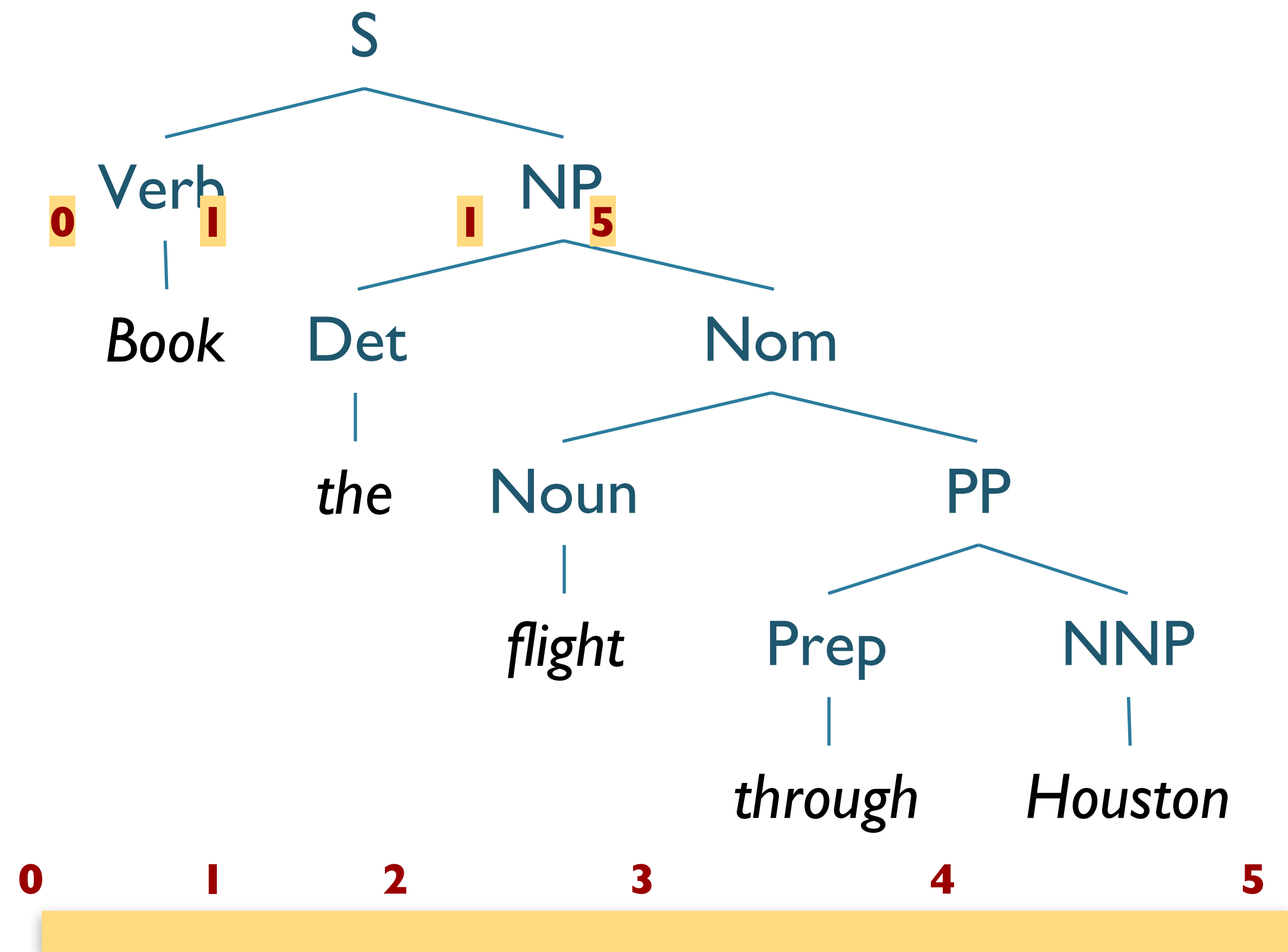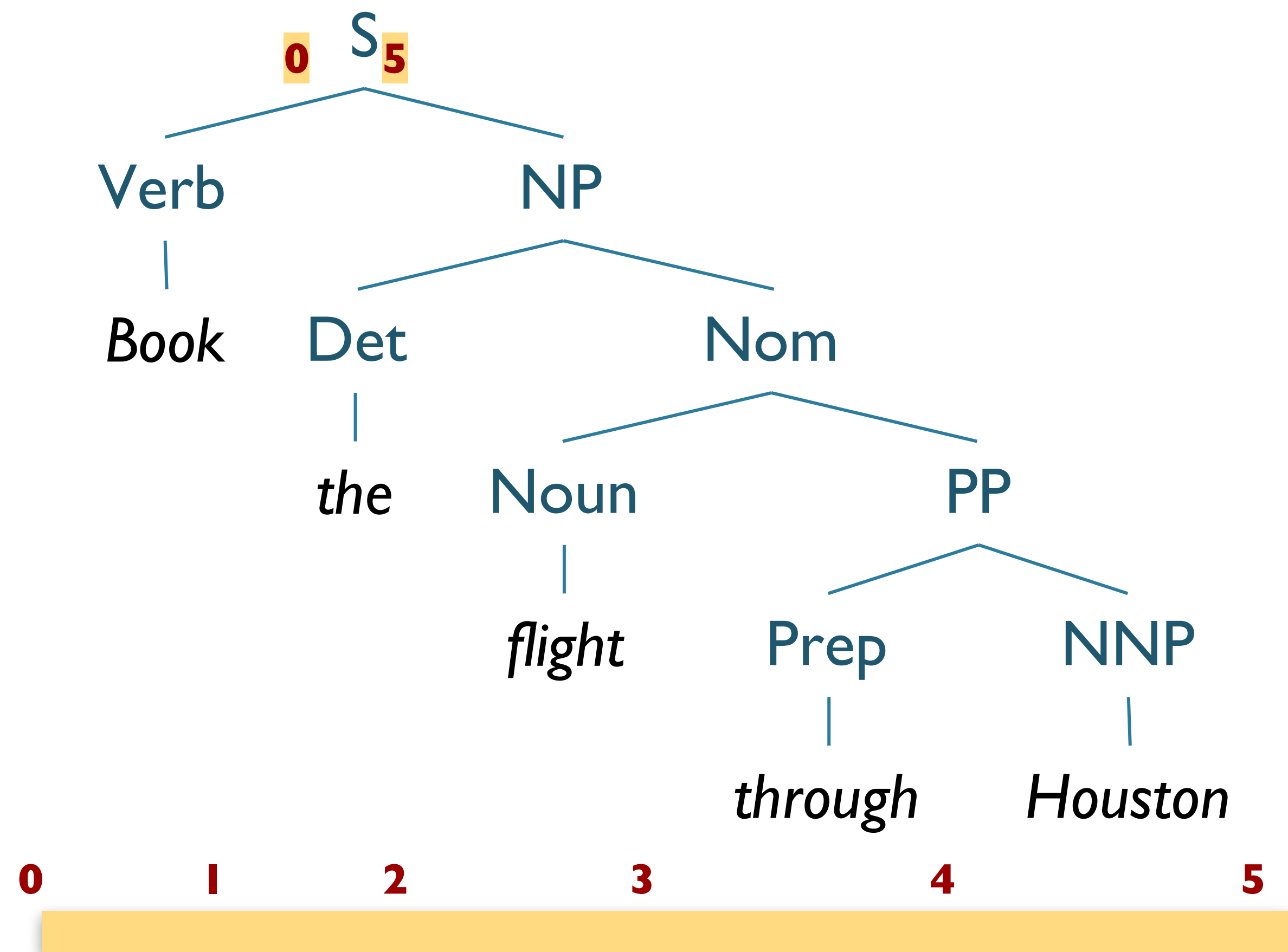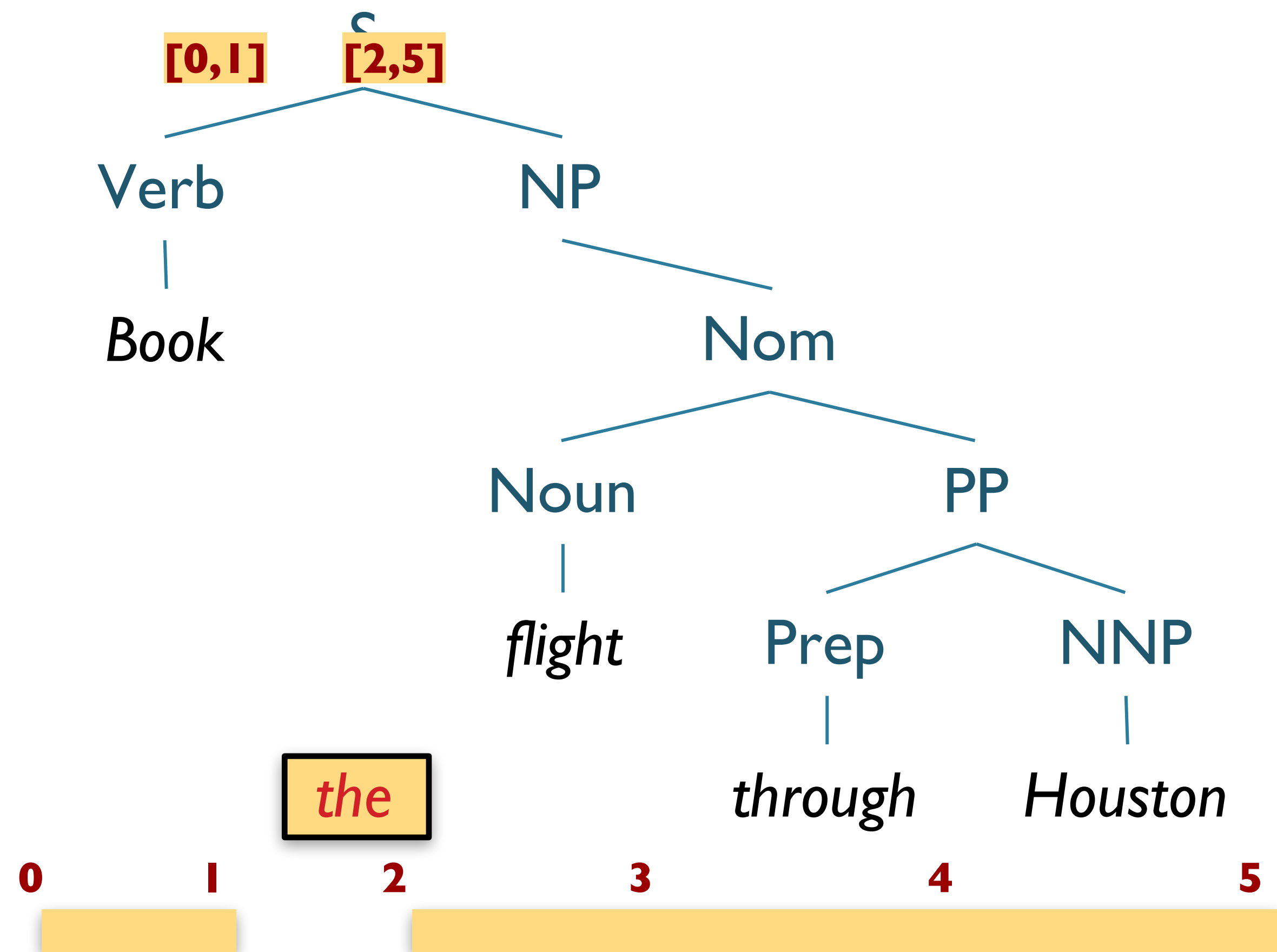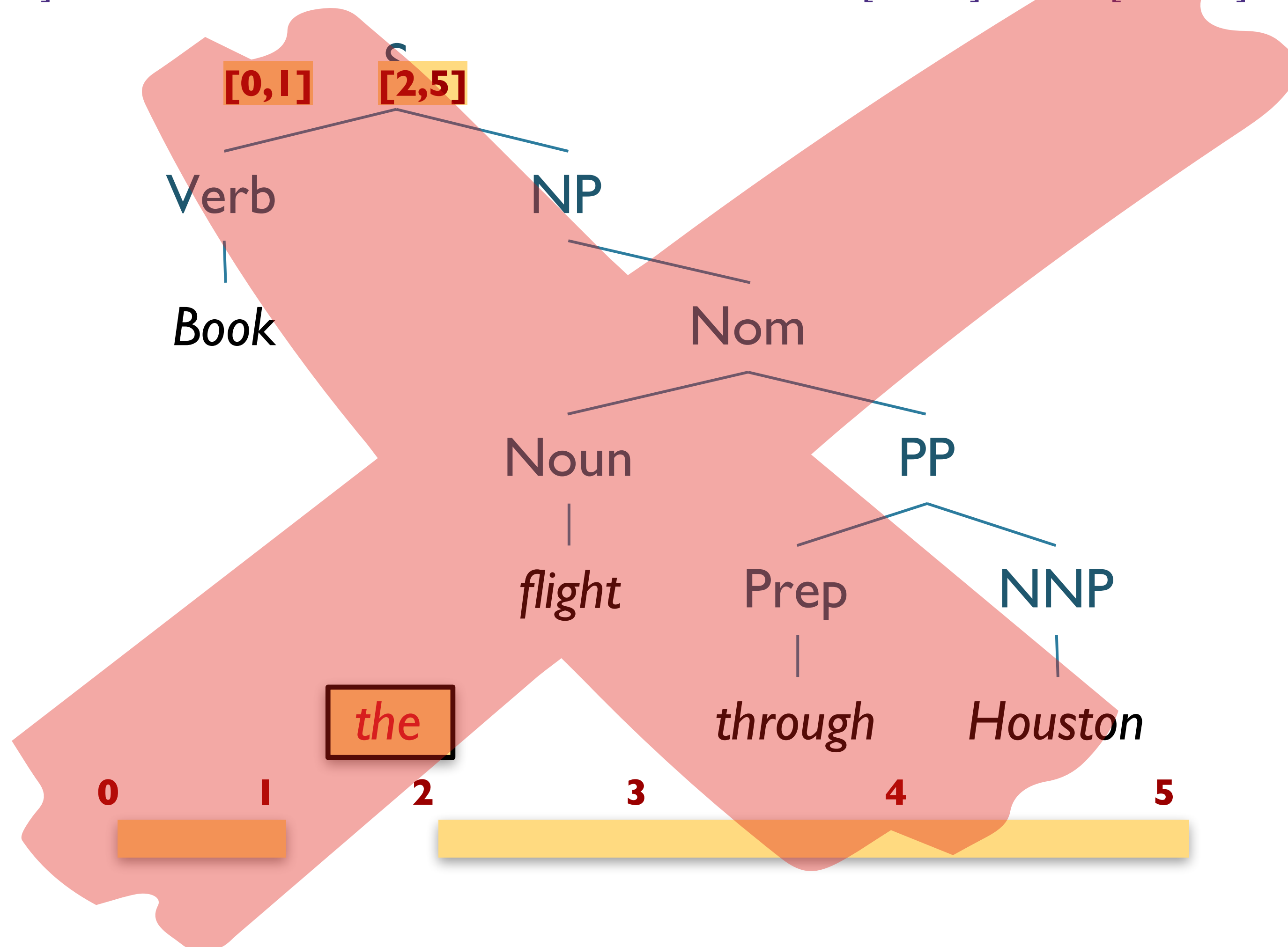**[0,1]**   **[2,5]**

Verb   NP

Book   Nom

Noun   PP

flight   Prep   NNP

the   through   Houston

0   1   2   3   4   5

CKY Parsing Example

$\mathscr{L}_1$ **Grammar**

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

	I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$
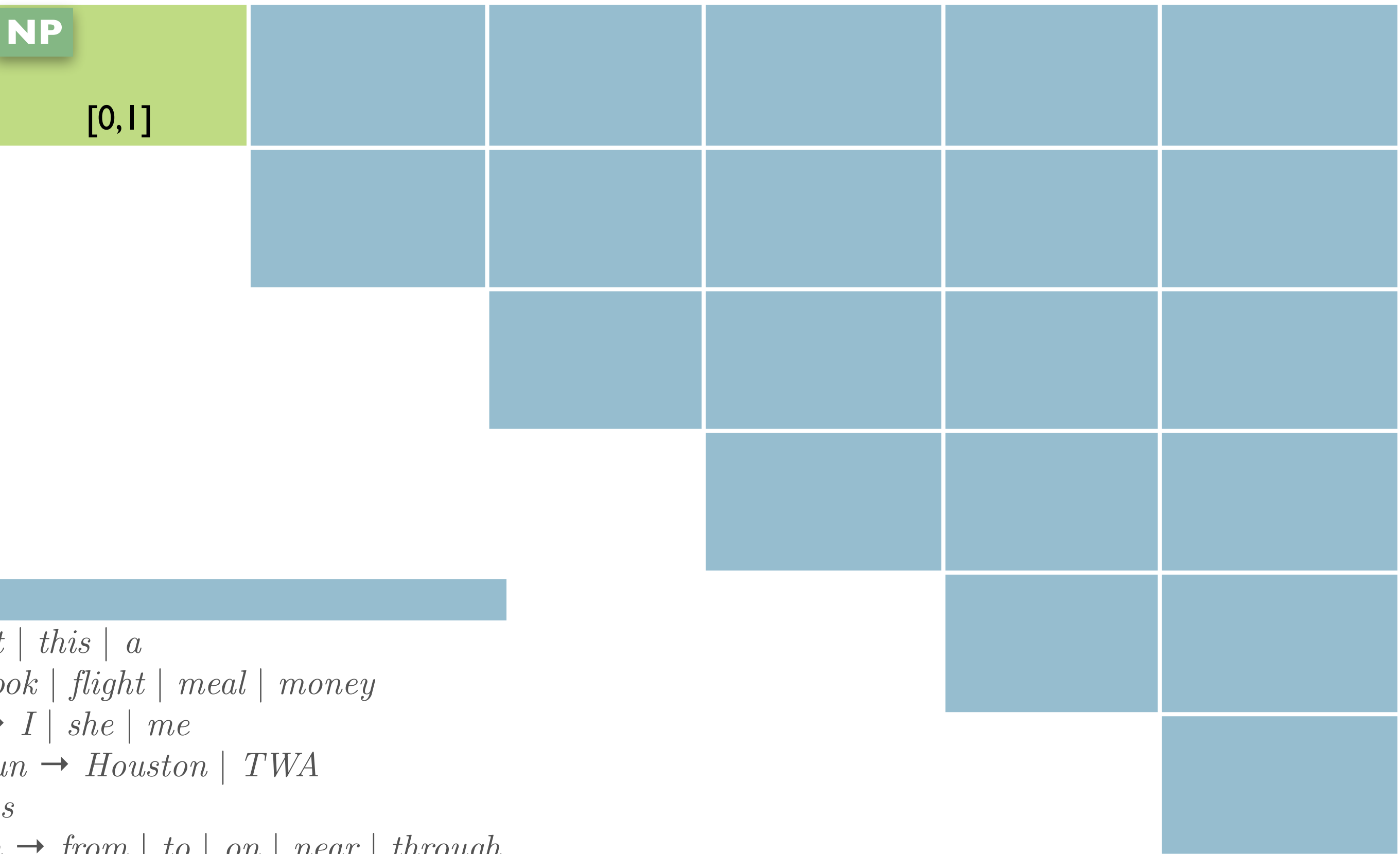
NP
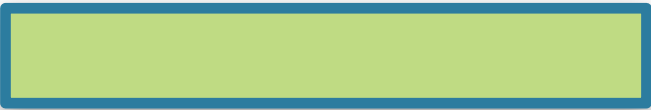[0,1]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun
[0,1]

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]					
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
- - - - - - - - - - -
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
- - - - - - - - - - -
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
- - - - - - - - - - -
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
- - - - - - - - - - -
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, NP, Pronoun [0,1]	[0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6
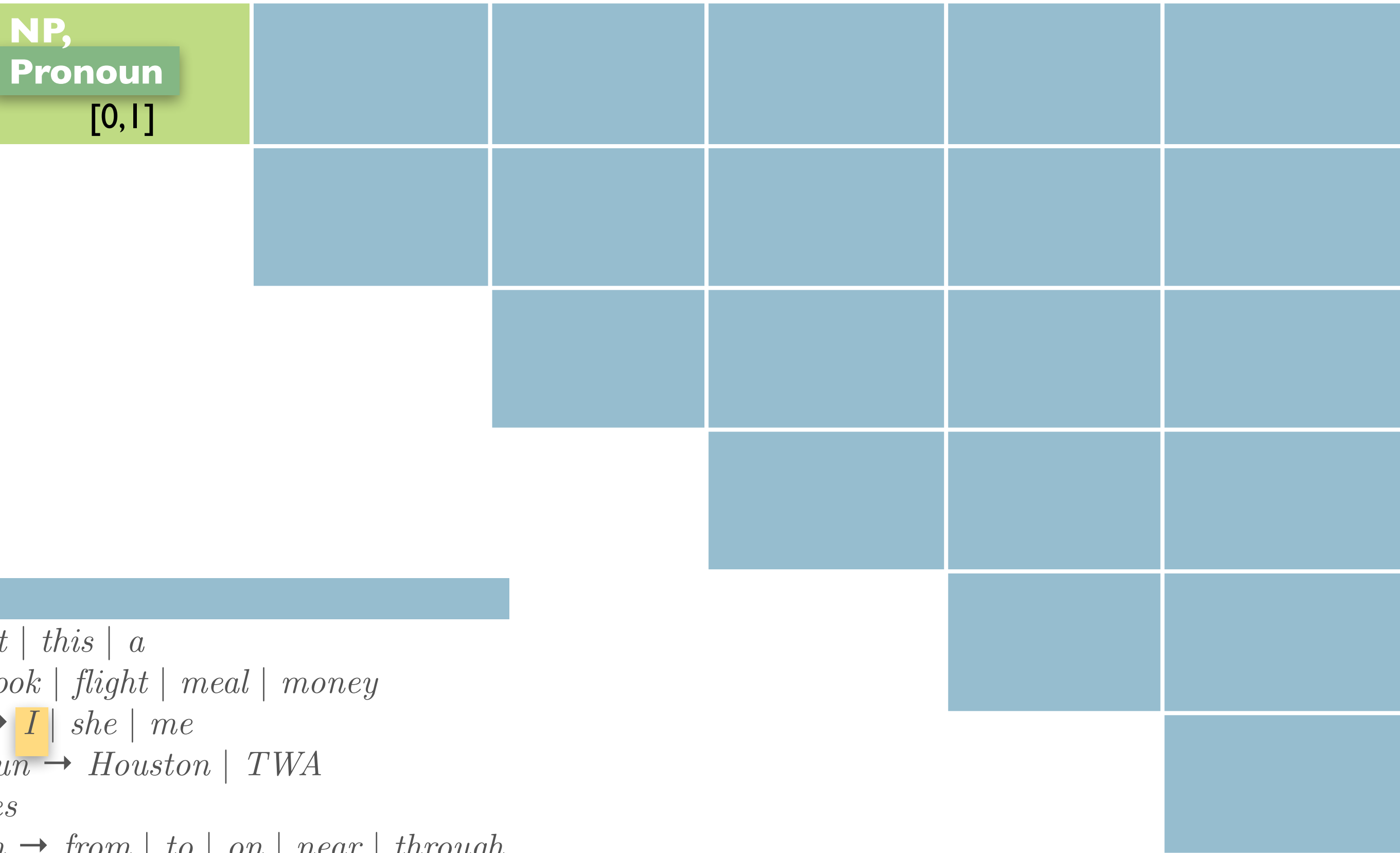
$\mathcal{L}_1$ Grammar

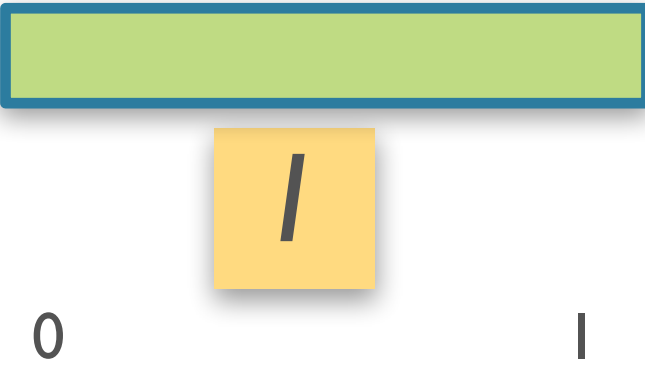$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$
- -
$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, NP, Pronoun [0,1]	**NP, Pronoun** [0,2]				
	Verb, VP, S [1,2]				

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
- -
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
- -
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
- -
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
- -
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, NP, Pronoun [0,1]	NP, Noun [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
- - -
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
- - -
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
- - -
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
- - -
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	NP, Pronoun [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow$ *NP* *VP*
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
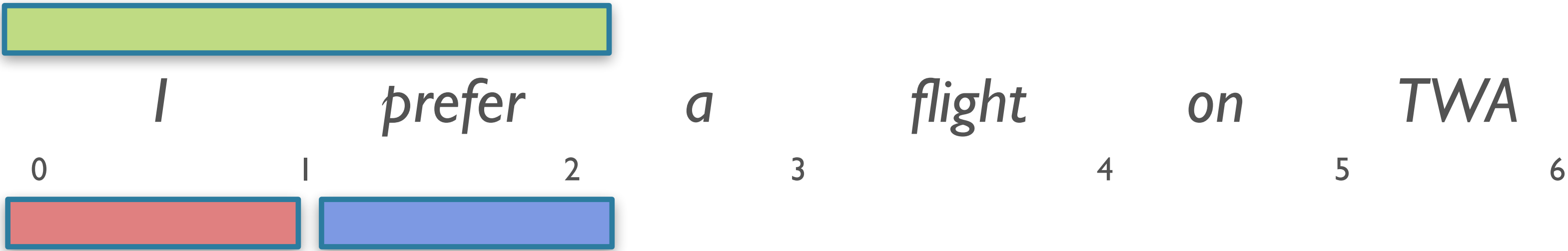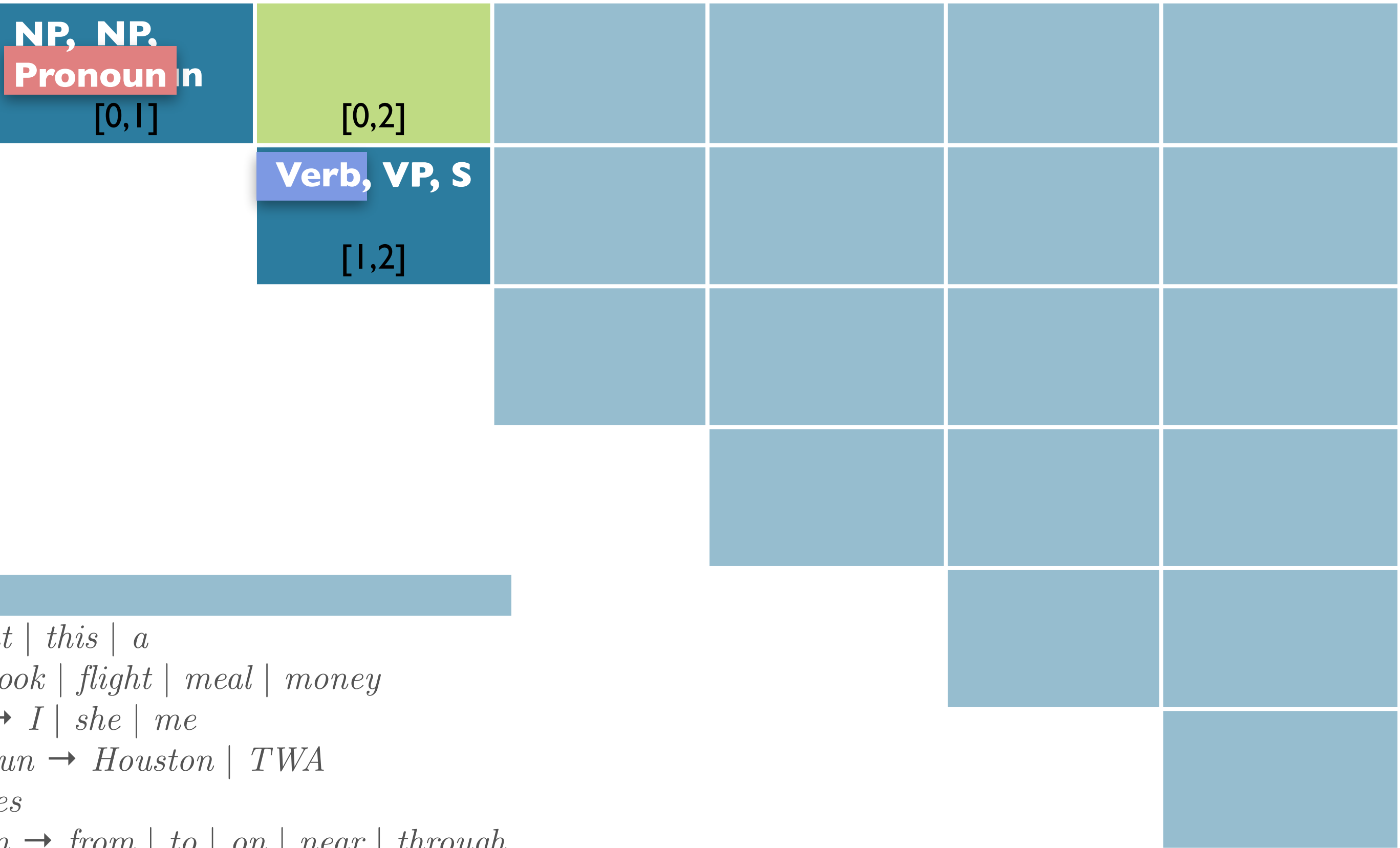$Verb \rightarrow book \mid include \mid prefer$

NP, NP, Pronoun [0,1]	S, S [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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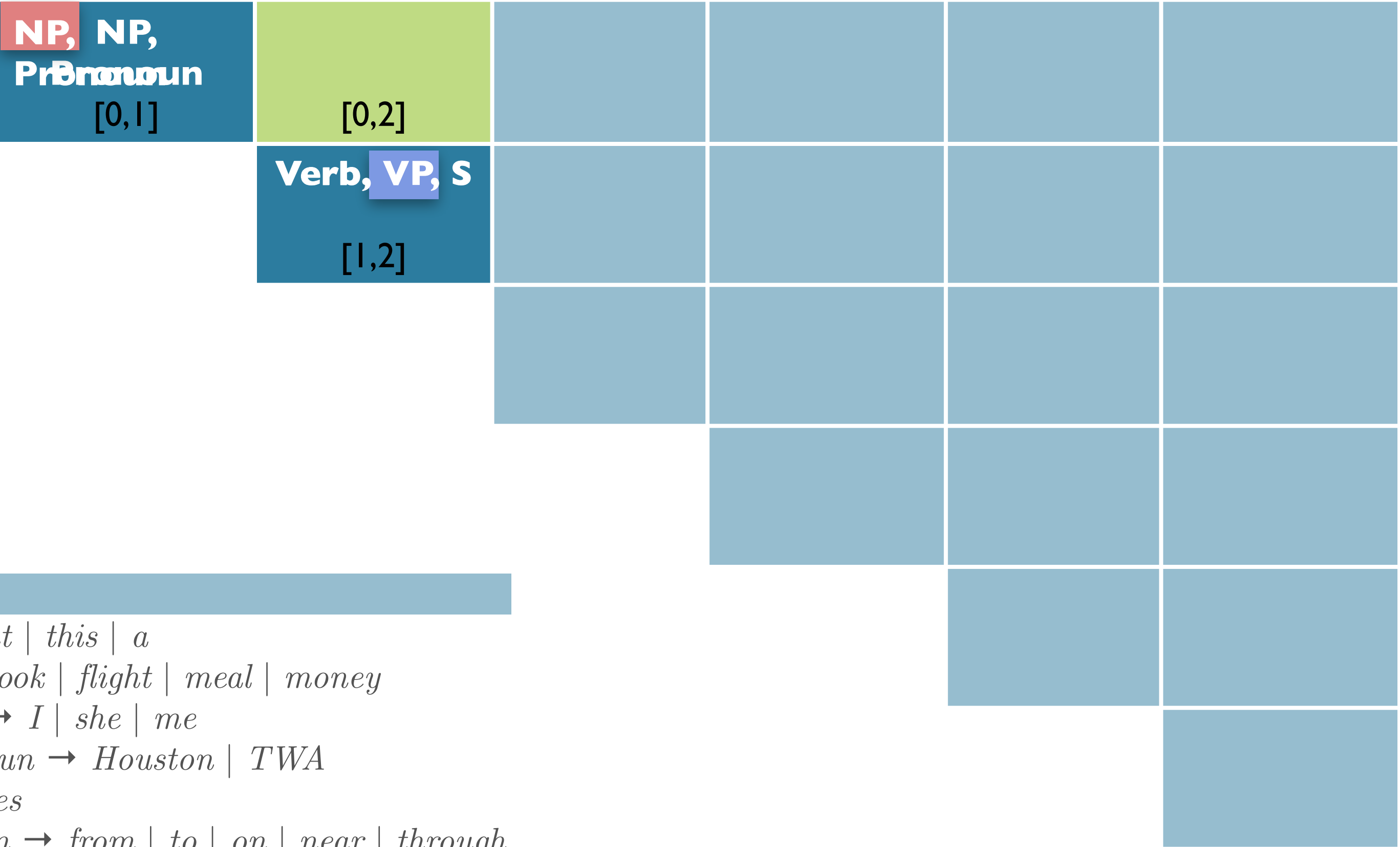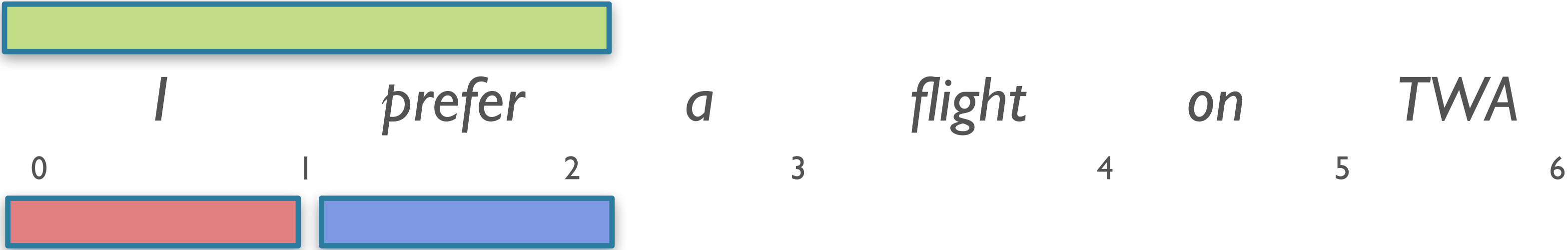$NP \rightarrow TWA \mid Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
- - - - - - - - - - - - - - -
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
- - - - - - - - - - - - - - -
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
- - - - - - - - - - - - - - -
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
- - - - - - - - - - - - - - -
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, NP, Pronoun [0,1]	S S [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, NP, Pronoun [0,1]	S, S [0,2]				
	Verb, VP, S [1,2]				

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]				
		Det [2,3]			

I (0) prefer (1) a (2) flight (3) on (4) TWA (5) (6)

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]			

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
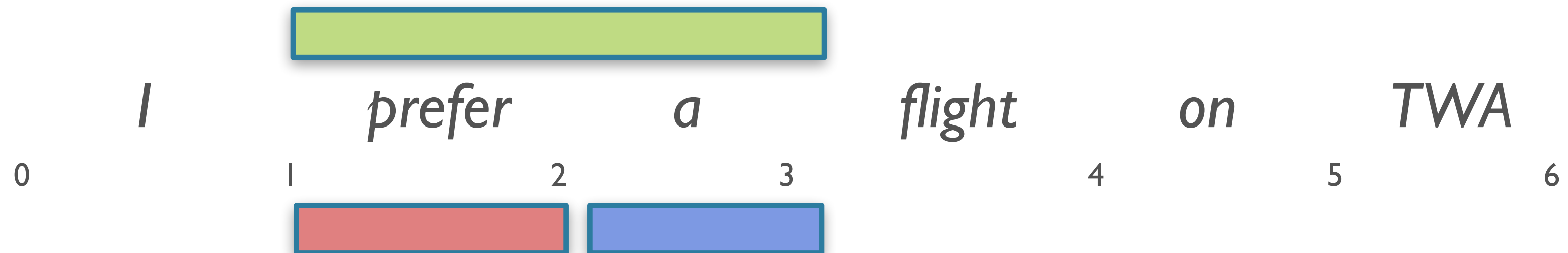
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
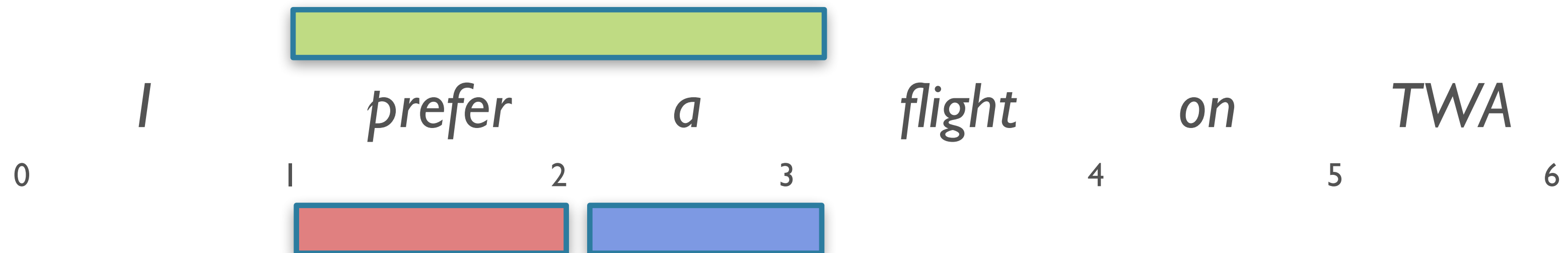Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]	VP, S [1,3]			
		Det Det [2,3]			

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \to NP\ VP$
$S \to X1\ VP$
$X1 \to Aux\ NP$
$S \to book\ |\ include\ |\ prefer$
$S \to Verb\ NP$
$S \to X2\ PP$
$S \to Verb\ PP$
$S \to VP\ PP$

$NP \to I\ |\ she\ |\ me$
$NP \to TWA\ |\ Houston$
$NP \to Det\ Nominal$

$Nominal \to book\ |\ flight\ |\ meal\ |\ money$
$Nominal \to Nominal\ Noun$
$Nominal \to Nominal\ PP$

$VP \to book\ |\ include\ |\ prefer$
$VP \to Verb\ NP$
$VP \to X2\ PP$
$X2 \to Verb\ NP$
$VP \to Verb\ PP$
$VP \to VP\ PP$

$PP \to Preposition\ NP$

Lexicon

$Det \to that\ |\ this\ |\ a$
$Noun \to book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \to I\ |\ she\ |\ me$
$Proper\text{-}Noun \to Houston\ |\ TWA$
$Aux \to does$
$Preposition \to from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \to book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]	VP, S [1,3]			
		Det Det [2,3]			

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]	[1,3]			
		Det Det [2,3]			

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \to that\ |\ this\ |\ a$
$Noun \to book\ |\ flight\ |\ meal\ |\ money$
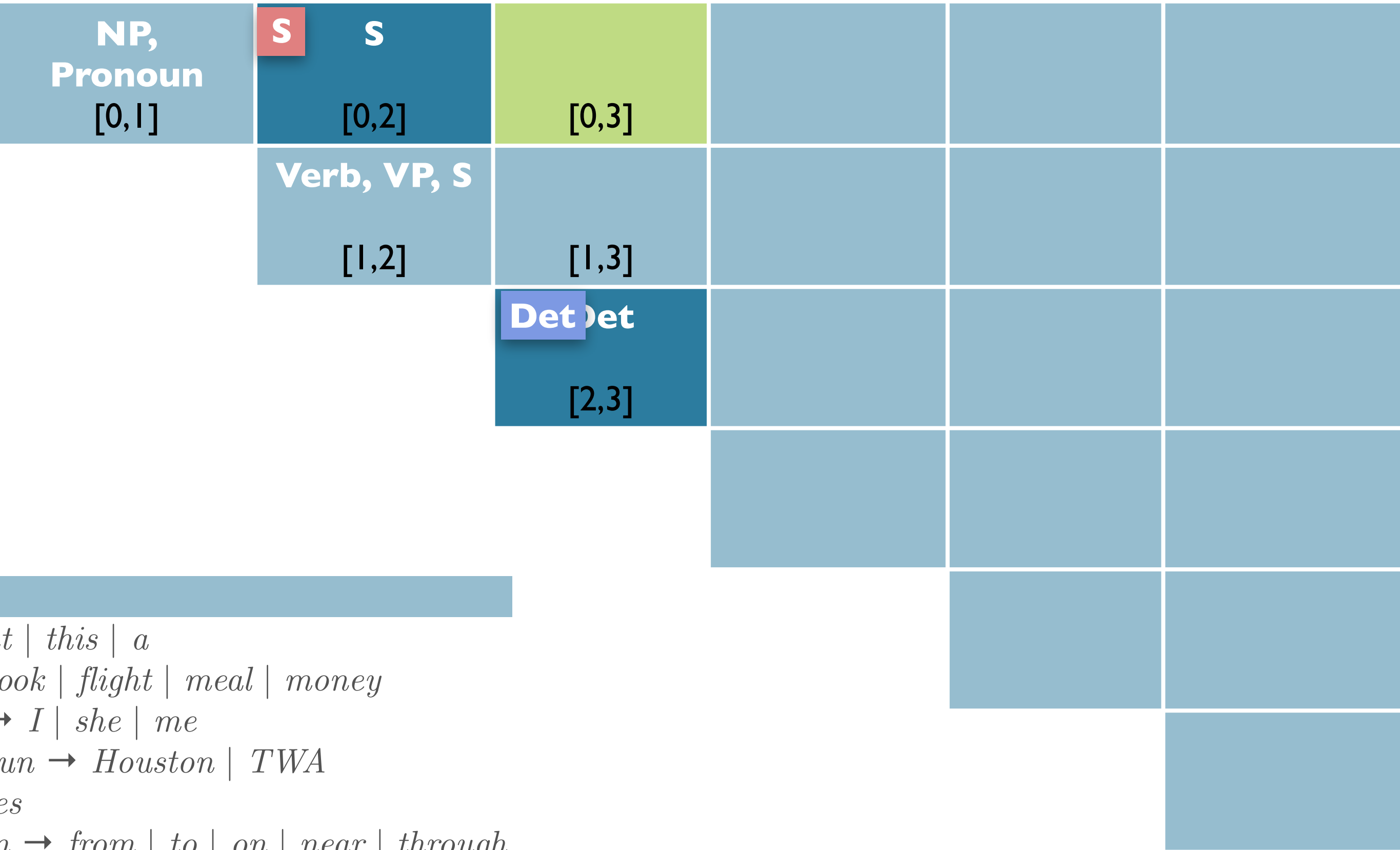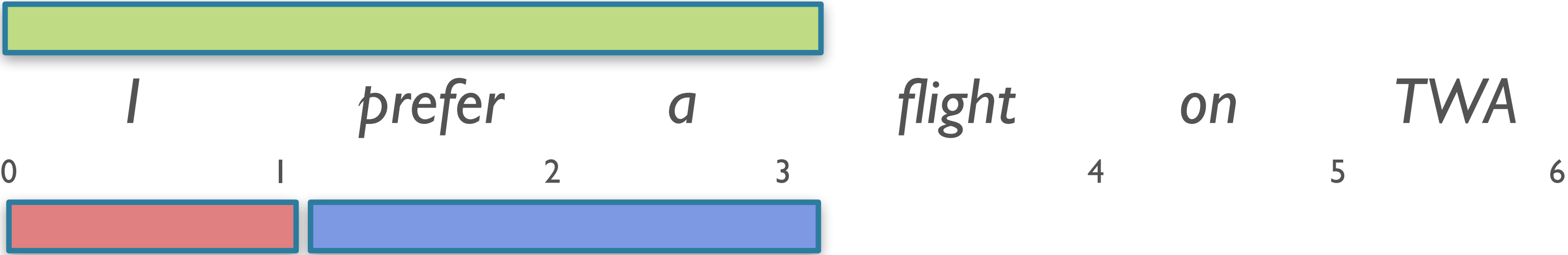$Pronoun \to I\ |\ she\ |\ me$
$Proper\text{-}Noun \to Houston\ |\ TWA$
$Aux \to does$
$Preposition \to from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \to book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]				
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]			

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
- -
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
- -
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
- -
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
- -
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]			

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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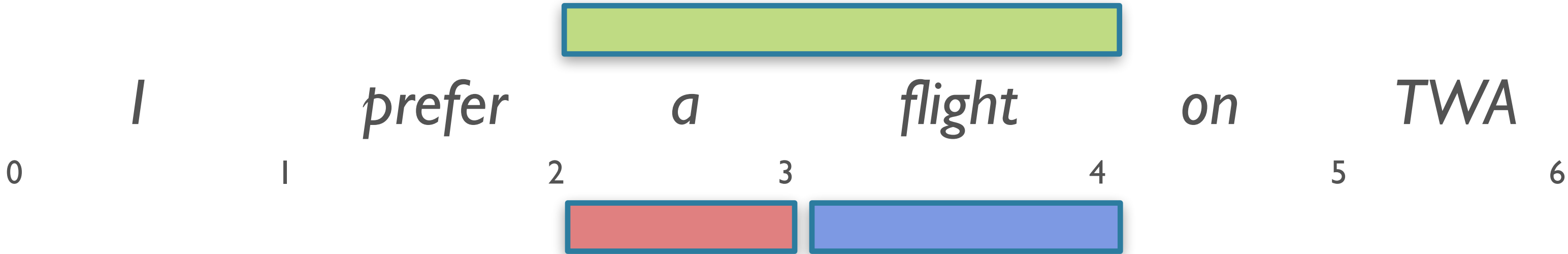
Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]			
		Det Det [2,3]			

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
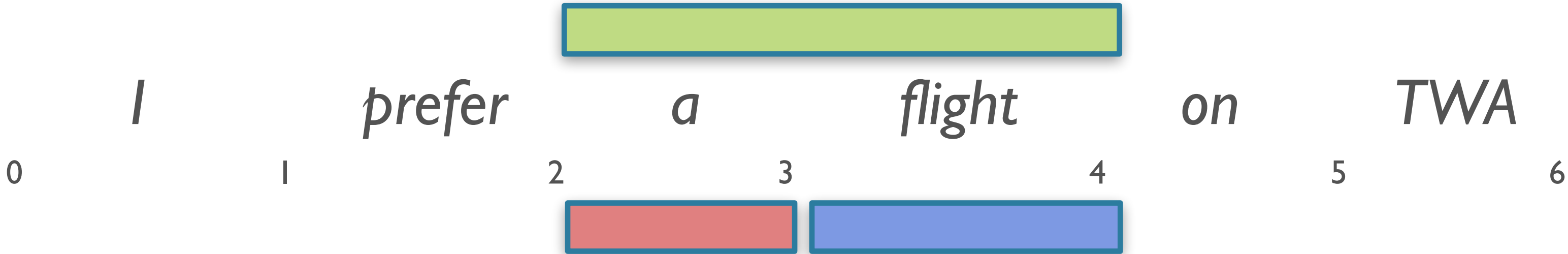$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun	S				
[0,1]	[0,2]	[0,3]			
	Verb, VP, S				
	[1,2]	[1,3]			
		Det			
		[2,3]			
			Noun, Nom		
			[3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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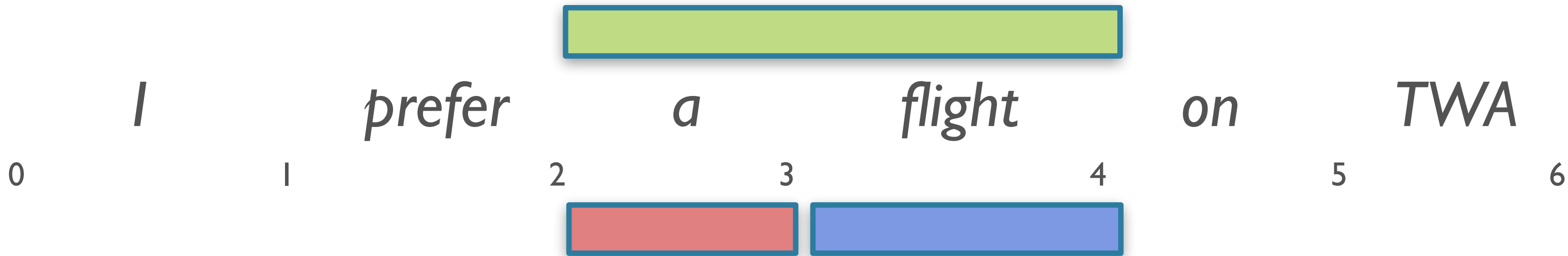$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]	[2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
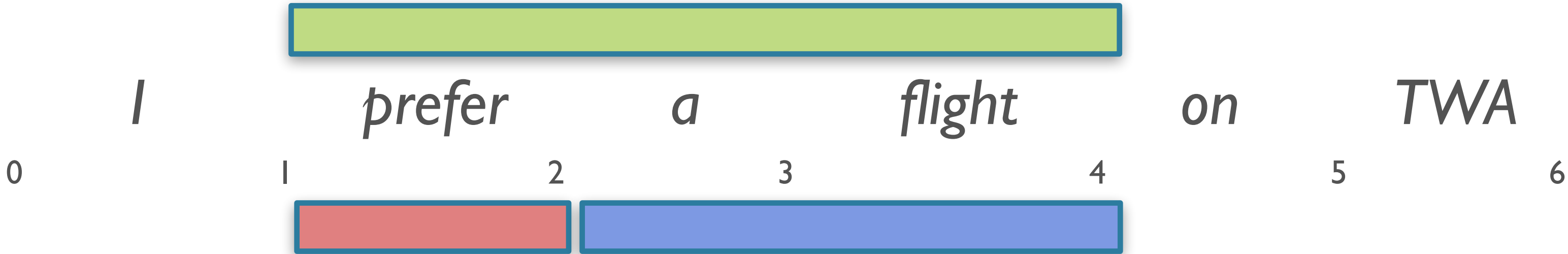$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]	[2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]			
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \to that\ |\ this\ |\ a$
$Noun \to book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \to I\ |\ she\ |\ me$
$Proper\text{-}Noun \to Houston\ |\ TWA$
$Aux \to does$
$Preposition \to from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \to book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	[1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
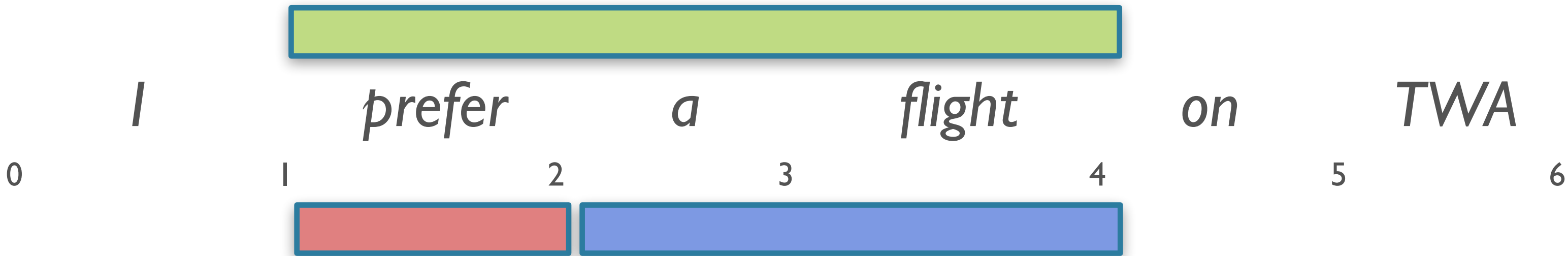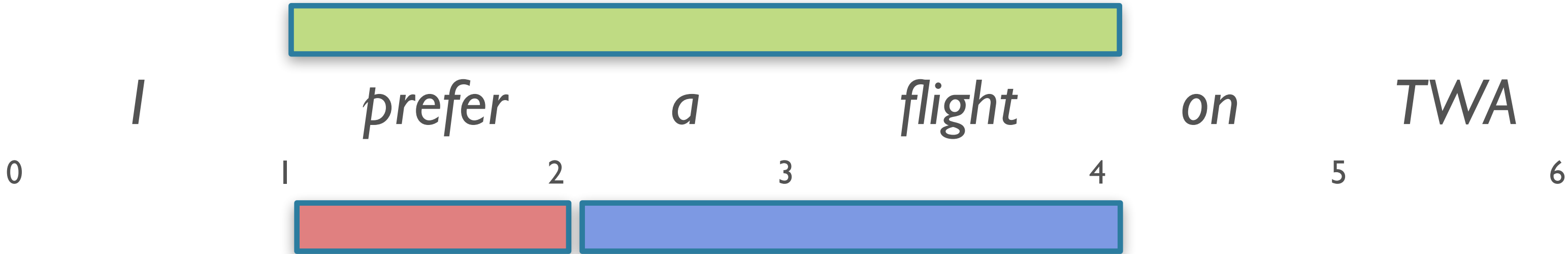$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	VP [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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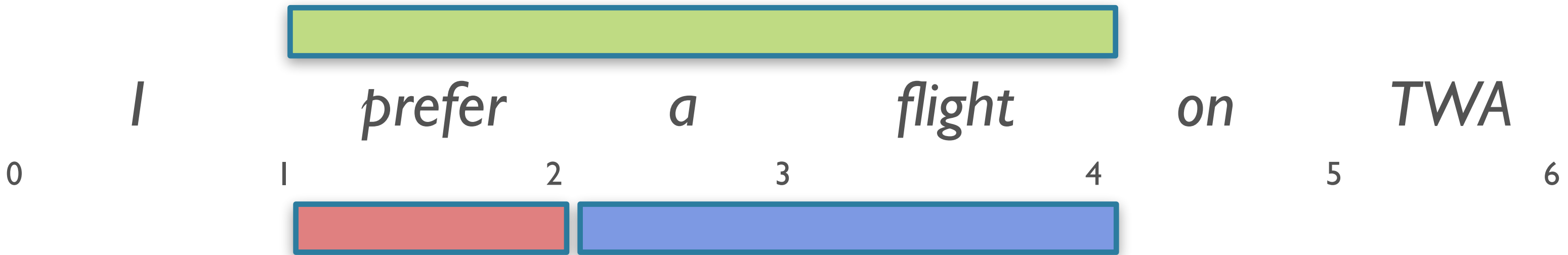- -
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
- -
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	VP, X2 [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I — prefer — a — flight — on — TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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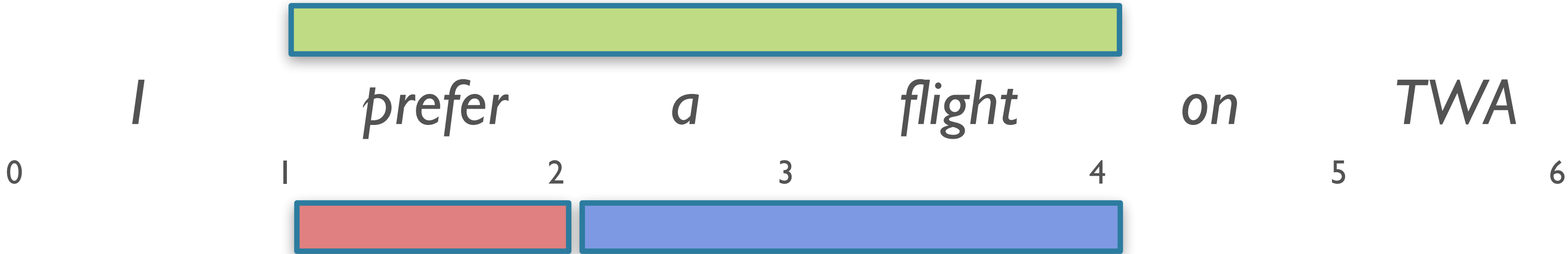- -
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
- -
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
	Det [2,3]	NP [2,4]		
		Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

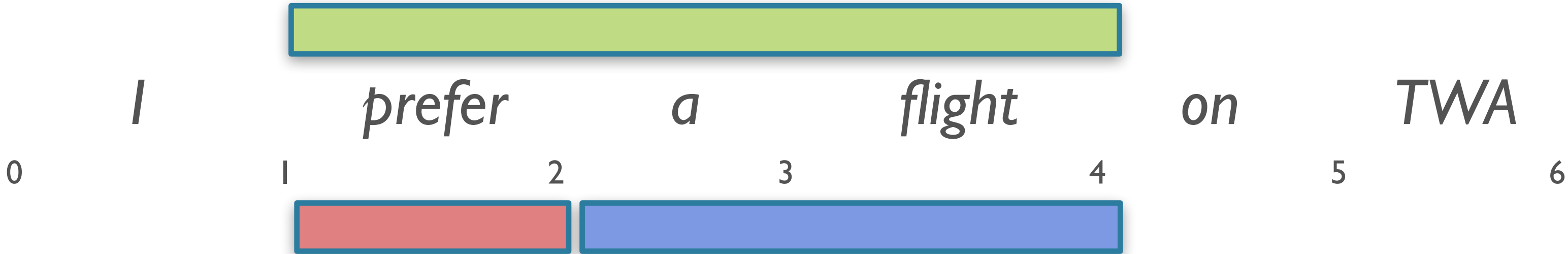$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$
- - - - - - - - - - - - - - - - - -
$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\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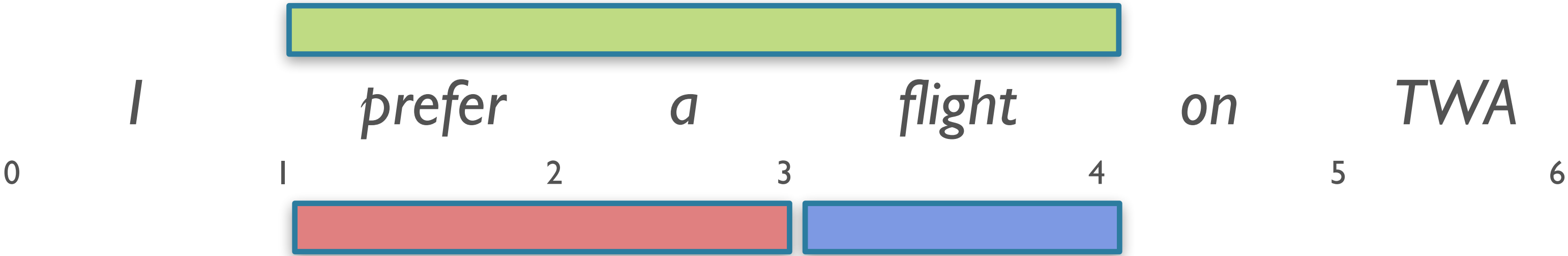- - - - - - - - - - - - - - - - - -
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
- - - - - - - - - - - - - - - - - -
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
Verb, VP, S [1,2]		[1,3]	VP, X2, S [1,4]		
	Det [2,3]	NP [2,4]			
		Noun, Nom [3,4]			

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
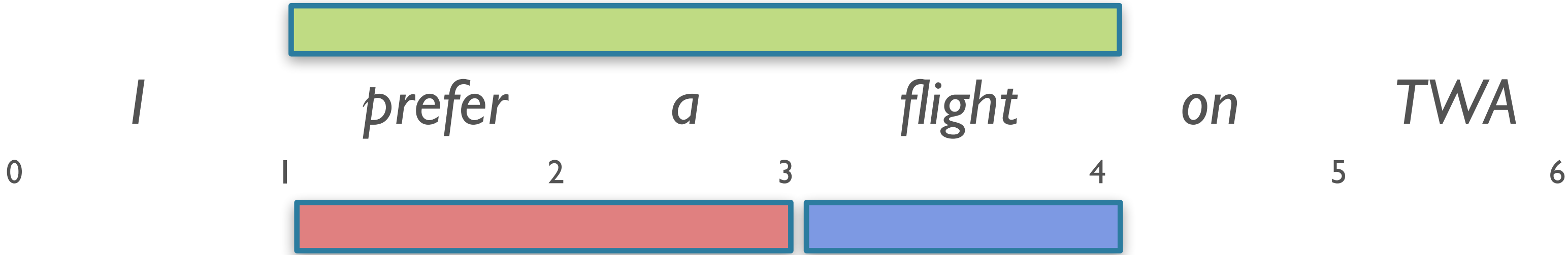$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
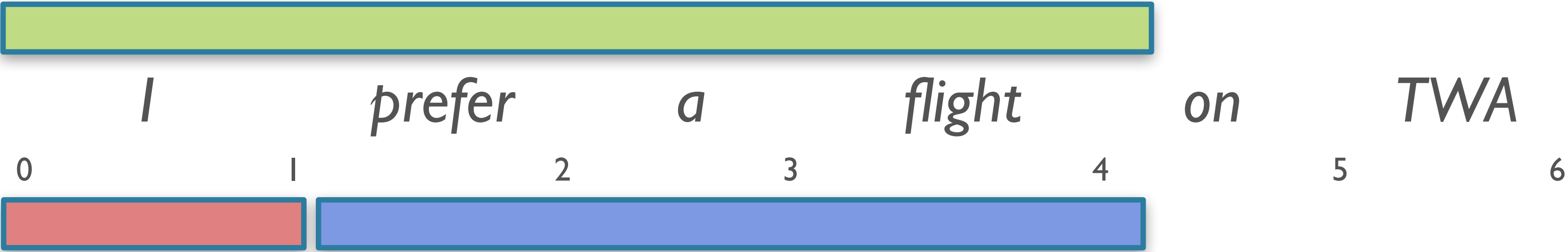$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]			
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	[0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow$ NP VP
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
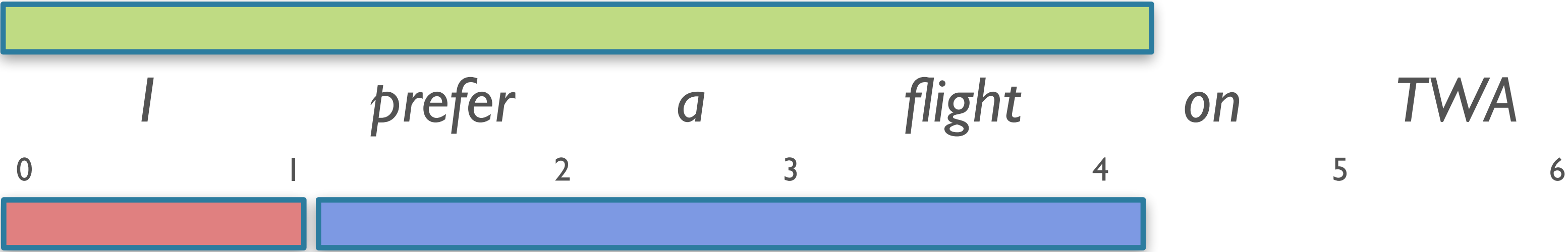$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	**S** [0,2]	[0,3]	**S** [0,4]		
	Verb, VP, S [1,2]	[1,3]	**VP, X2, S** [1,4]		
		Det [2,3]	**NP** [2,4]		
			Noun, Nom [3,4]		

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
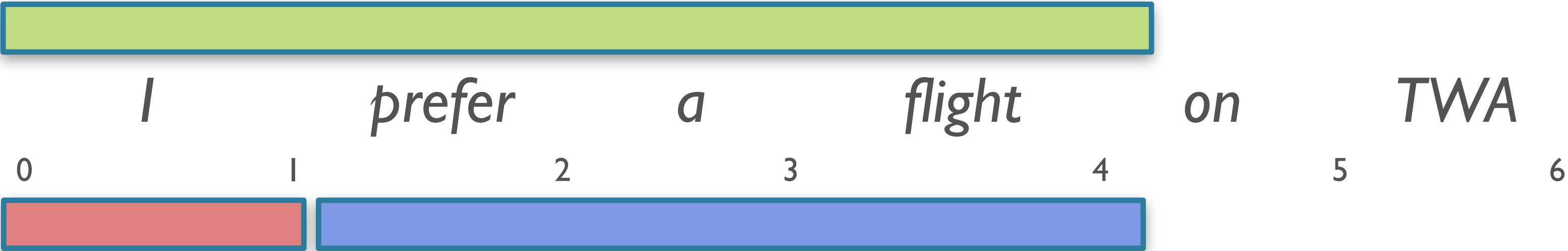$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	**S** [0,2]	[0,3]	**S** [0,4]		
	Verb, VP, S [1,2]	[1,3]	**VP, X2, S** [1,4]		
		Det [2,3]	**NP** [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	**S** [0,2]	[0,3]	**S** [0,4]		
	Verb, VP, S [1,2]	[1,3]	**VP, X2, S** [1,4]		
		Det [2,3]	**NP** [2,4]		
			Noun, Nom [3,4]		

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

ℒ₁ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathscr{L}_1$ Grammar

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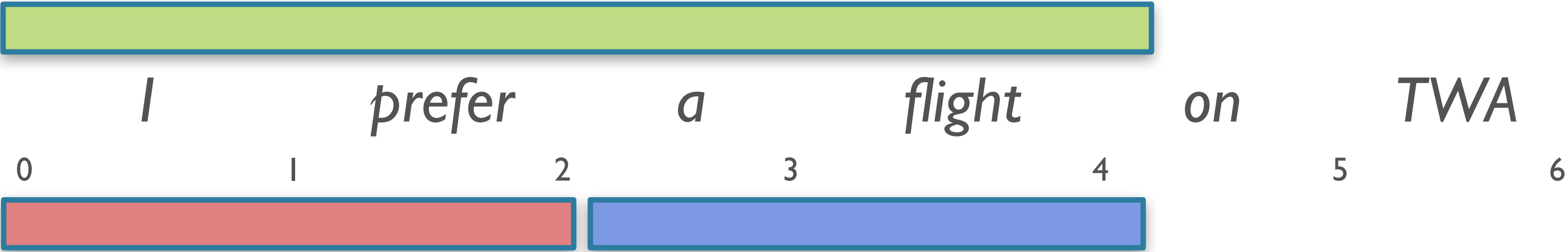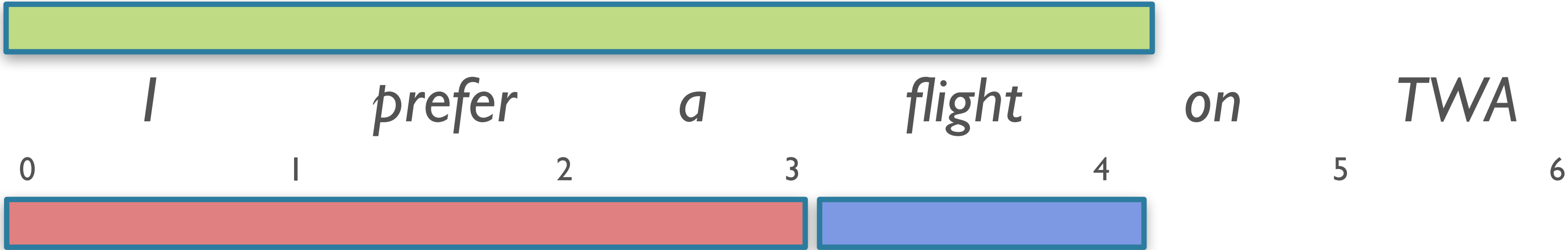$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP

NP → I | she | me
NP → TWA | Houston
NP → Det Nominal

Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP

VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP

PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
	Det [2,3]	NP [2,4]			
		Noun, Nom [3,4]			

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
Verb, VP, S [1,2]		[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		

	I	prefer	a	flight	on	TWA
	0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

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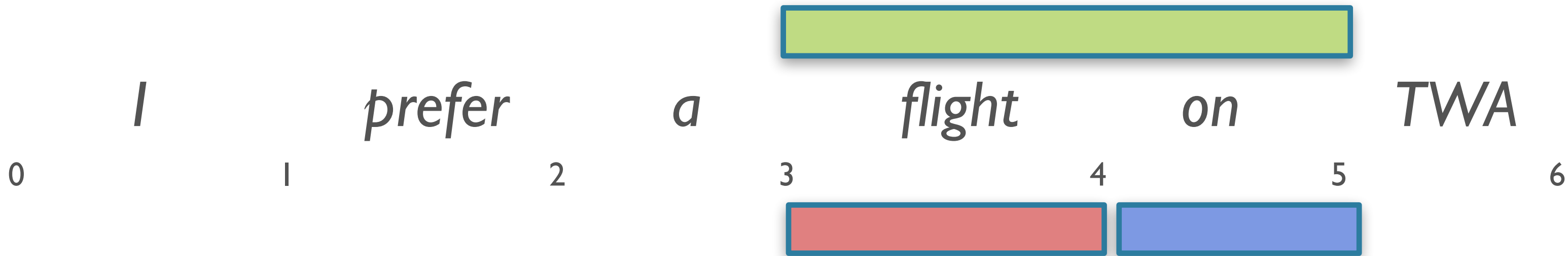$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]		
				Prep [4,5]	

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
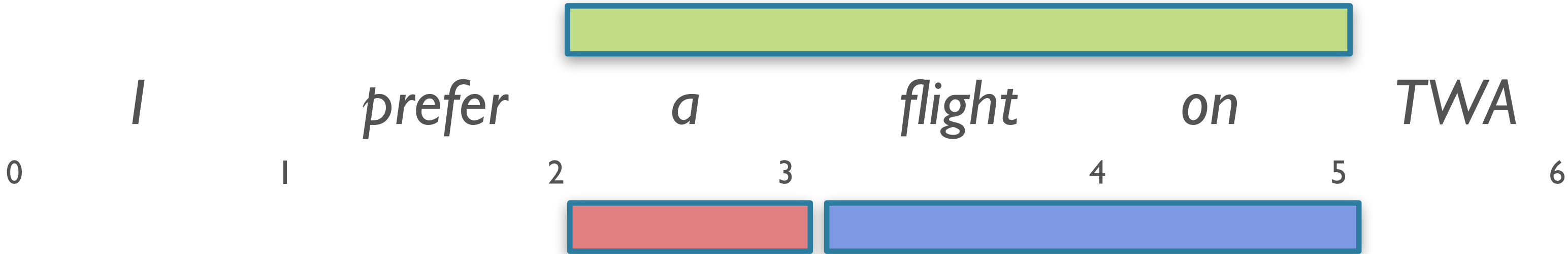$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]		
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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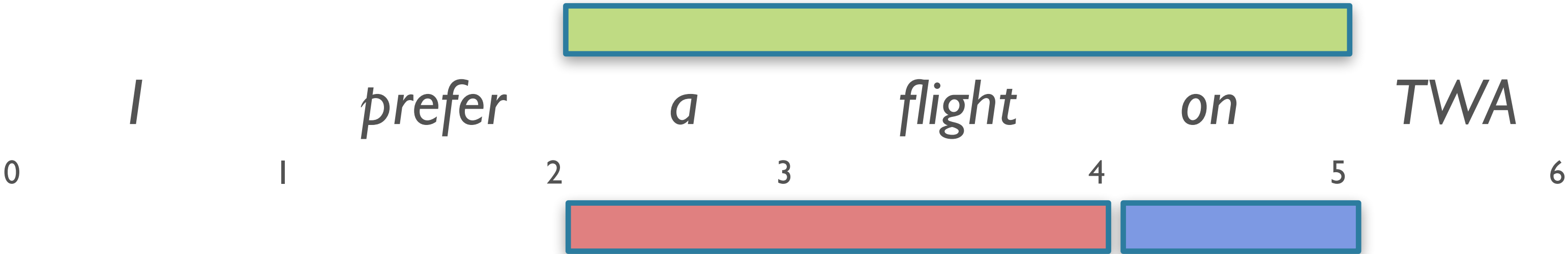$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]		
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
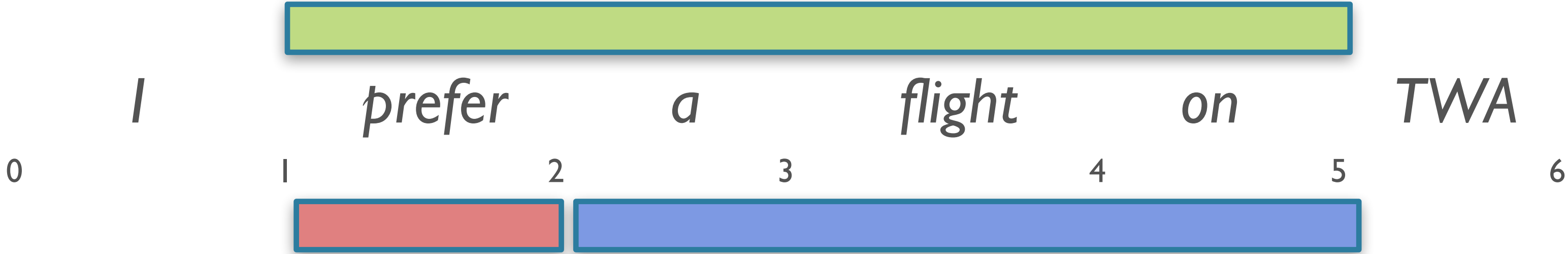$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	
	Det [2,3]	NP [2,4]	[2,5]	
		Noun, Nom [3,4]	[3,5]	
			Prep [4,5]	

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \to that\ |\ this\ |\ a$
$Noun \to book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \to I\ |\ she\ |\ me$
$Proper\text{-}Noun \to Houston\ |\ TWA$
$Aux \to does$
$Preposition \to from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \to book\ |\ include\ |\ prefer$

NP, Pronoun	S		S		
[0,1]	[0,2]	[0,3]	[0,4]		
	Verb, VP, S		VP, X2, S		
	[1,2]	[1,3]	[1,4]	[1,5]	
		Det	NP		
		[2,3]	[2,4]	[2,5]	
			Noun, Nom		
			[3,4]	[3,5]	
				Prep	
				[4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
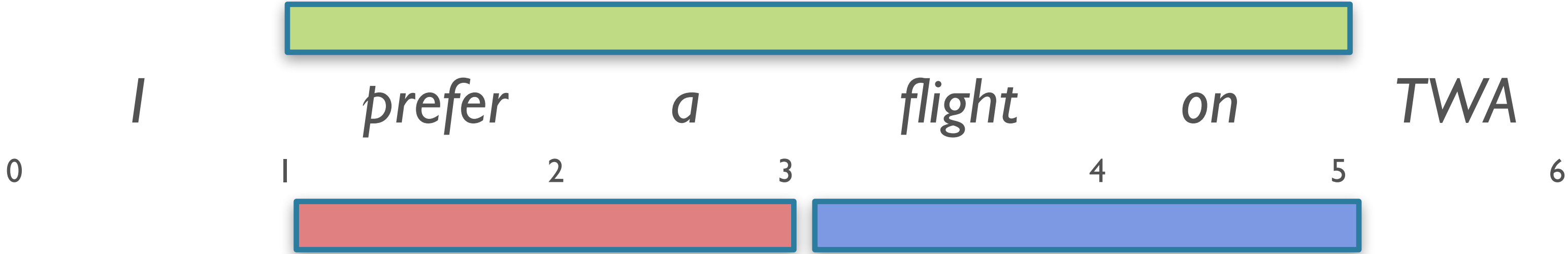$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
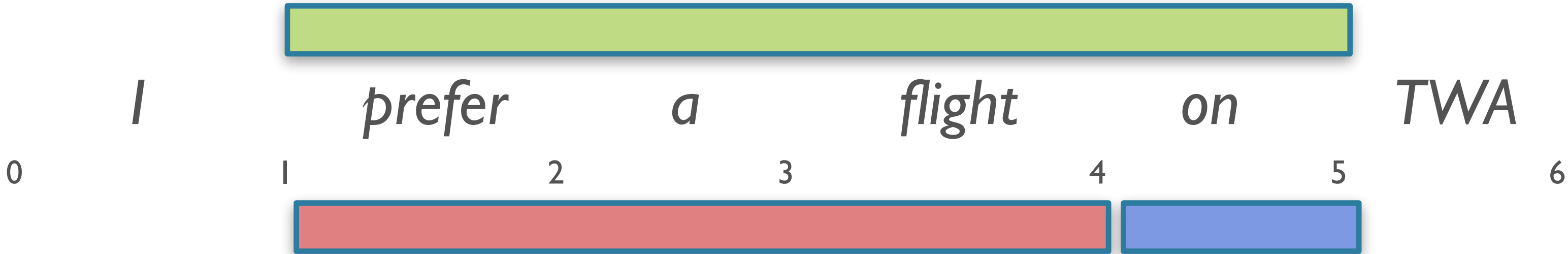$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]		
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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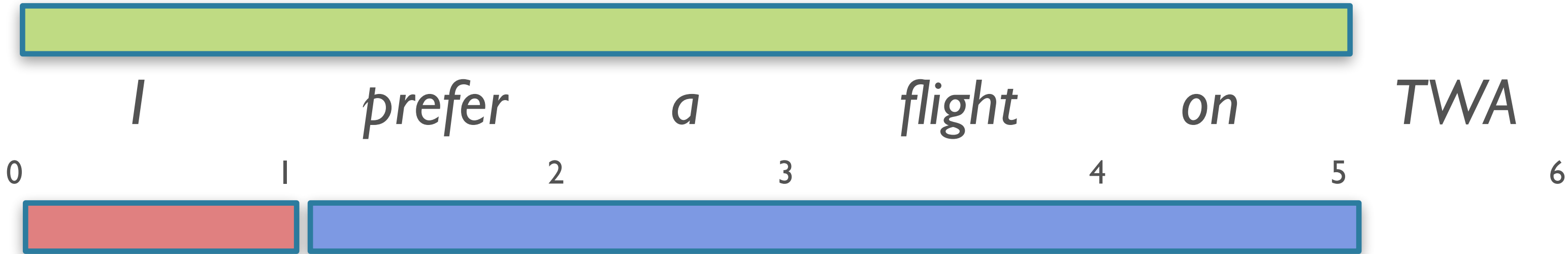$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]
			Noun, Nom [3,4]	[3,5]
				Prep [4,5]

I prefer a flight on TWA

0   1   2   3   4   5   6

ℒ₁ Grammar

S → NP VP
S → X1 VP
X1 → Aux NP
S → book | include | prefer
S → Verb NP
S → X2 PP
S → Verb PP
S → VP PP
NP → I | she | me
NP → TWA | Houston
NP → Det Nominal
Nominal → book | flight | meal | money
Nominal → Nominal Noun
Nominal → Nominal PP
VP → book | include | prefer
VP → Verb NP
VP → X2 PP
X2 → Verb NP
VP → Verb PP
VP → VP PP
PP → Preposition NP

Lexicon

Det → that | this | a
Noun → book | flight | meal | money
Pronoun → I | she | me
Proper-Noun → Houston | TWA
Aux → does
Preposition → from | to | on | near | through
Verb → book | include | prefer

NP, Pronoun	S		S		
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	Verb, VP, S		VP, X2, S		
	[1,2]	[1,3]	[1,4]	[1,5]	
		Det	NP		
		[2,3]	[2,4]	[2,5]	
			Noun, Nom		
			[3,4]	[3,5]	
				Prep	
				[4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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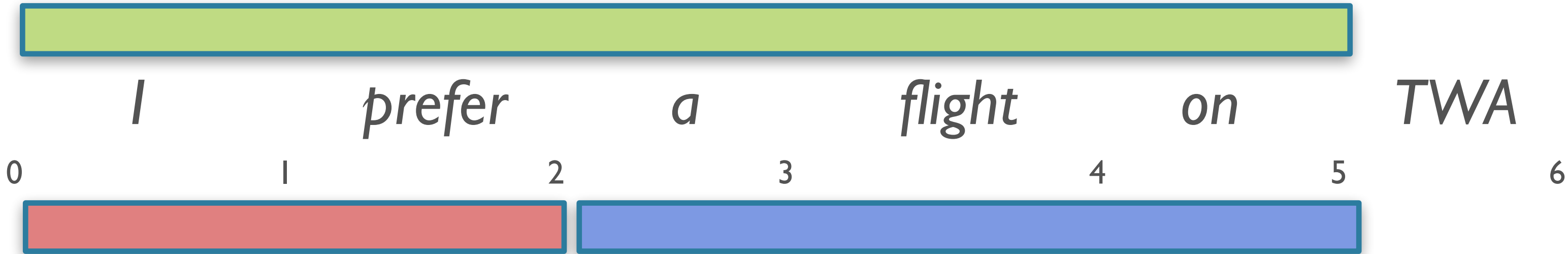$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$
- - - - - - - - - - - - - - - -
$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$
- - - - - - - - - - - - - - - -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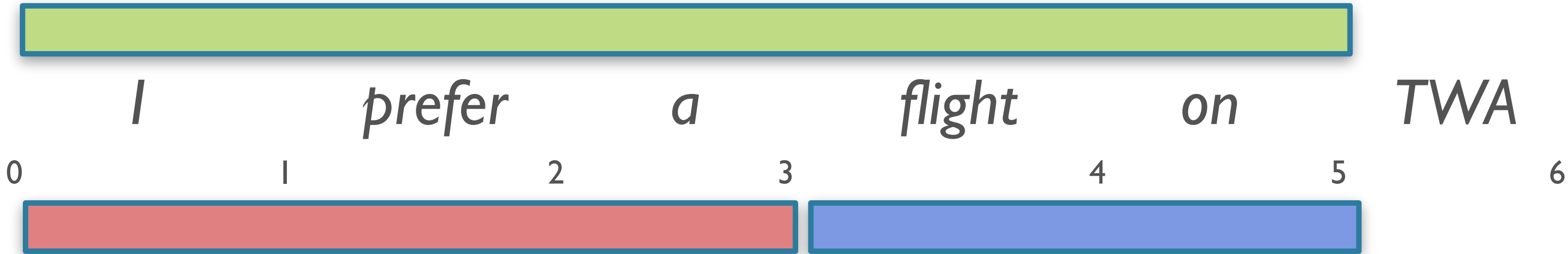$Nominal \rightarrow Nominal\ PP$
- - - - - - - - - - - - - - - -
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
- - - - - - - - - - - - - - - -
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
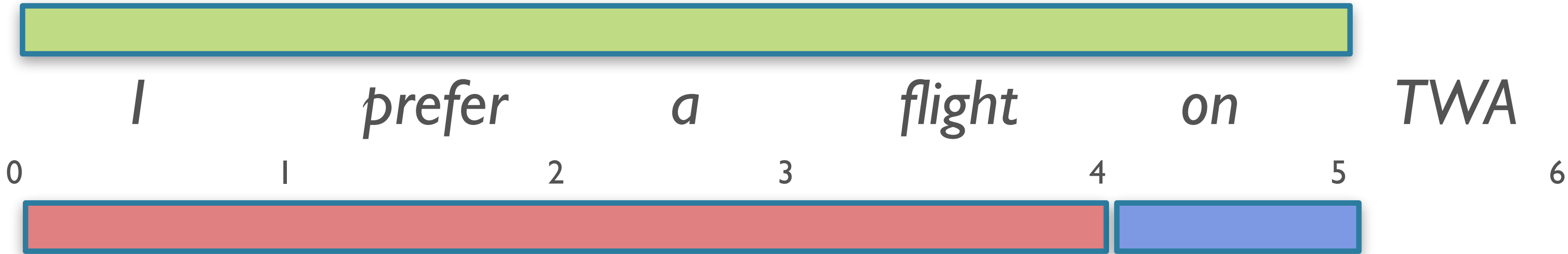$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
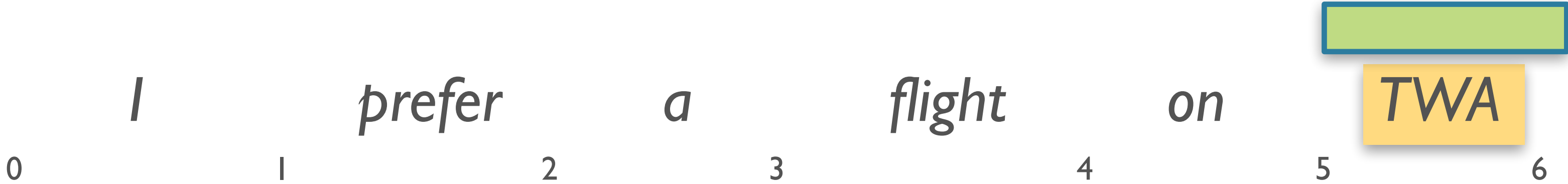$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
	Det [2,3]	NP [2,4]	[2,5]	
		Noun, Nom [3,4]	[3,5]	
			Prep [4,5]	

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

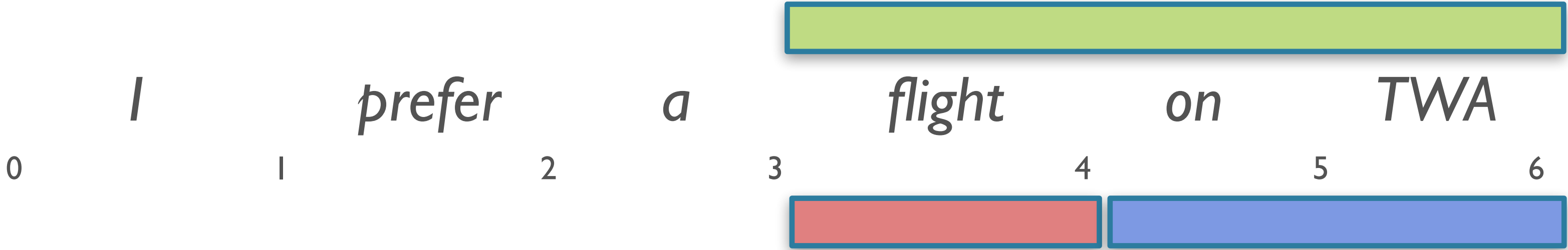| NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	
			Noun, Nom [3,4]	[3,5]	
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]		
	Det [2,3]	NP [2,4]	[2,5]		
		Noun, Nom [3,4]	[3,5]	Nom [3,6]	
			Prep [4,5]	PP [4,6]	
				NNP, NP [5,6]	

I   prefer   a   flight   on   TWA
0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
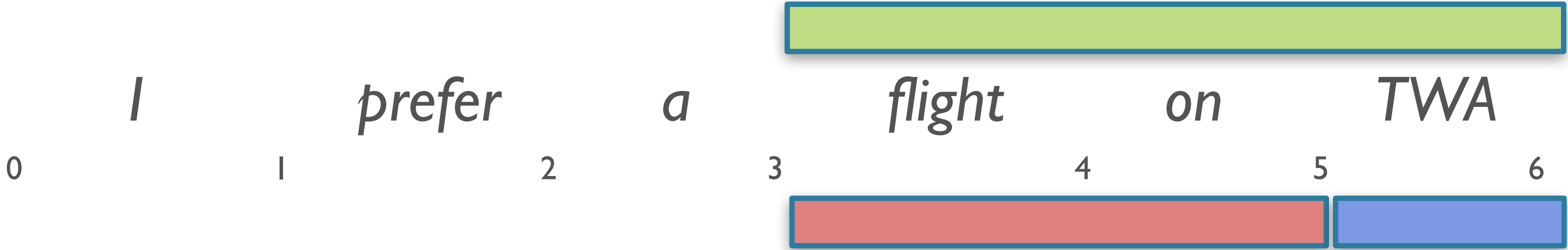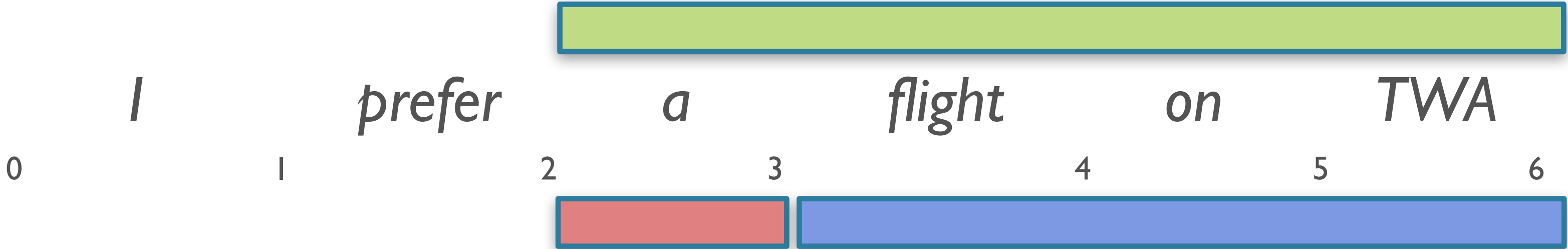$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]
		Det [2,3]	NP [2,4]	[2,5]
			Noun, Nom [3,4]	[3,5]
				Prep [4,5]

Additional cells: Nom [3,6], PP [4,6], NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
	Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
	Noun, Nom [3,4]	[3,5]	Nom [3,6]
		Prep [4,5]	PP [4,6]
			NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I prefer a flight on TWA
0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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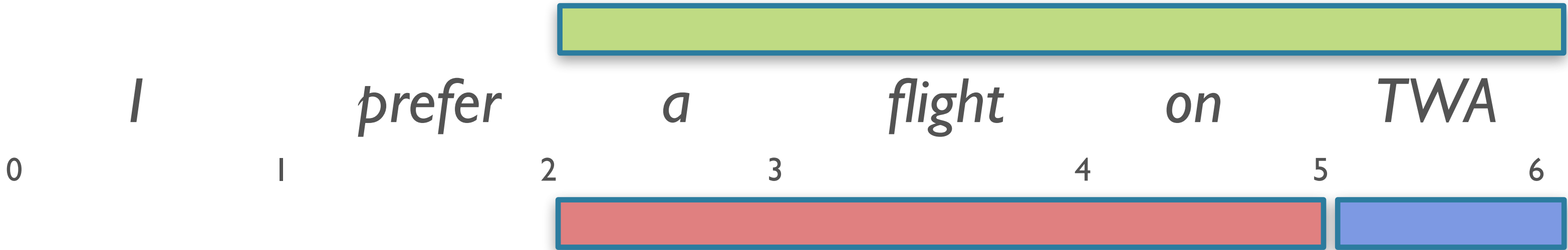$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
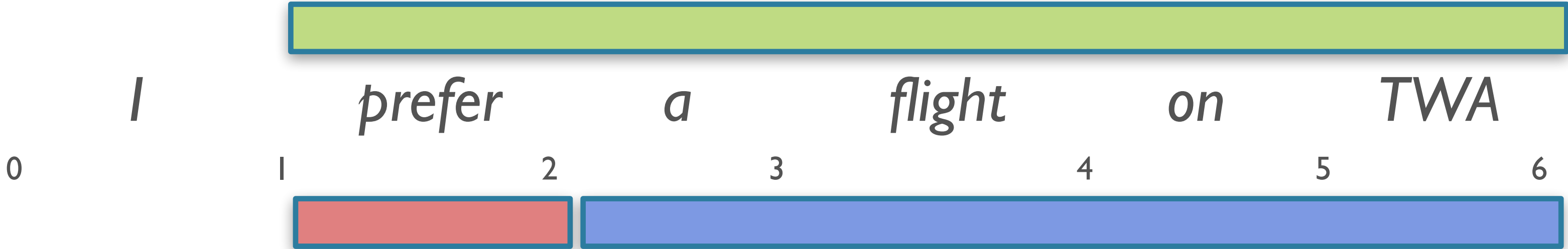$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	[1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
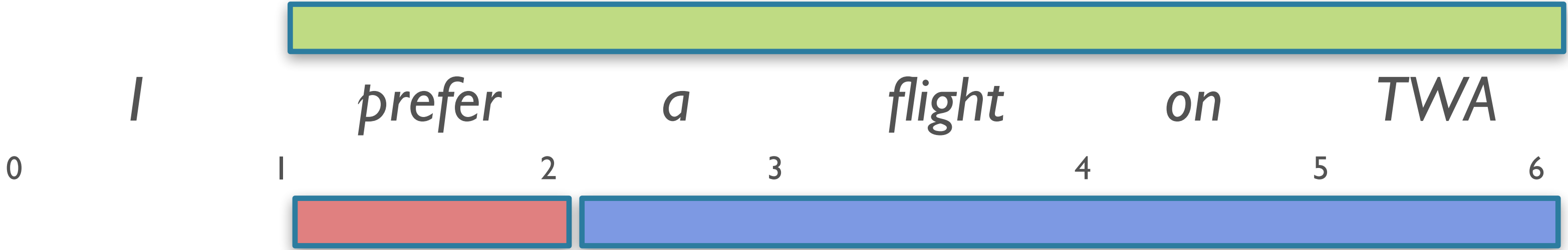$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

UNIVERSITY of WASHINGTON

$\mathcal{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun	S		S		
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	Verb, VP, S		VP, X2, S		VP, X2
	[1,2]	[1,3]	[1,4]	[1,5]	[1,6]
		Det	NP		NP
		[2,3]	[2,4]	[2,5]	[2,6]
			Noun, Nom		Nom
			[3,4]	[3,5]	[3,6]
				Prep	PP
				[4,5]	[4,6]
					NNP, NP
					[5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
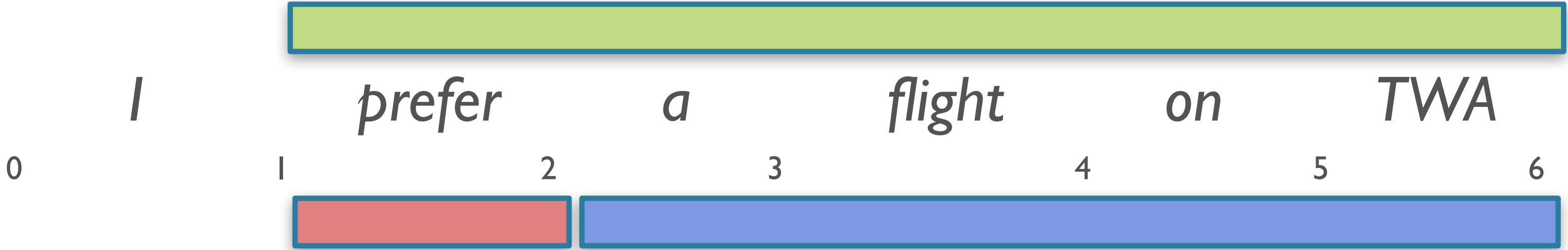$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
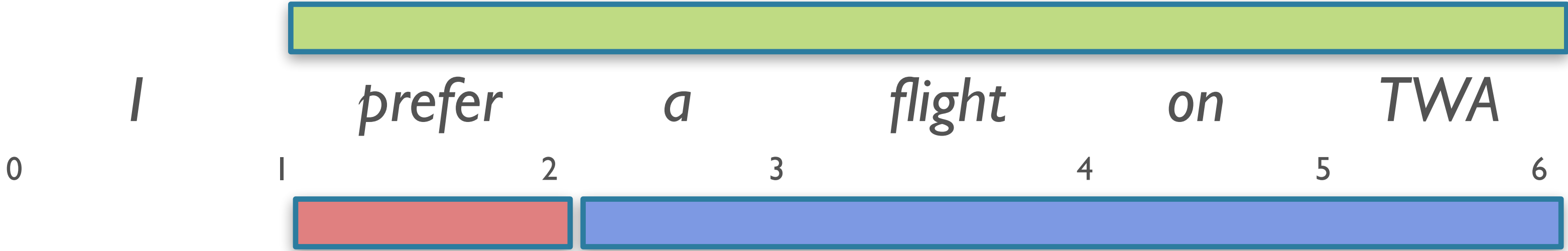$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
	Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
		Noun, Nom [3,4]	[3,5]	Nom [3,6]
			Prep [4,5]	PP [4,6]
				NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
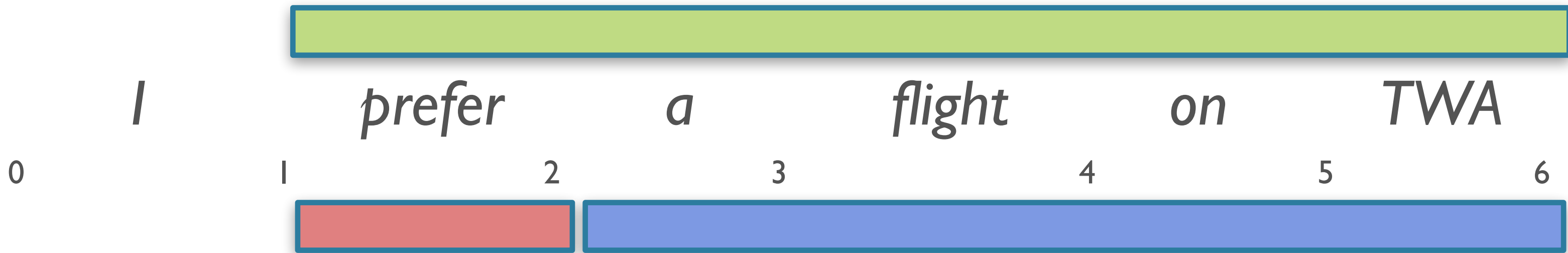$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun	S		S		
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	
	Verb, VP, S		VP, X2, S		VP, X2, S
	[1,2]	[1,3]	[1,4]	[1,5]	[1,6]
	Det	NP			NP
	[2,3]	[2,4]	[2,5]	[2,6]	
	Noun, Nom		Nom		
	[3,4]	[3,5]	[3,6]		
	Prep	PP			
	[4,5]	[4,6]			
	NNP, NP				
	[5,6]				

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
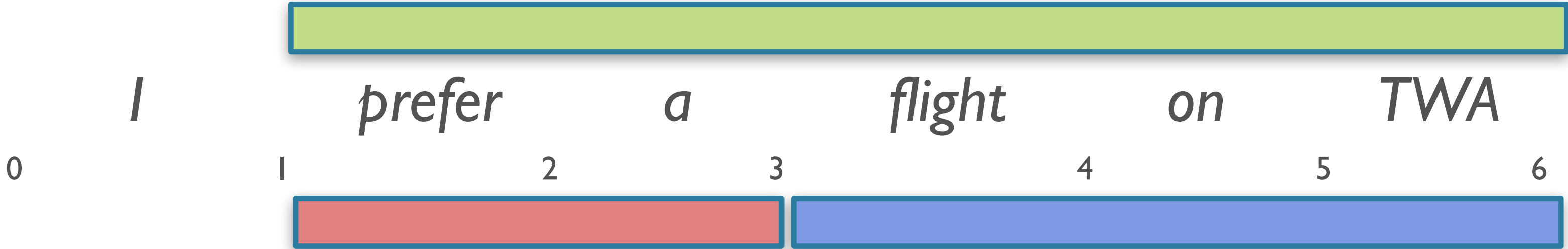$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
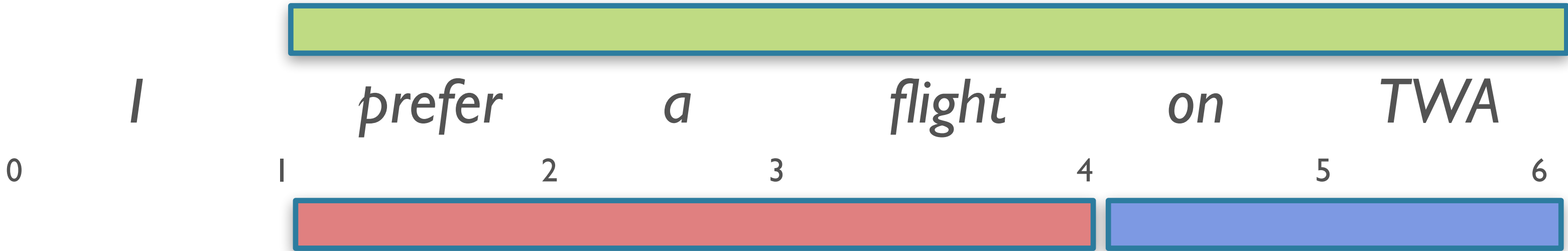$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

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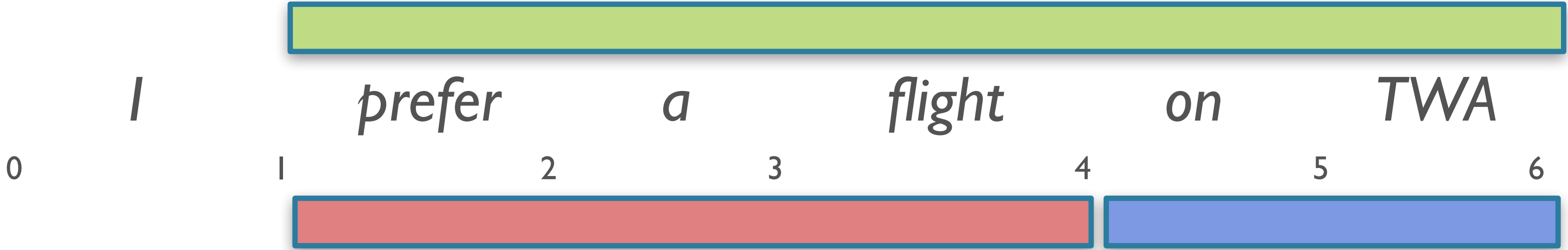$Nominal \rightarrow Nominal\ PP$
$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$
$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
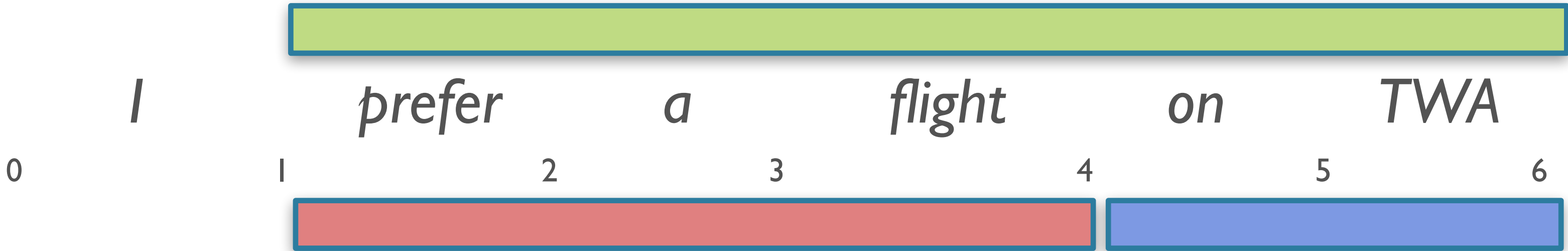$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
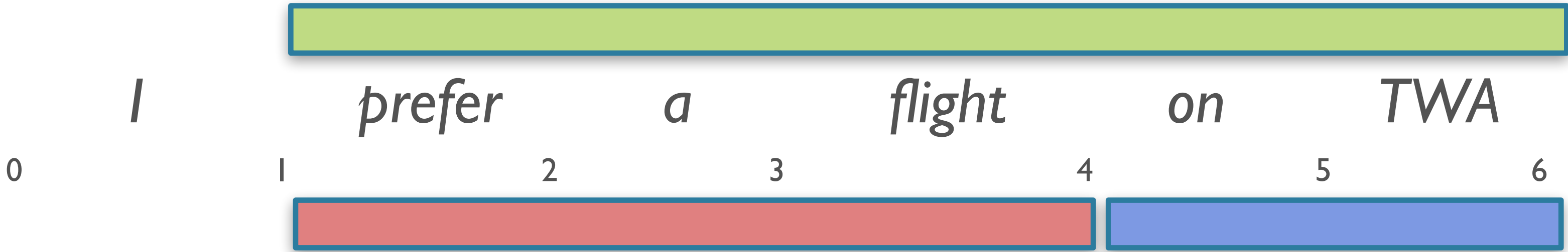$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	[0,6]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I prefer a flight on TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
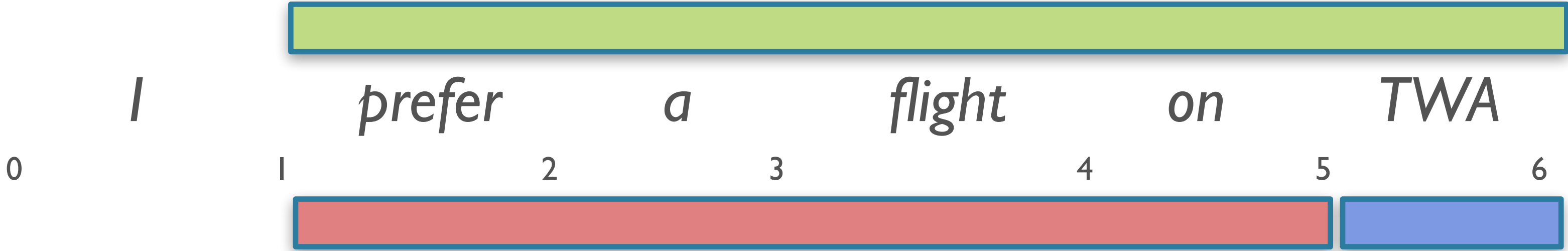$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
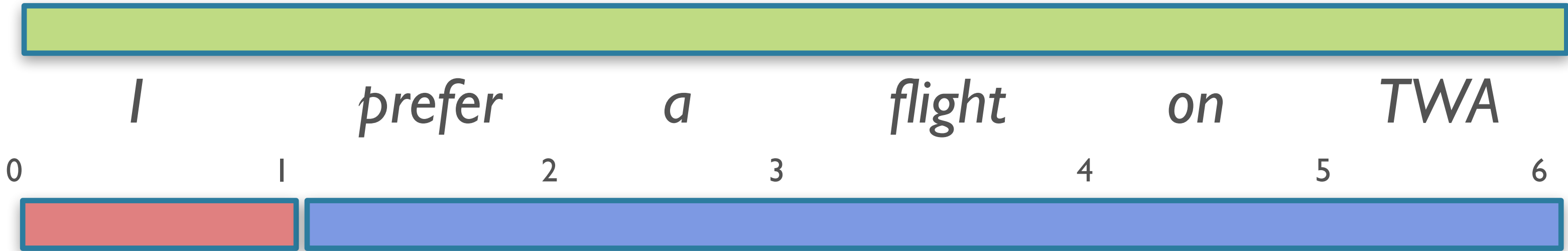$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun	S		S		
[0,1]	[0,2]	[0,3]	[0,4]	[0,5]	[0,6]
	Verb, VP, S		VP, X2, S		VP, X2, S
	[1,2]	[1,3]	[1,4]	[1,5]	[1,6]
		Det	NP		NP
		[2,3]	[2,4]	[2,5]	[2,6]
			Noun, Nom		Nom
			[3,4]	[3,5]	[3,6]
				Prep	PP
				[4,5]	[4,6]
					NNP, NP
					[5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow$ *NP* *VP*
$S \rightarrow X1 \ VP$
$X1 \rightarrow Aux \ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb \ NP$
$S \rightarrow X2 \ PP$
$S \rightarrow Verb \ PP$
$S \rightarrow VP \ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal \ Noun$
$Nominal \rightarrow Nominal \ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb \ NP$
$VP \rightarrow X2 \ PP$
$X2 \rightarrow Verb \ NP$
$VP \rightarrow Verb \ PP$
$VP \rightarrow VP \ PP$

$PP \rightarrow Preposition \ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
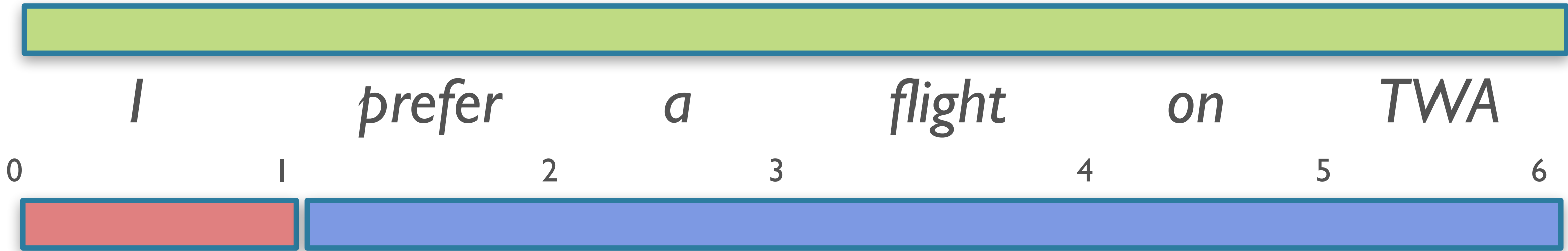$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	**S** [0,2]	[0,3]	**S** [0,4]	[0,5]	**S** [0,6]
	Verb, VP, S [1,2]	[1,3]	**VP, X2, S** [1,4]	[1,5]	**VP, X2, S** [1,6]
		Det [2,3]	**NP** [2,4]	[2,5]	**NP** [2,6]
			Noun, Nom [3,4]	[3,5]	**Nom** [3,6]
				Prep [4,5]	**PP** [4,6]
					NNP, NP [5,6]

I	prefer	a	flight	on	TWA
0	1	2	3	4	5	6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
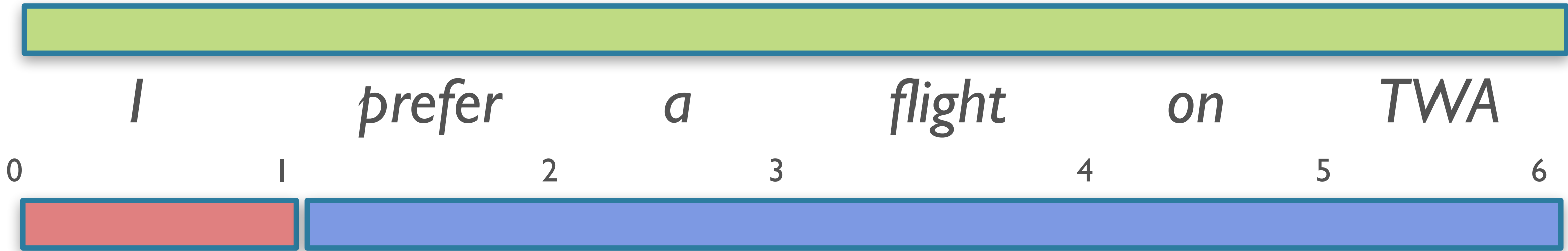$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	S [0,6]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathscr{L}_1$ Grammar

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

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	S [0,6]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book \mid include \mid prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

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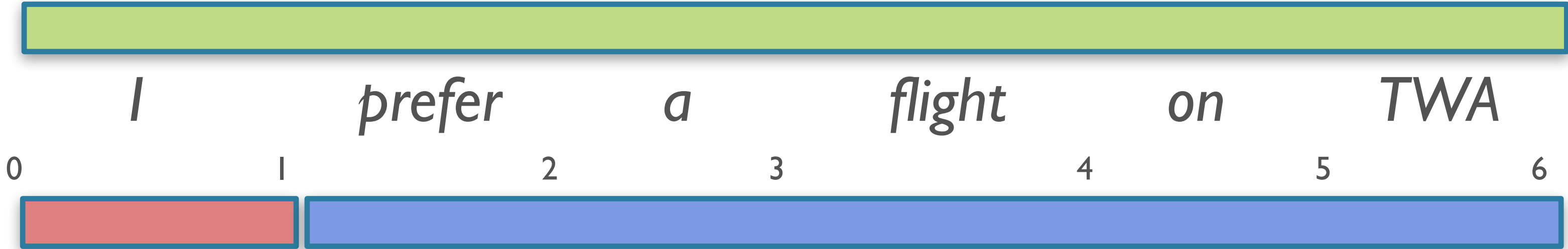$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book \mid flight \mid meal \mid money$
$Nominal \rightarrow Nominal\ Noun$
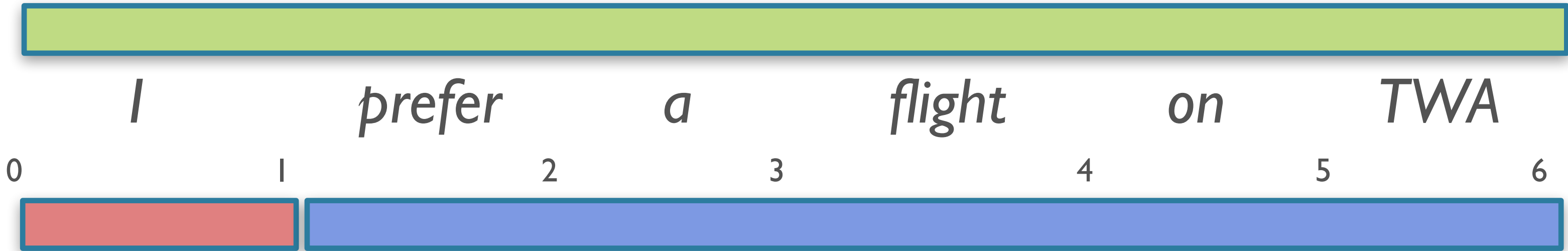$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book \mid include \mid prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that \mid this \mid a$
$Noun \rightarrow book \mid flight \mid meal \mid money$
$Pronoun \rightarrow I \mid she \mid me$
$Proper\text{-}Noun \rightarrow Houston \mid TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from \mid to \mid on \mid near \mid through$
$Verb \rightarrow book \mid include \mid prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	S [0,6]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

$\mathcal{L}_1$ Grammar

$S \rightarrow NP\ VP$
$S \rightarrow X1\ VP$
$X1 \rightarrow Aux\ NP$
$S \rightarrow book\ |\ include\ |\ prefer$
$S \rightarrow Verb\ NP$
$S \rightarrow X2\ PP$
$S \rightarrow Verb\ PP$
$S \rightarrow VP\ PP$

$NP \rightarrow I\ |\ she\ |\ me$
$NP \rightarrow TWA\ |\ Houston$
$NP \rightarrow Det\ Nominal$

$Nominal \rightarrow book\ |\ flight\ |\ meal\ |\ money$
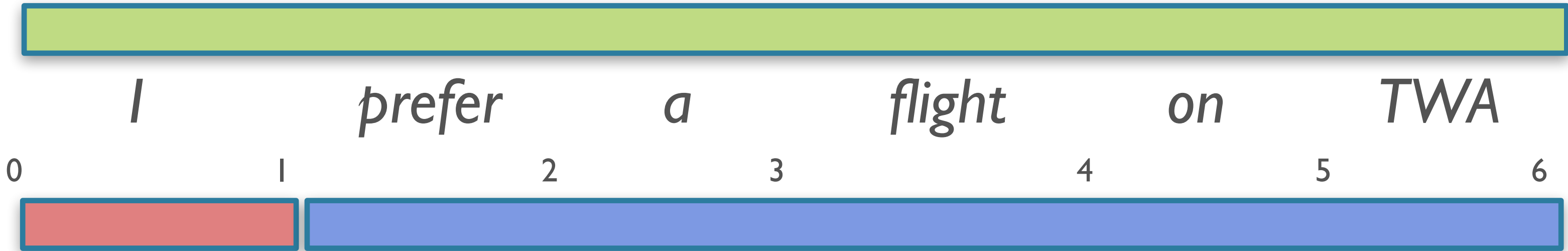$Nominal \rightarrow Nominal\ Noun$
$Nominal \rightarrow Nominal\ PP$

$VP \rightarrow book\ |\ include\ |\ prefer$
$VP \rightarrow Verb\ NP$
$VP \rightarrow X2\ PP$
$X2 \rightarrow Verb\ NP$
$VP \rightarrow Verb\ PP$
$VP \rightarrow VP\ PP$

$PP \rightarrow Preposition\ NP$

Lexicon

$Det \rightarrow that\ |\ this\ |\ a$
$Noun \rightarrow book\ |\ flight\ |\ meal\ |\ money$
$Pronoun \rightarrow I\ |\ she\ |\ me$
$Proper\text{-}Noun \rightarrow Houston\ |\ TWA$
$Aux \rightarrow does$
$Preposition \rightarrow from\ |\ to\ |\ on\ |\ near\ |\ through$
$Verb \rightarrow book\ |\ include\ |\ prefer$

NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	S [0,6]
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP, X2, S [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

I   prefer   a   flight   on   TWA

0   1   2   3   4   5   6

Current CKY Algorithm

Limitations:

Only stores non-terminals in cell

    Not rules or cells corresponding to RHS

  Stores SETS of non-terminals

    Multiple rules with same LHS collide

Currently only ***acceptance/recognition***

CKY *Parser*

- Pair each nonterminal with back-pointer to cells from which it was derived

- Last step:
  - construct trees from back-pointers in $[\ 0,\ n\ ]$

NP, Pronoun [0,1]	**S** [0,2]	[0,3]	**S** [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	**VP, X2, S** [1,4]	[1,5]	**VP** [1,6]
		Det [2,3]	**NP** [2,4]	[2,5]	**NP** [2,6]
			Noun, Nom [3,4]	[3,5]	**Nom** [3,6]
				Prep [4,5]	**PP** [4,6]
					NNP, NP [5,6]

$VP \rightarrow VP\ PP$

```
    bp_1 = BackPointer()
bp_1.l_child = [VP, (1,4)]
bp_1.r_child = [PP, (4,6)]
```

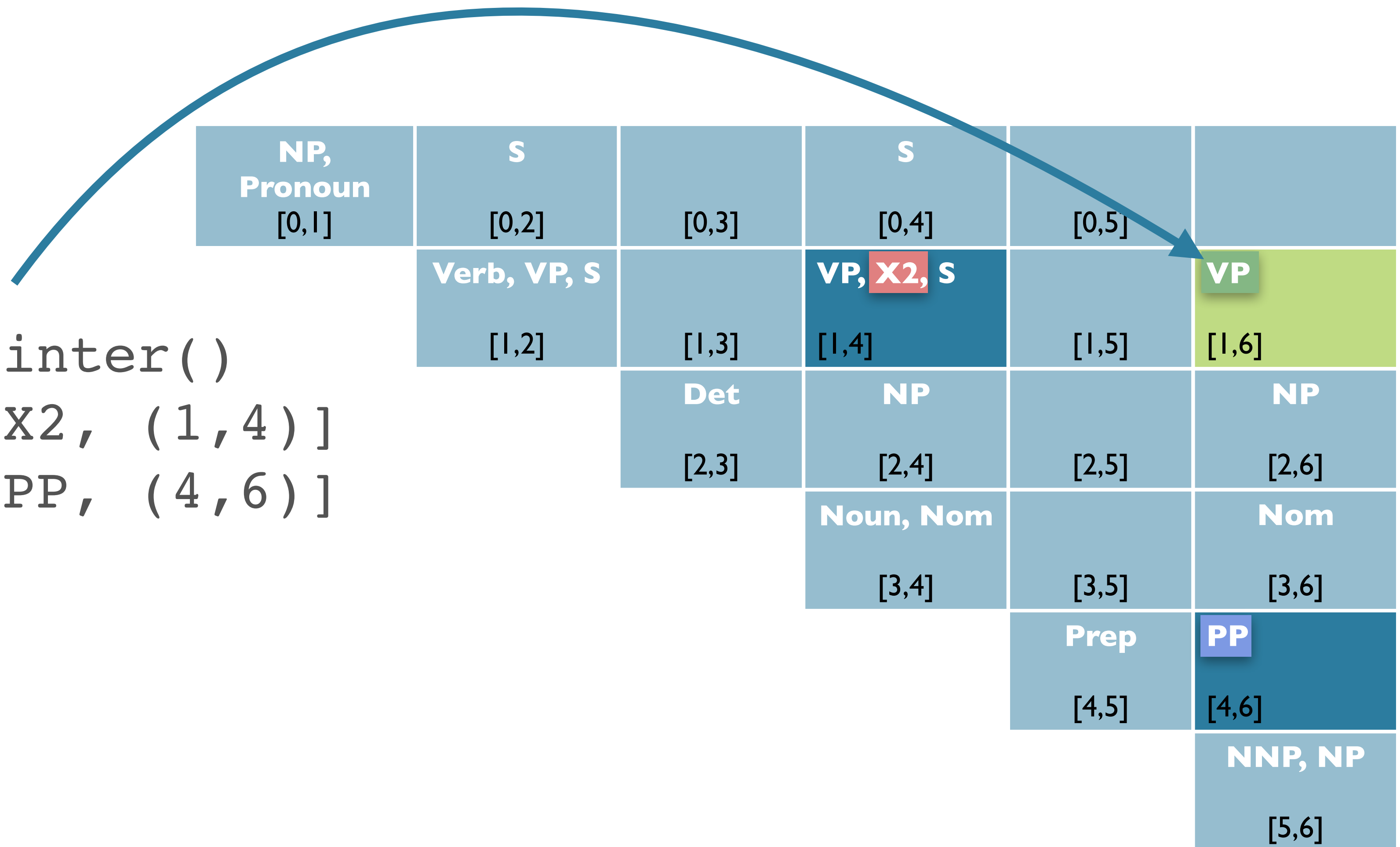| NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP [1,6]
	Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
		Noun, Nom [3,4]	[3,5]	Nom [3,6]
			Prep [4,5]	PP [4,6]
				NNP, NP [5,6]
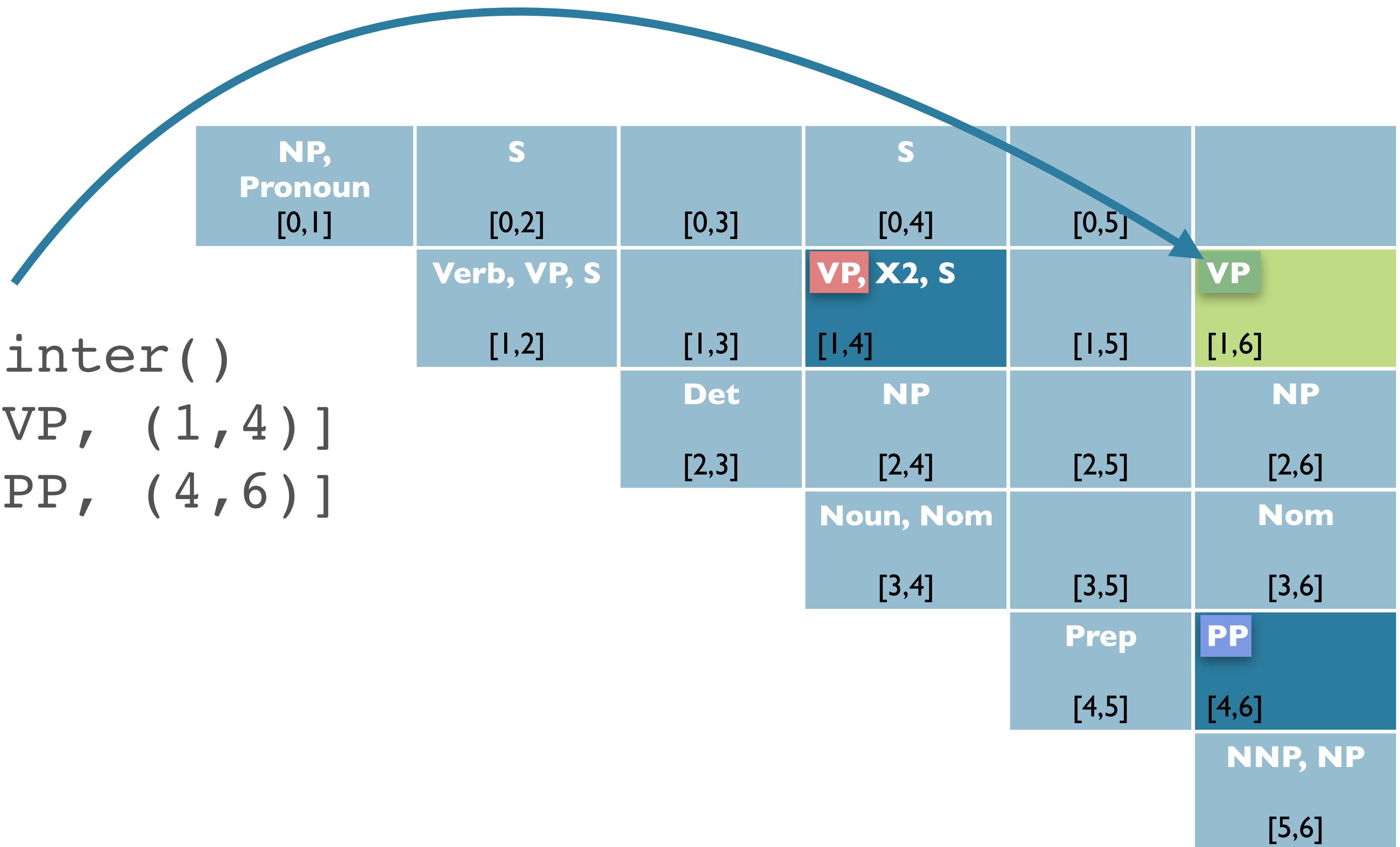
$VP \rightarrow X2\ PP$

```
   bp_2 = BackPointer()
bp_2.l_child = [X2, (1,4)]
bp_2.r_child = [PP, (4,6)]
```
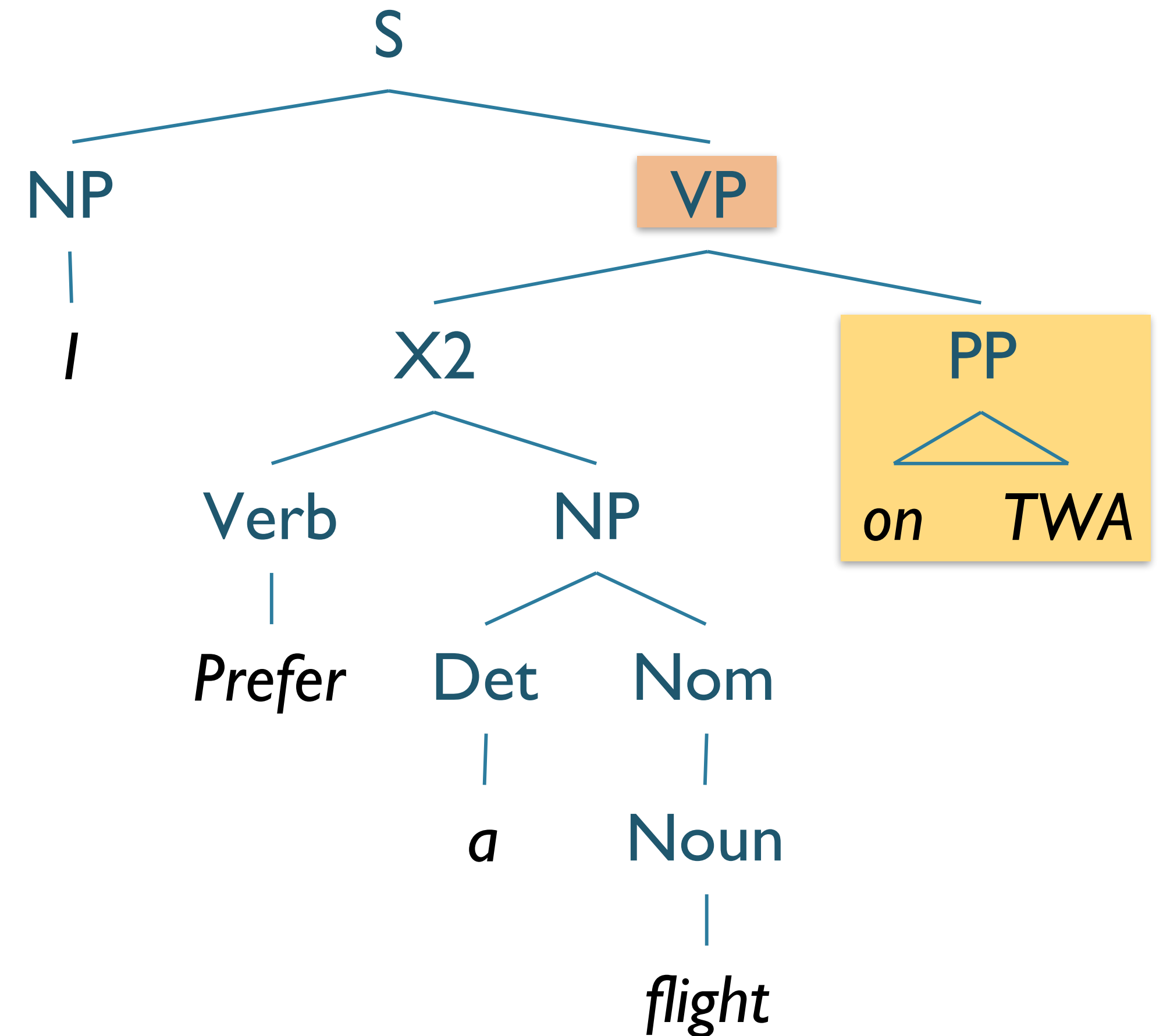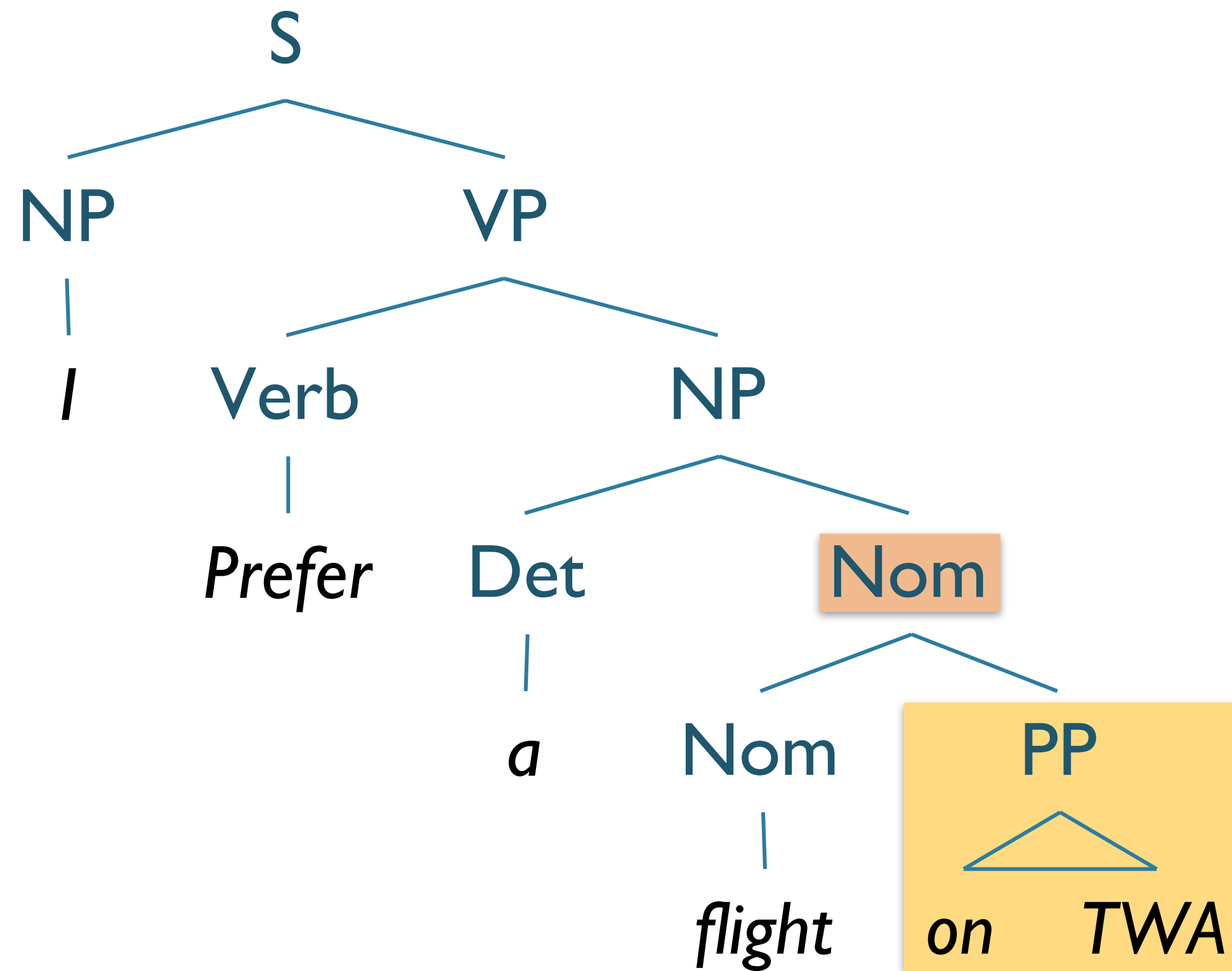
NP, Pronoun [0,1]	S [0,2]	[0,3]	S [0,4]	[0,5]	
	Verb, VP, S [1,2]	[1,3]	VP, X2, S [1,4]	[1,5]	VP [1,6]
		Det [2,3]	NP [2,4]	[2,5]	NP [2,6]
			Noun, Nom [3,4]	[3,5]	Nom [3,6]
				Prep [4,5]	PP [4,6]
					NNP, NP [5,6]

Resulting Parses

CKY Discussion

Running time:

$O(n^3)$ where n is the length of the input string

Inner loop grows as square of # of non-terminals

Expressiveness:

As implemented, requires CNF

Weak equivalence to original grammar

Doesn't capture full original structure

Back-conversion?

Can do binarization, terminal conversion

Unit productions requires change in CKY

Unit Testing

Unit Testing

- Strategy of testing individual pieces of code in isolation

- Helps ensure:

  - Basic functionality in isolation

  - Complex functionality when individual components are combined

- In many industry jobs, you can't commit code without unit tests!

Unit Testing in Python

- Many good tutorials on the web [here's one]

- In a nutshell:

```python
from unittest import TestCase

class longTests(TestCase):
 def test_three(self):
   length_3_rule = parse_productions('A -> B C D')
   target_rules = parse_productions('''A -> B _X0_
                                      _X0_ -> C D''')
   self.assertSetEqual(set(target_rules),
                       set(fix_long_rules(length_3_rule)))
```

Unit Testing in Python

- "nose" is a test running framework that will detect all `test_*` method functions

`python3 -m nose hw2.py`

Unit Testing in Python

- "nose" is a test running framework that will detect all `test_*` method functions

`python3 -m nose hw2.py`

```
AssertionError: Items in the first set but not the second:
A -> B _X0_
_X0_ -> C D
Items in the second set but not the first:
A -> B C
-------------------------------------------------------------
Ran 12 tests in 0.040s

FAILED (failures=1)
```

Unit Testing

- Good practice:

  - Save input that crashes your program for a unit test

- Other popular unit testing frameworks for python (e.g. in 574):

  - pytest: https://docs.pytest.org/