Phrasal Weight Effect on Word Order

light-before-heavy vs. heavy-before-light

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- What about heavy-before-light?

Outline

1. Introduction: light-before-heavy preference

2. Heavy how?
   - Weight measured in length
   - Weight measured in distance
   - Weight measured in memory cost

3. What about heavy before light?

Light-before-heavy: English Particle verb

- English particle verb construction (PV)

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(1) a. Chris put on [$_{DP}$ a hat which Alex made with merino wool].

b. Chris put [$_{DP}$ a hat which Alex made with merino wool] on.

Light-before-heavy: English HNPS

- English heavy NP shift

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(2) a. Max put [DP boxes] [PP in his car].

Light-before-heavy: English HNPS

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(2) a. Max put [DP boxes] [PP in his car].

b. ??Max put [PP in his car] [DP boxes].

Light-before-heavy: English HNPS

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(2) a. Max put [DP boxes] [PP in his car].

b. ??Max put [PP in his car] [DP boxes].

c. HNPS Max put [PP in his car] [DP all the boxes of home furnishings].

Light-before-heavy: English HNPS

- English heavy NP shift

(2) a. Max put [DP boxes] [PP in his car].

b. ??Max put [PP in his car] [DP boxes].

c. HNPS Max put [PP in his car] [DP all the boxes of home furnishings].

d. ?Max put [DP all the boxes of home furnishings] [PP in his car].

Light-before-heavy: English HNPS

- Non-decreasing weight (Wasow 1997)

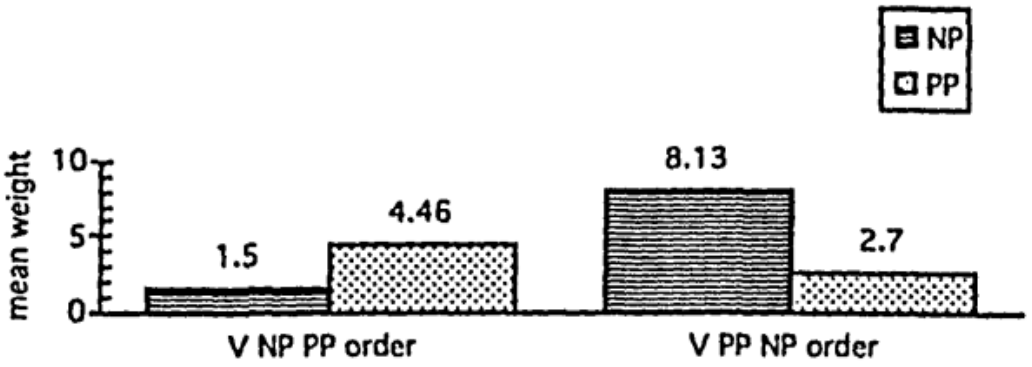

FIGURE 5. Mean weights in HNPS (in phrasal nodes).

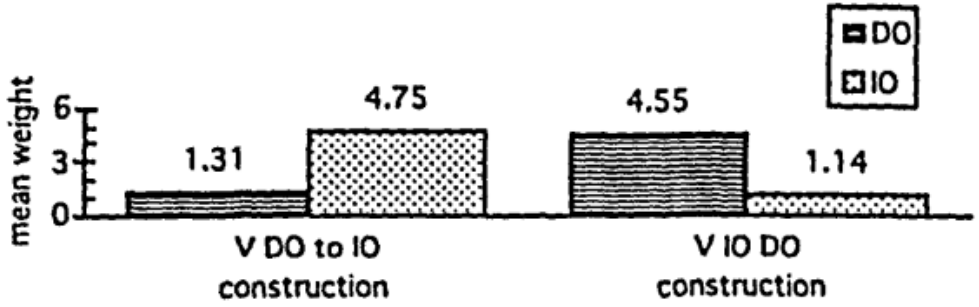

FIGURE 6. Mean weights in DA (in phrasal nodes).

Light-before-heavy: Mandarin *ba*

(3) a. Zhangsan ba [DP daocha] fang (le) [PP zai yong tanmu zhizuo
Z. ba knife.fork put (LE) on use sandalwood make
de zhuozi-shang]
DE table-top

b. Zhangsan [PP zai yong tanmu zhizuo de zhuozi-shang] fang
Z. on use sandalwood make DE table-top put
(le) [DP daocha]
(LE) knife.fork
'Z put a set of knife and fork on the table that is made of sandalwood.'

Light-before-heavy: Mandarin *ba*

(4) Zhangsan ba [DP daocha] [vP fang (le) [PP zai zhuozi-shang]]
Z. ba knife.fork put (LE) on table-top
'Z put of knife and fork on the table.'

	DP	vP	
Mean number of characters	4.73	6.82	$p < 0.001$
Mean number of phrases	3.1	4.8	$p < 0.001$
Mean subtree height	4.3	5.3	$p < 0.001$

Table 1: Mean weight values of ba sentences extracted from Chinese Treebank 8.0 (Liu 2022)

Weight measured in length

- A phrase is heavy when...
  - Production: 5-word or 10-word DP, more HNPS order (Stallings et al. 1998)
  - Reading time: 9-word DP, longer reading time in PV separated order (e.g., look...up) (Gonnerman and Hayes 2005)
  - Corpus frequency: 11+ Characters, more likely occurs in a *ba* construction (Liu 2007)
- But...

(5) a. Max put [$_{DP}$ a box which Chris carefully packed] in the car.

b. Max put [$_{DP}$ a very very very heavy box] in the car.

Weight measured in recognition distance

(6) HNPS and constituent recognition distance

adapted from (Hawkins 1994, 57)

a. I [$_{VP}$ gave [[$_{DP}$ the old book that was very difficult to find] [[$_{PP}$ to Mary]].
1 2 3 4 5 6 7 8 9 10 11

b. I [$_{VP}$ gave [[$_{PP}$ to Mary] [[$_{DP}$ the old book that was very difficult to find]].
1 2 3 4

Weight measured in recognition distance

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c. I [$_{VP}$ gave [[$_{PP}$ to Mary] [[$_{DP}$ the very ... very very very very old book]].
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1 2 3 4

d. I [$_{VP}$ gave [[$_{PP}$ to Mary] [[$_{DP}$ the old book]].
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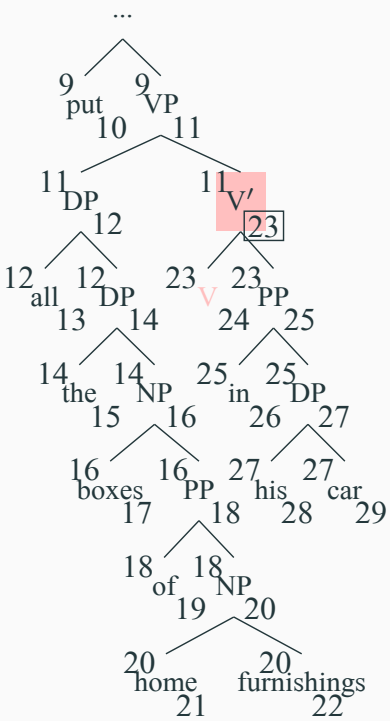
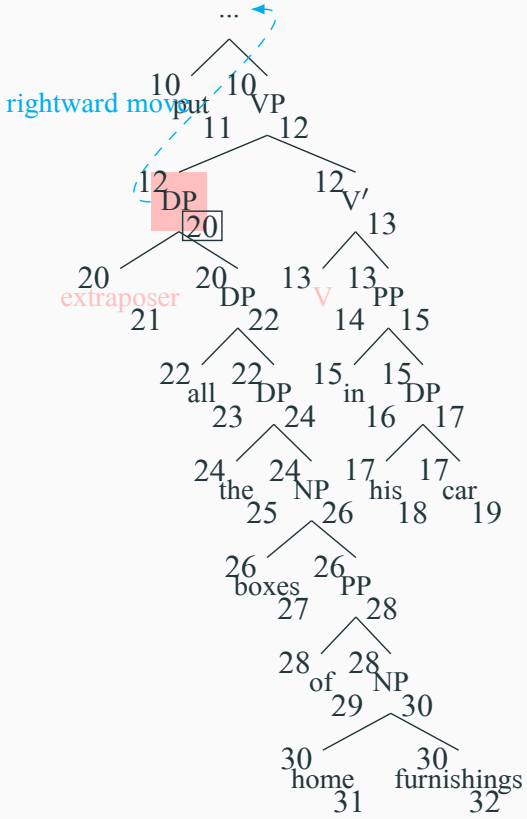
Weight measured in memory cost - HNPS

(7) put [DP ...boxes...] [PP in...]
canonical order



(8) put [PP in...] [DP ...boxes...]
HNPS order



Weight measured in memory cost - toy sentence 1

(9) • C Max T v packed boxes.

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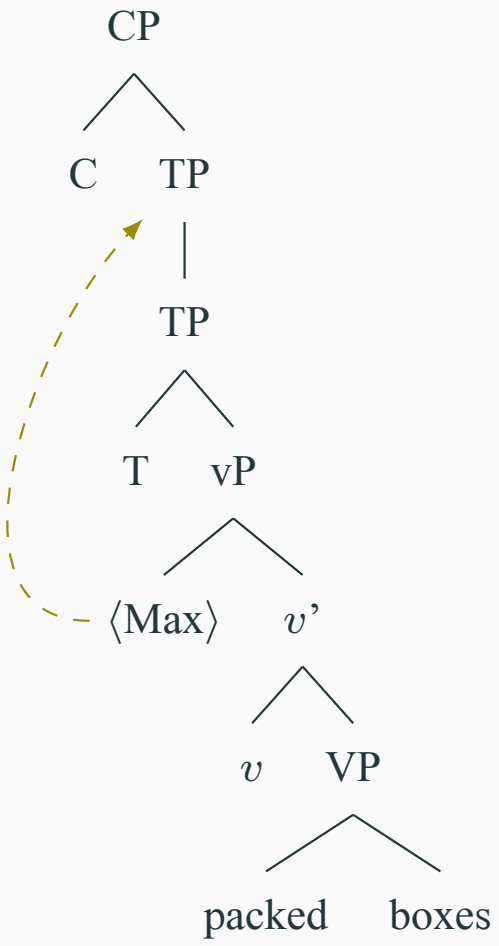

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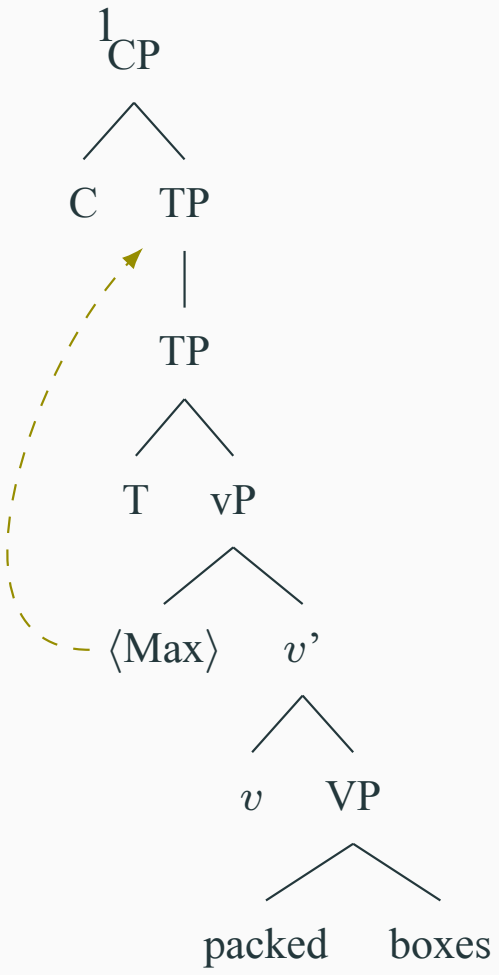

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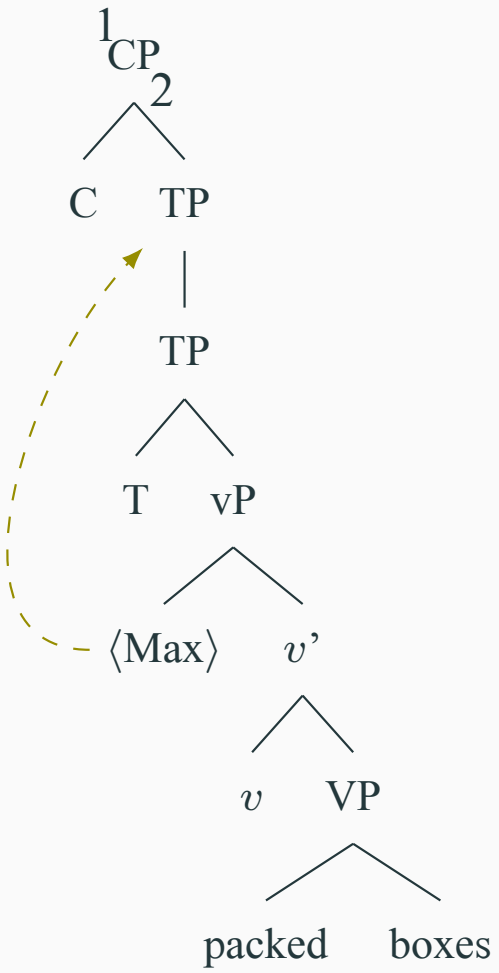

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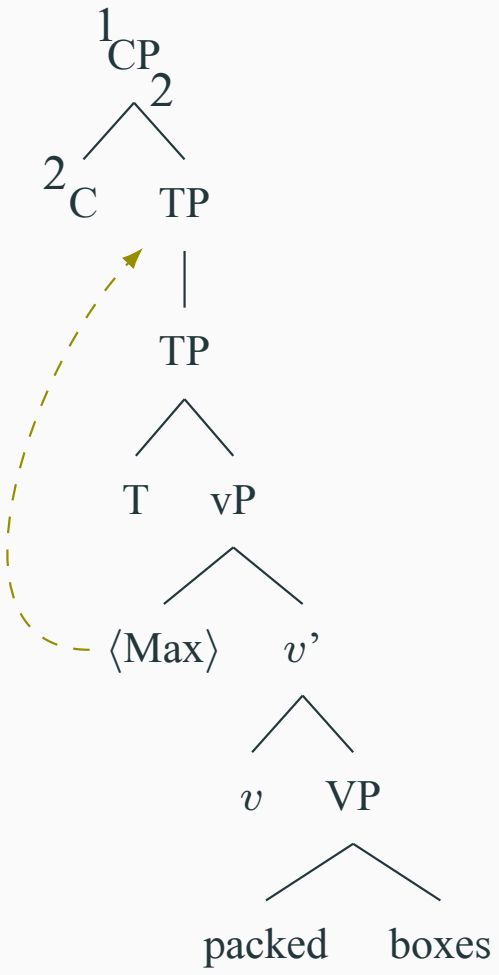

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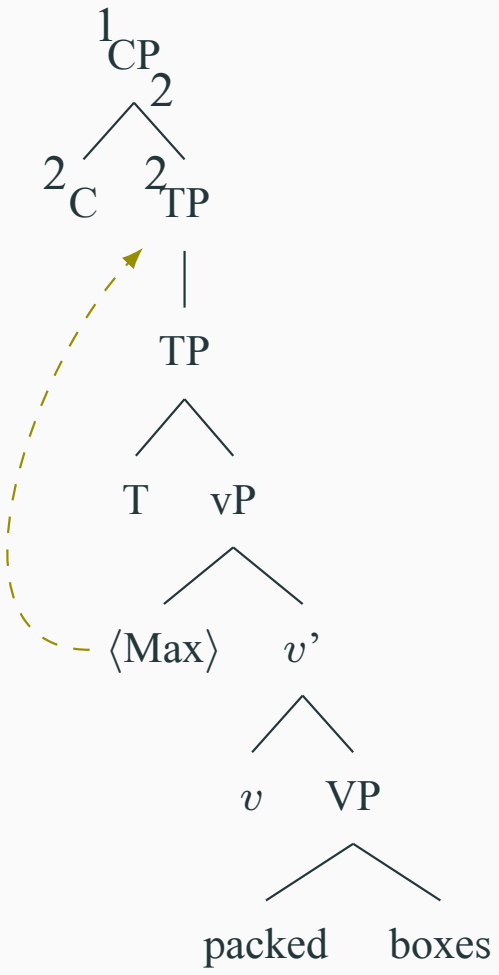

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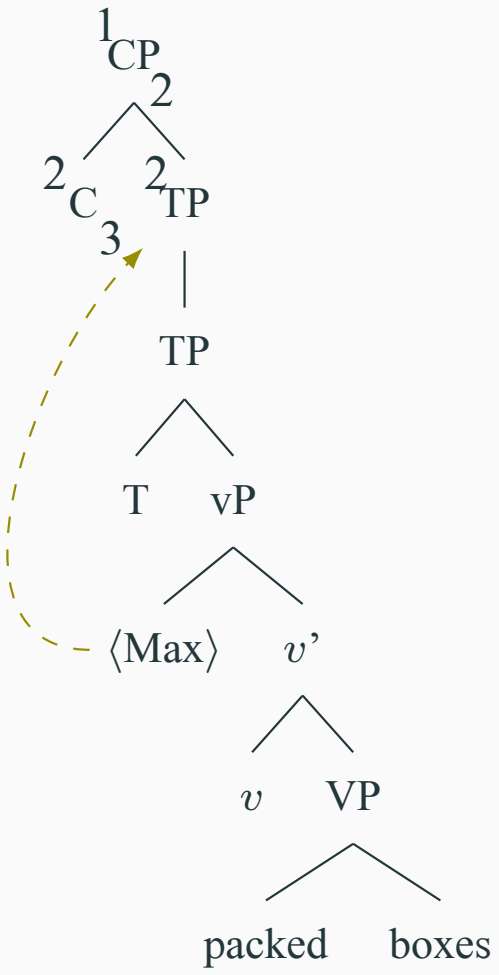

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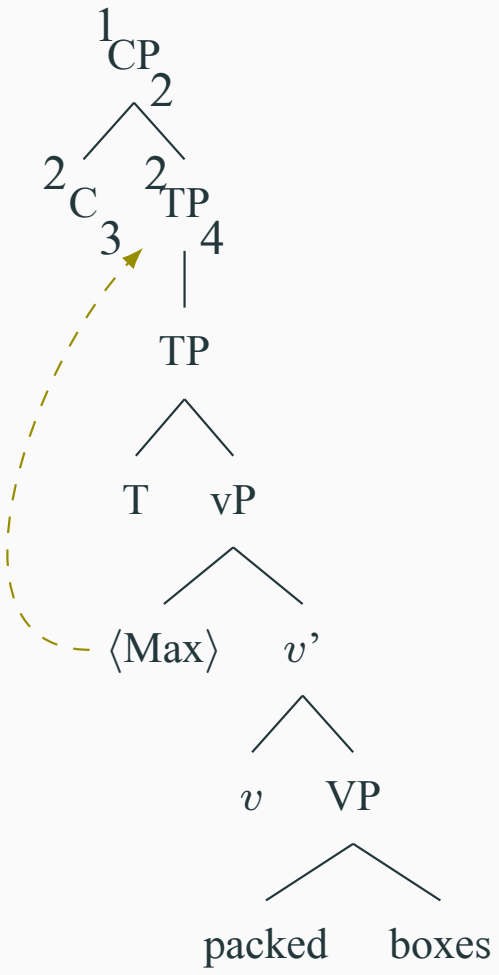

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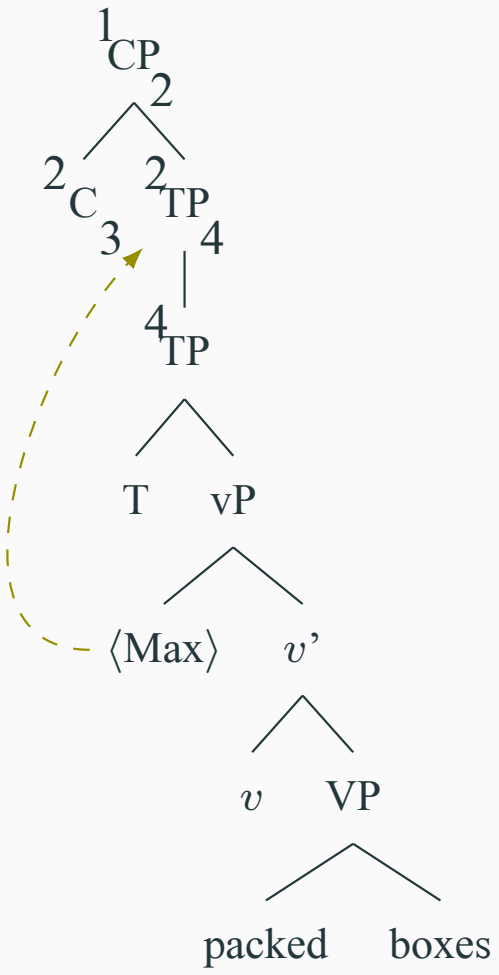

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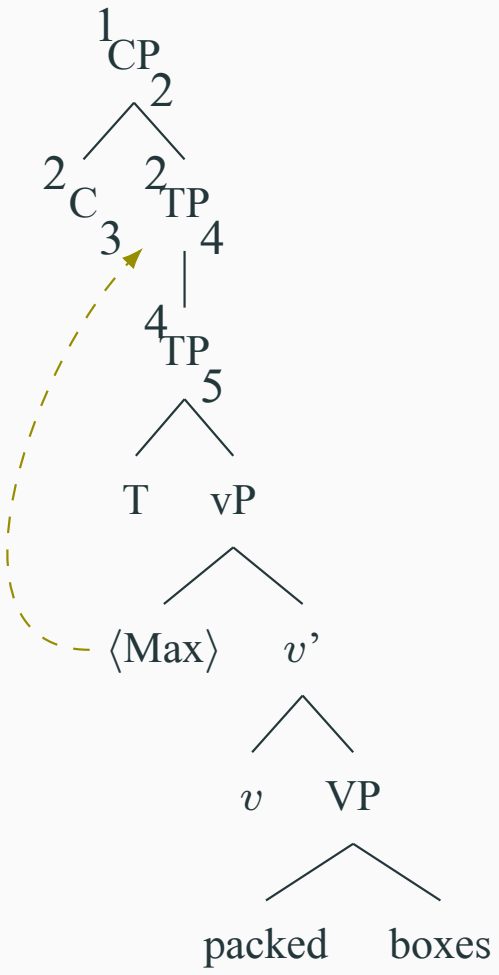

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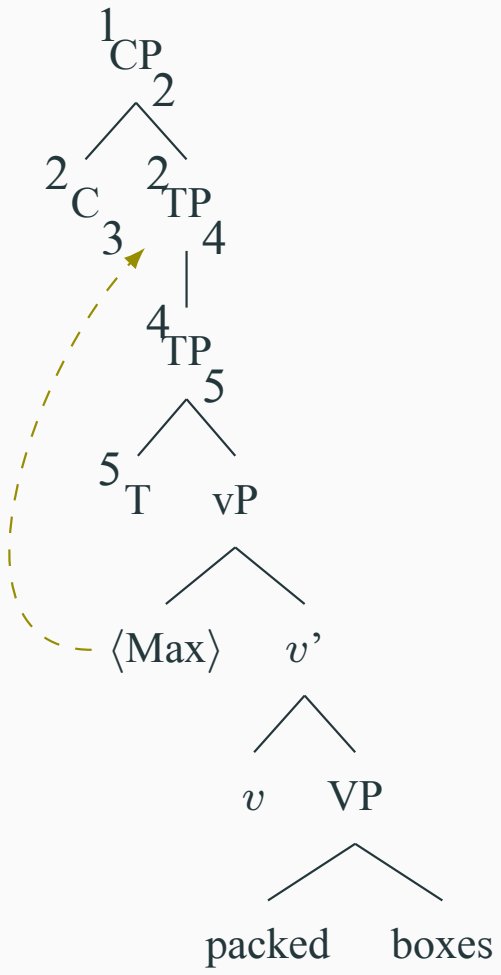

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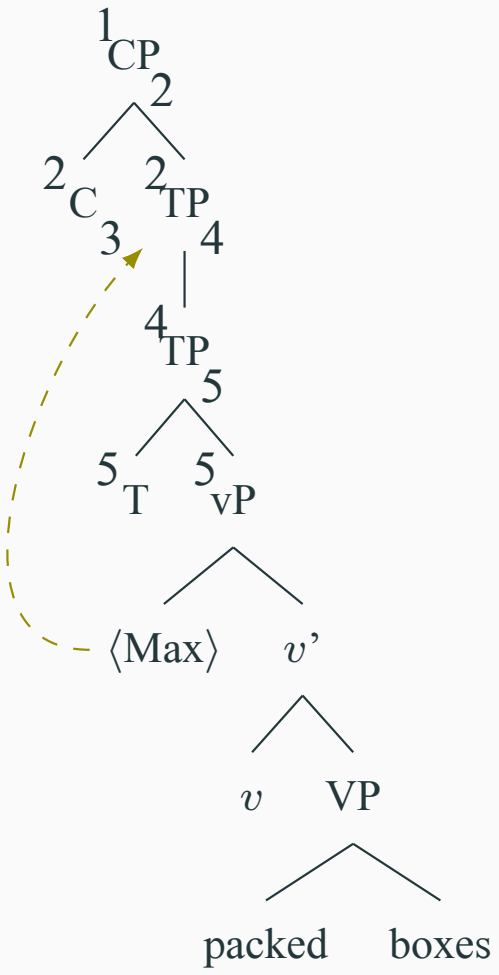

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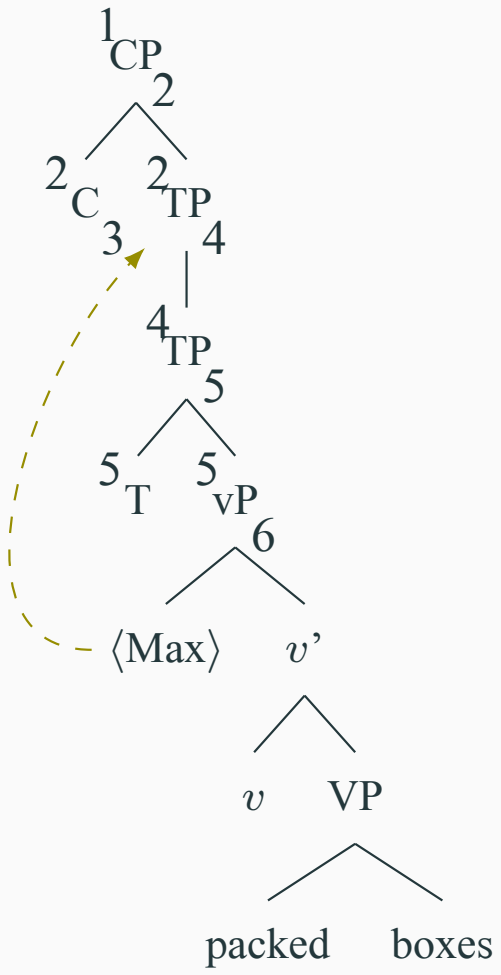

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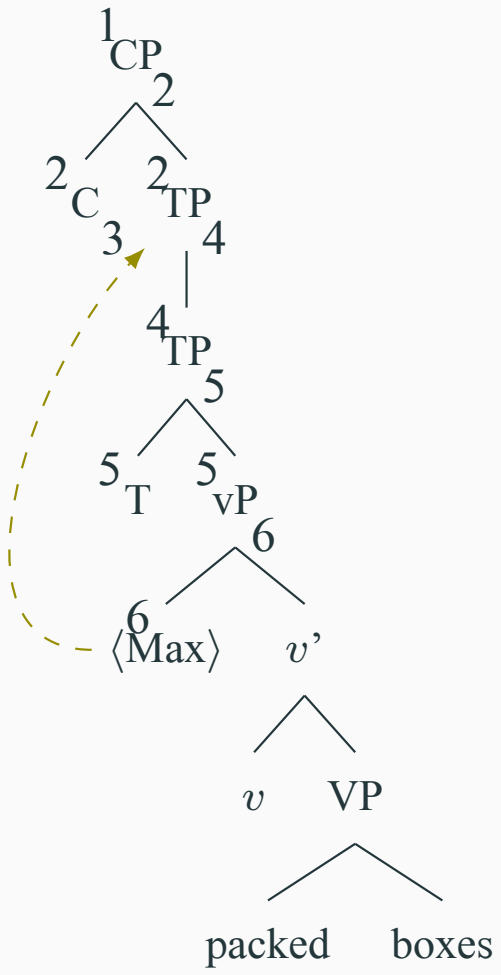

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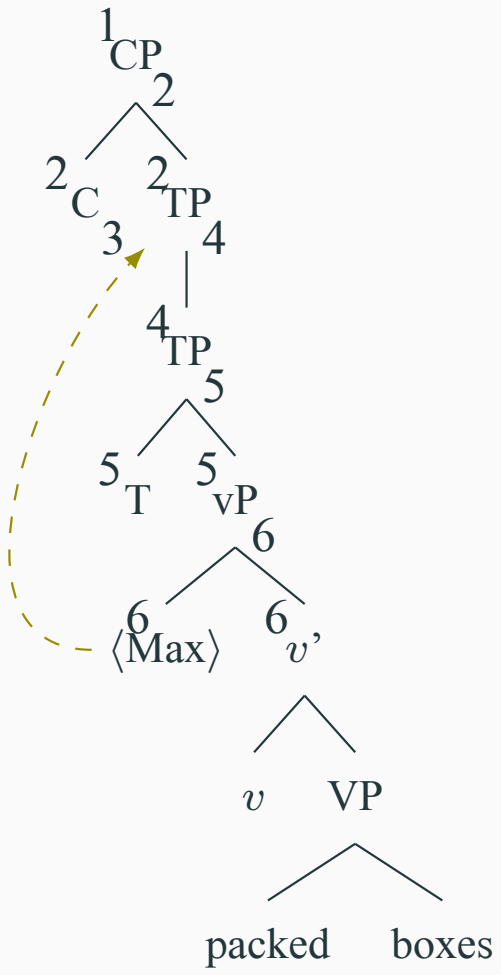

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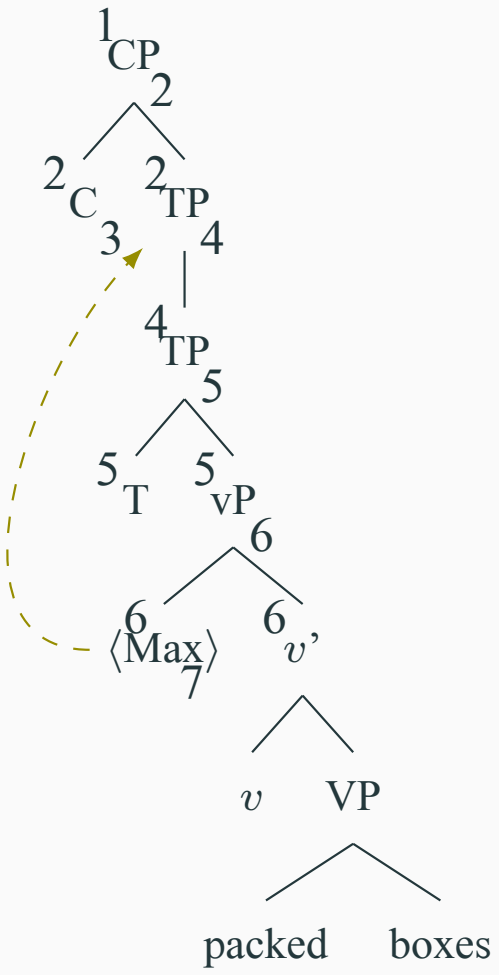

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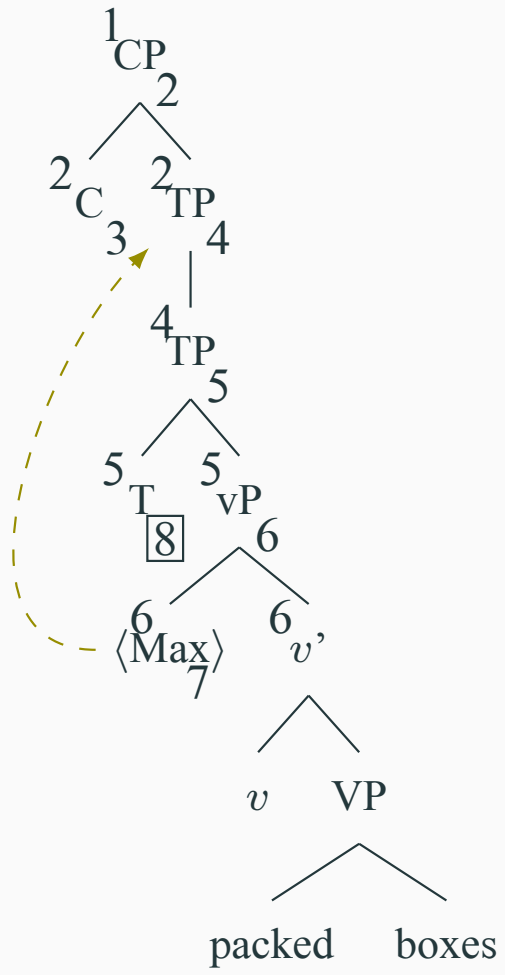

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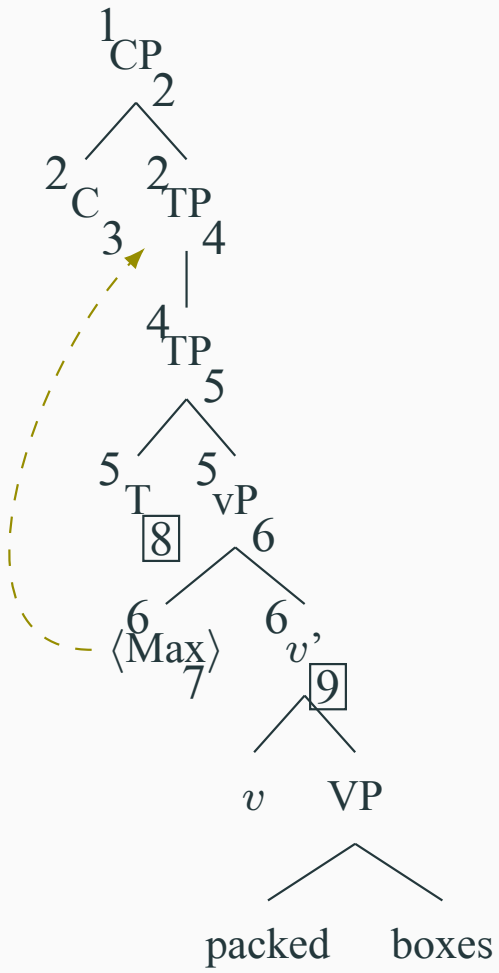

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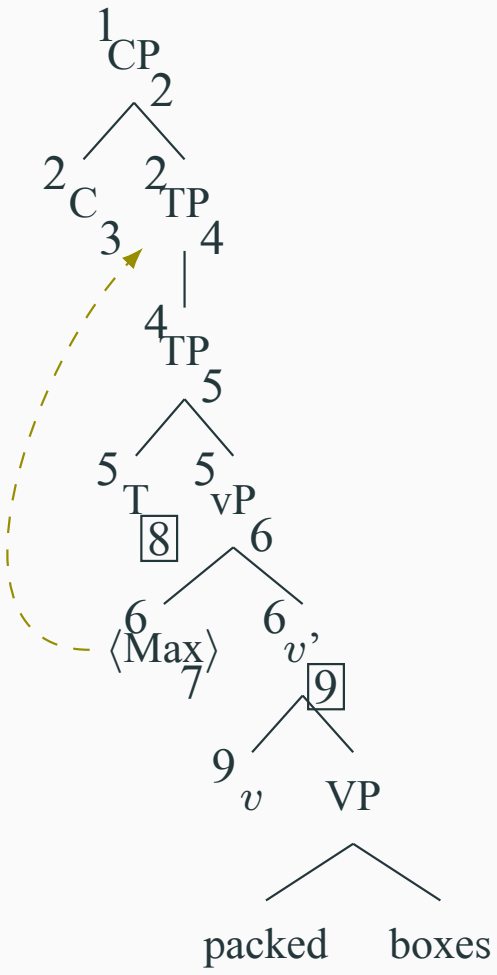

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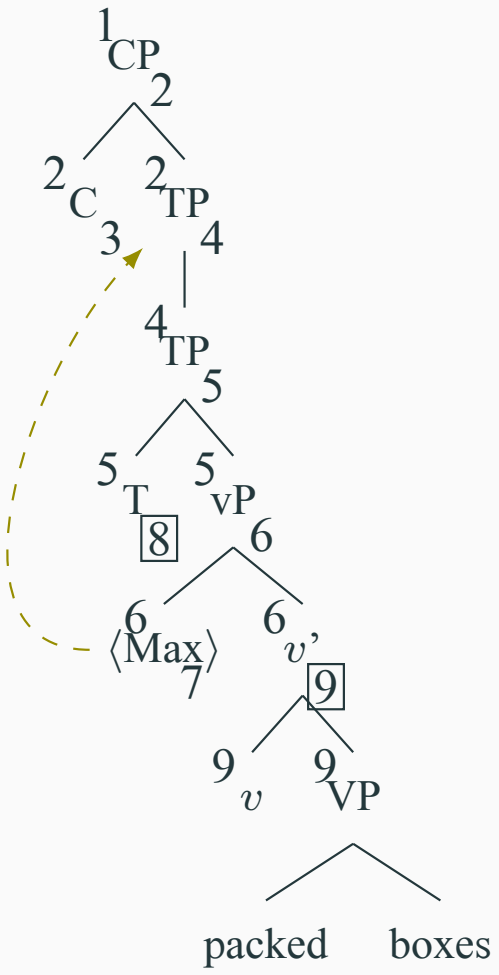
(9) C Max T • *v* packed boxes.

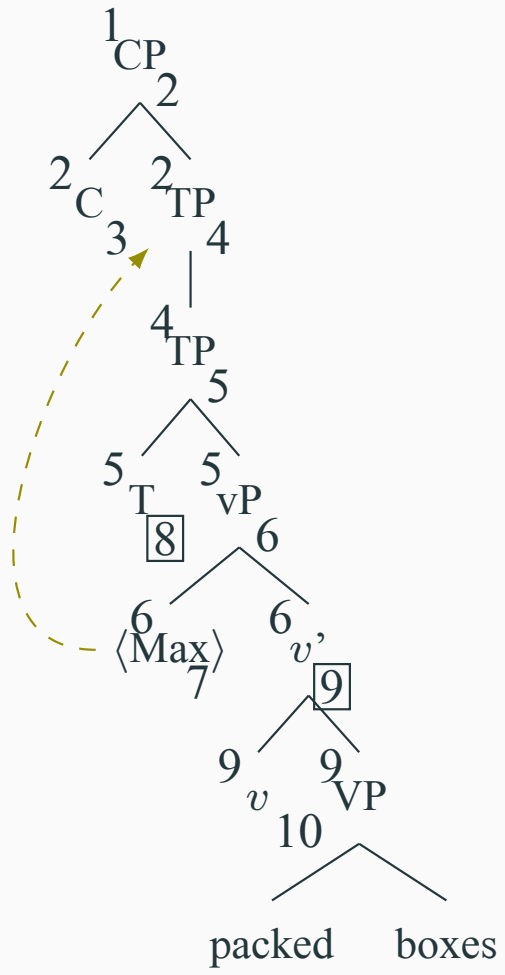
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

(9) C Max T v • packed boxes.

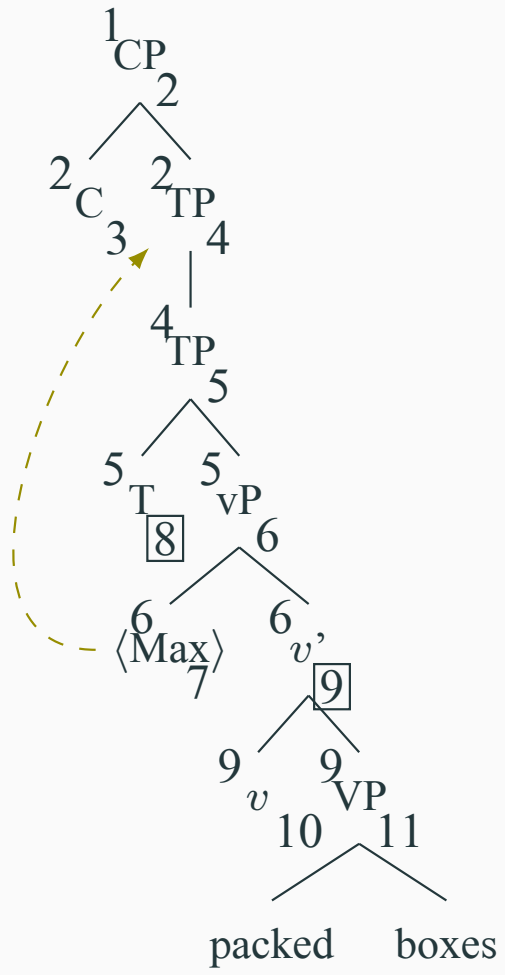
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

(9) C Max T v • packed boxes.

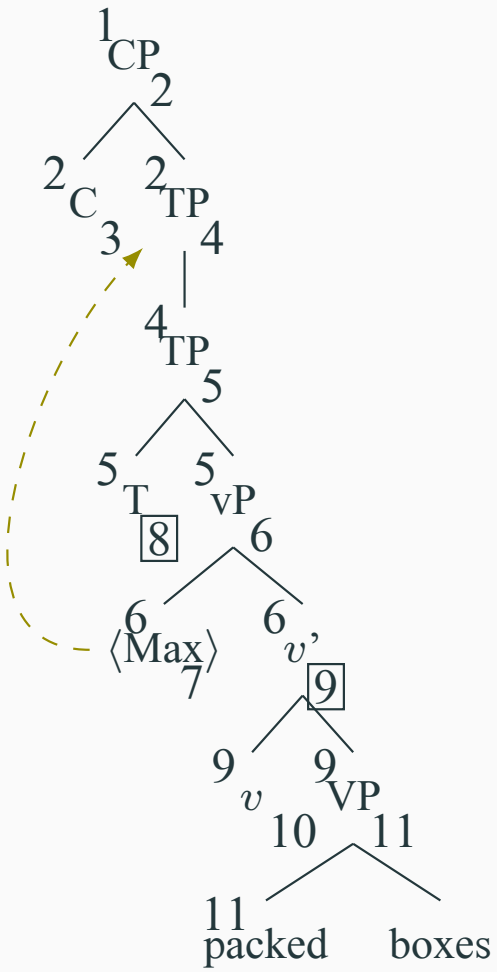
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

(9) C Max T v • packed boxes.

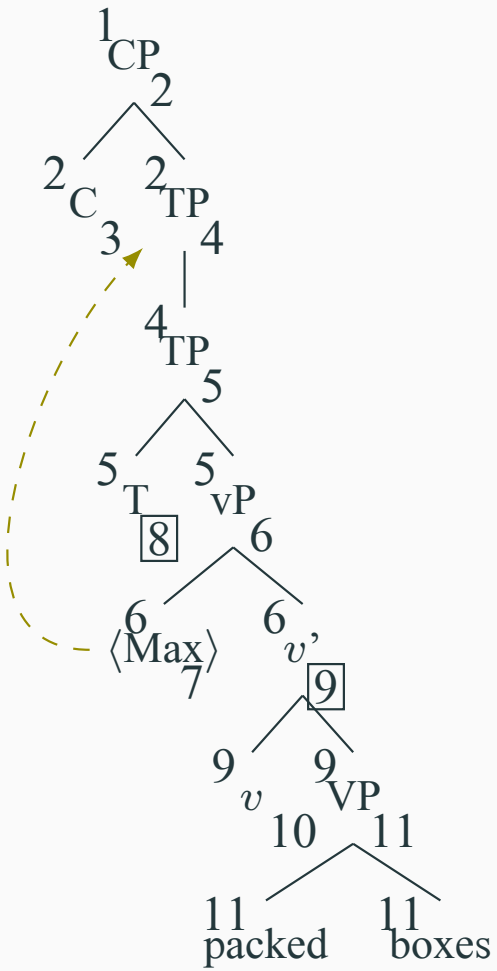
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

(9) C Max T *v* • packed boxes.

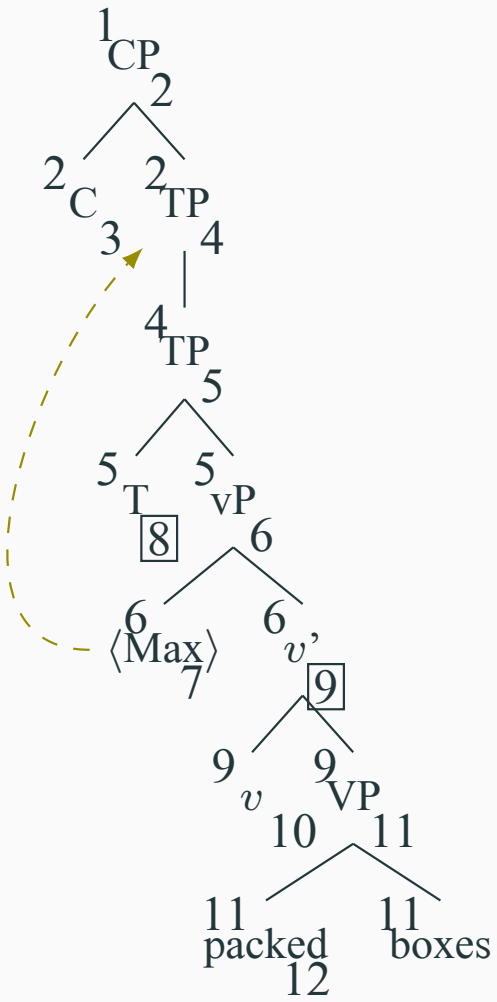
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

(9) C Max T *v* packed • boxes.

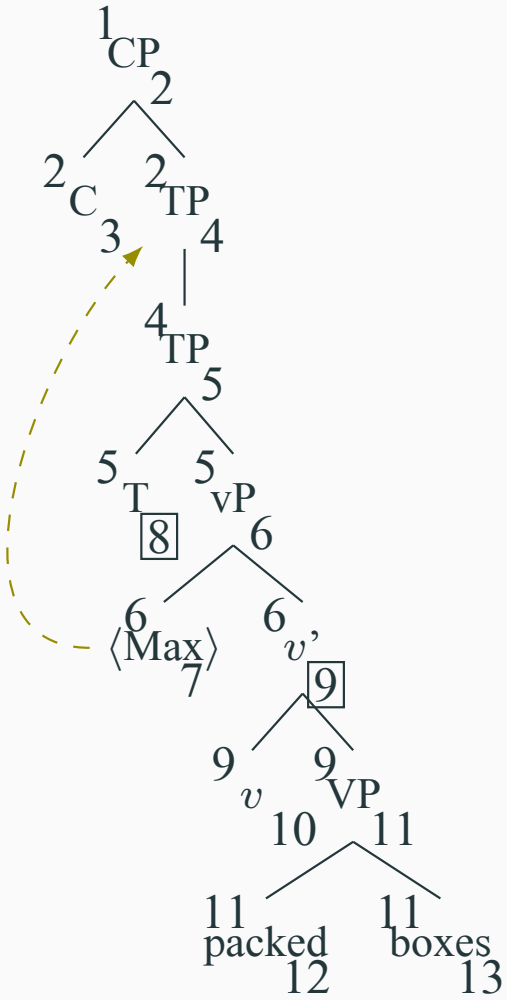
Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



Weight measured in memory cost - toy sentence 1

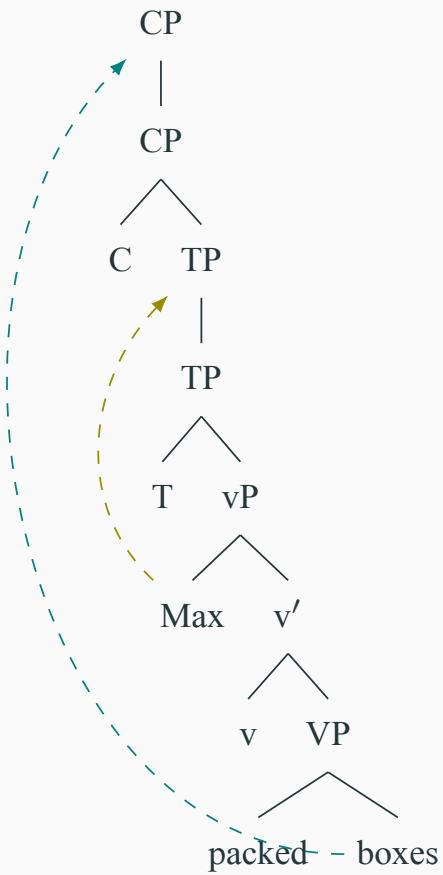
(9) C Max T v packed boxes. $\ltimes$

Step 1	CP is conjectured	look for C
Step 2	CP expands to C and TP	look for C
Step 3	C is found	look for Max
Step 4	TP expands to TP	look for Max
Step 5	TP expands to T and vP	look for Max
Step 6	vP expands to Max and v′	look for Max
Step 7	Max is found	look for T
Step 8	T is found	look for v
Step 9	v′ expands to v and VP	look for v
Step 10	v is found	look for packed
Step 11	VP expands to packed and boxes	look for packed
Step 12	packed is found	look for boxes
Step 13	boxes is found	done



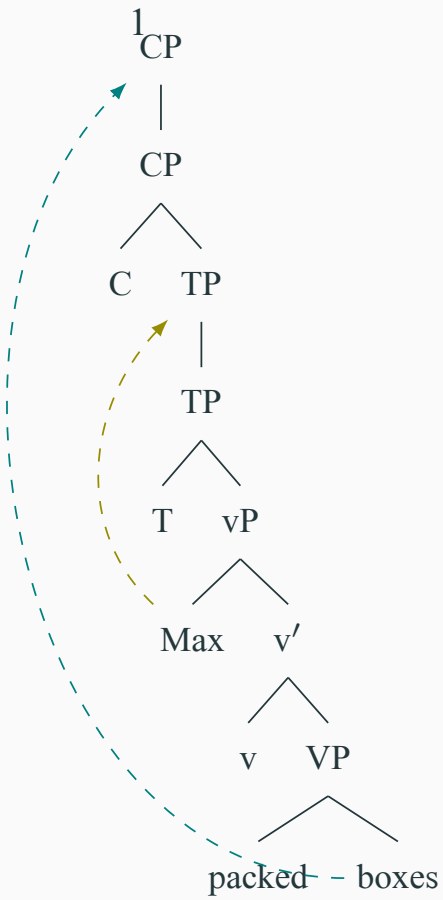
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



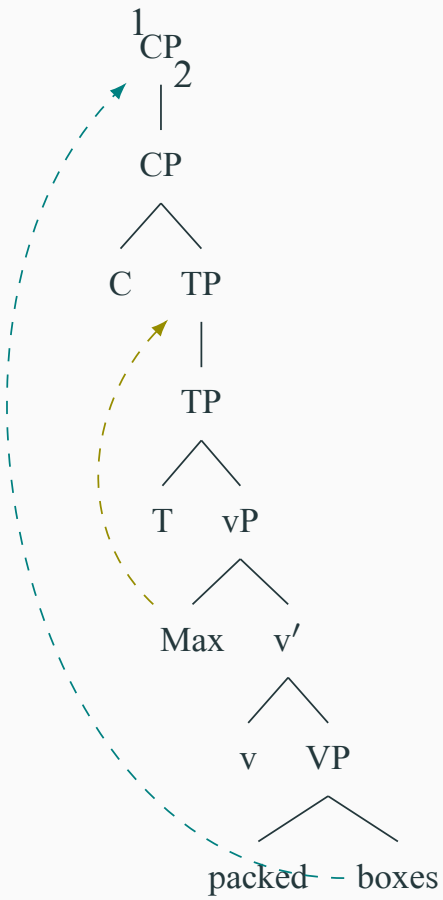
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



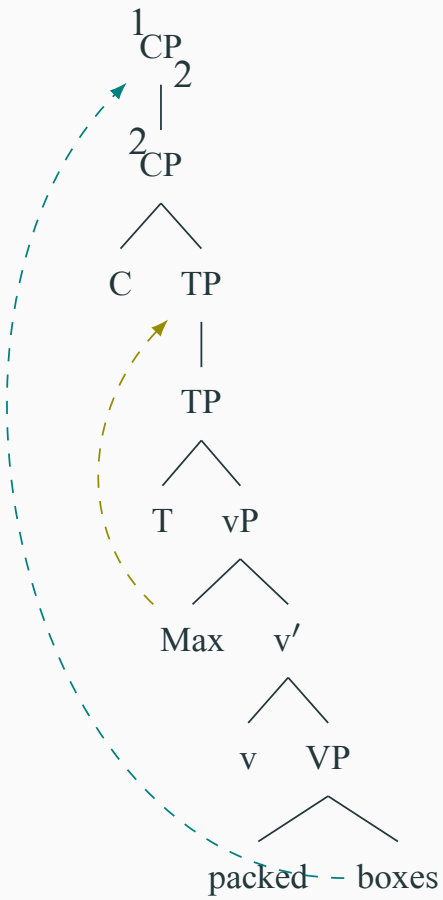
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



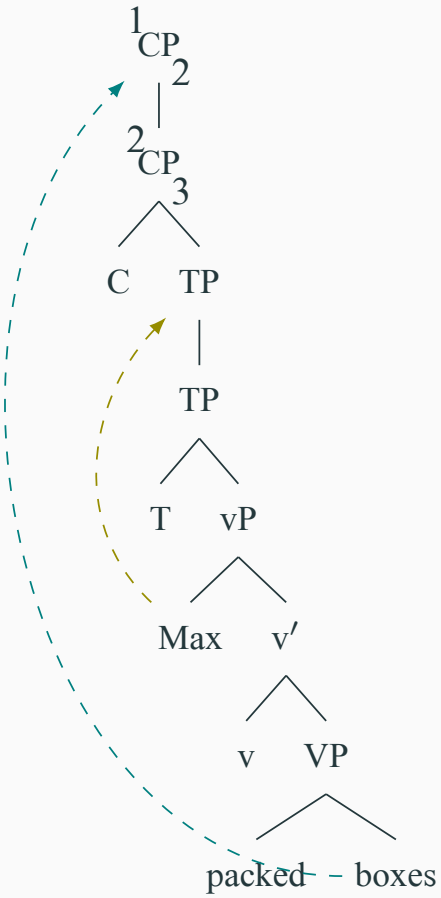
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



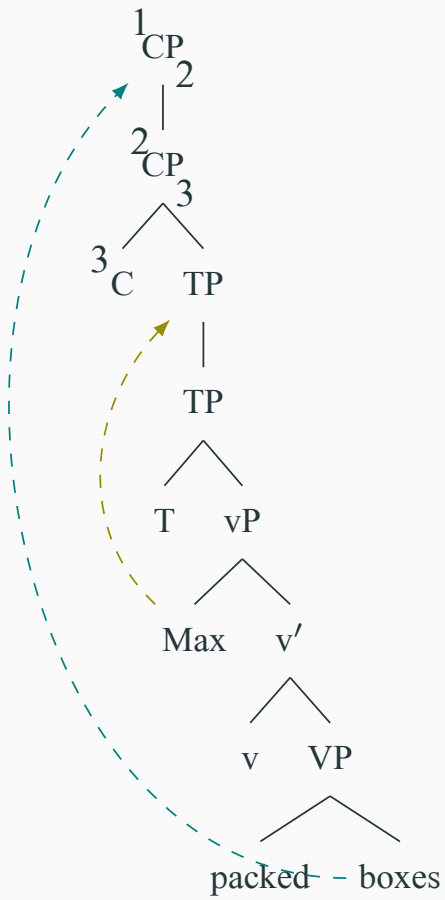
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



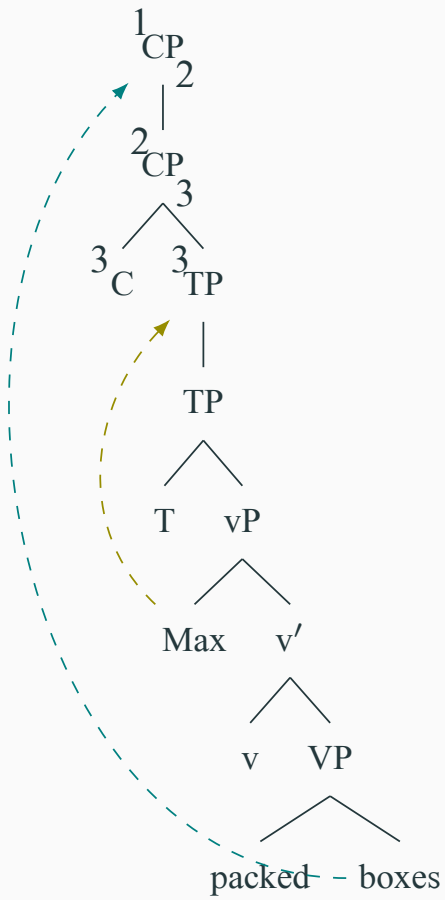
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



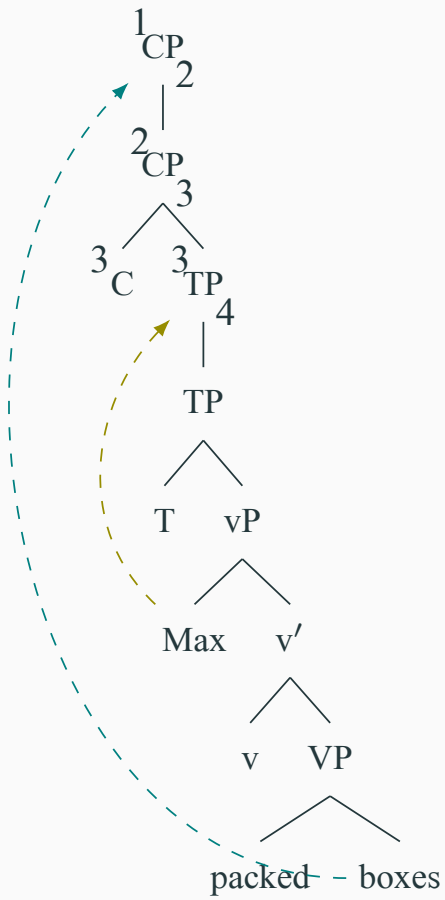
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



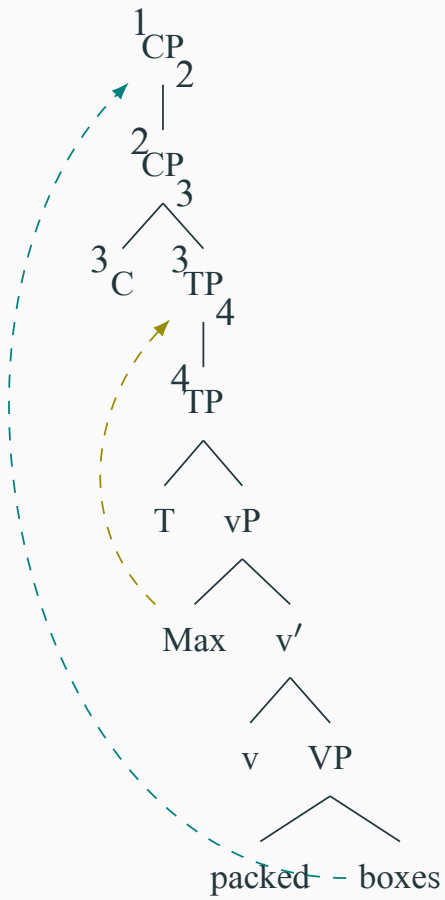
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



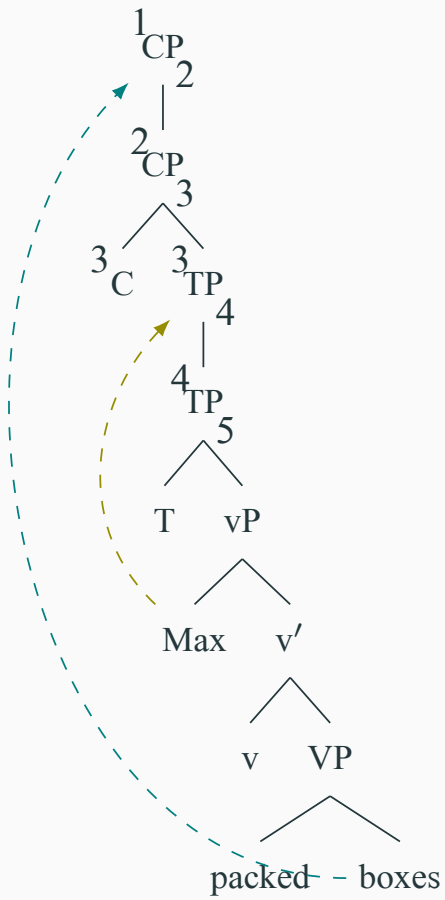
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



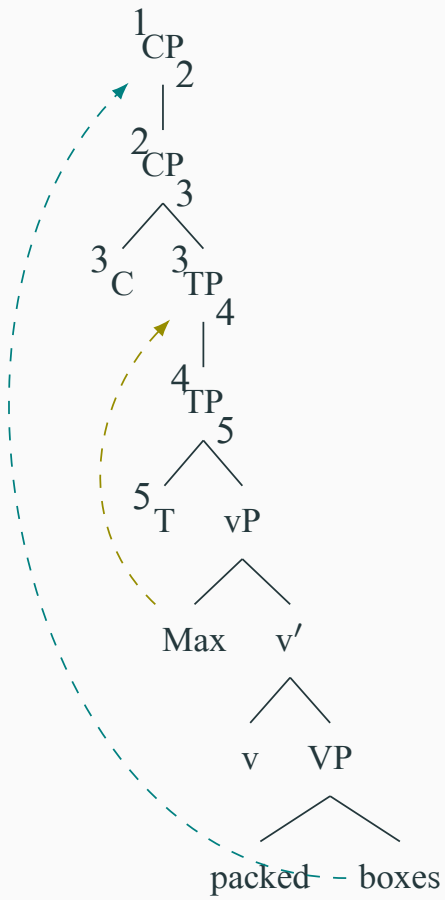
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



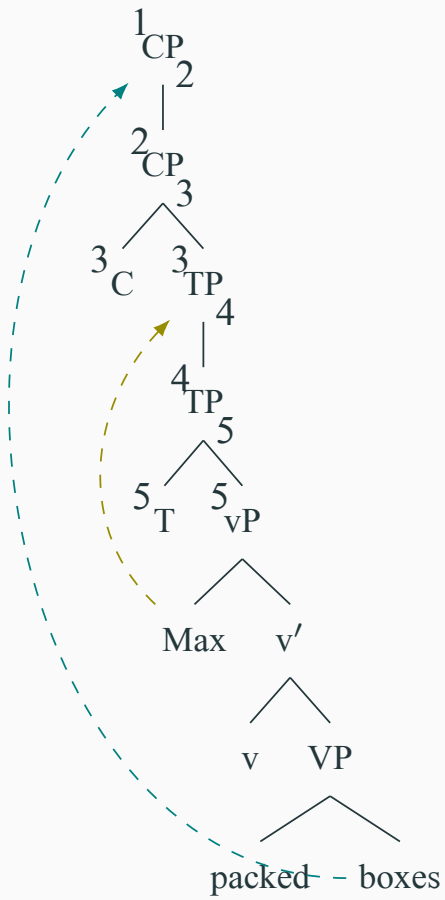
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



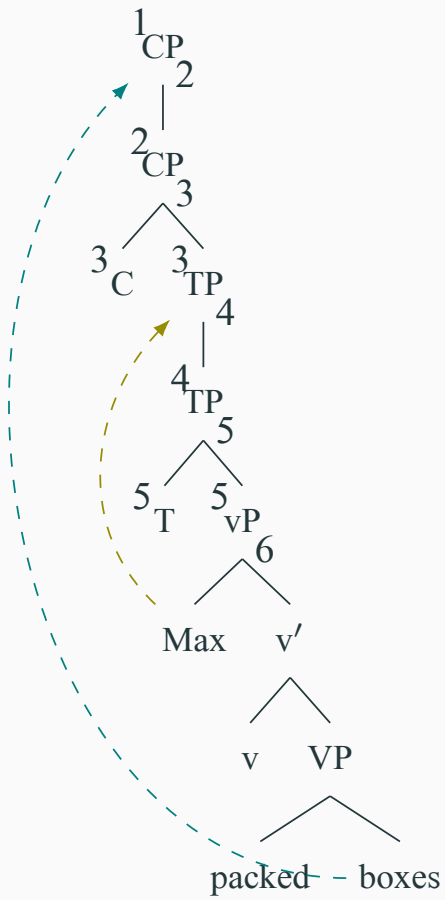
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



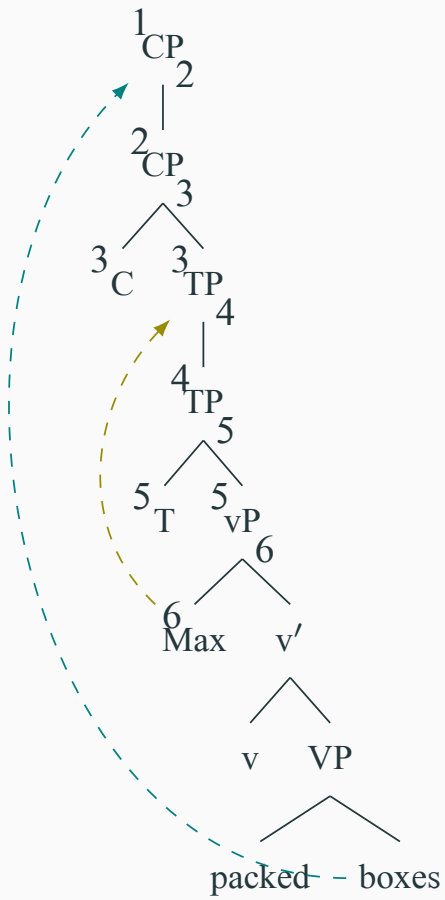
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



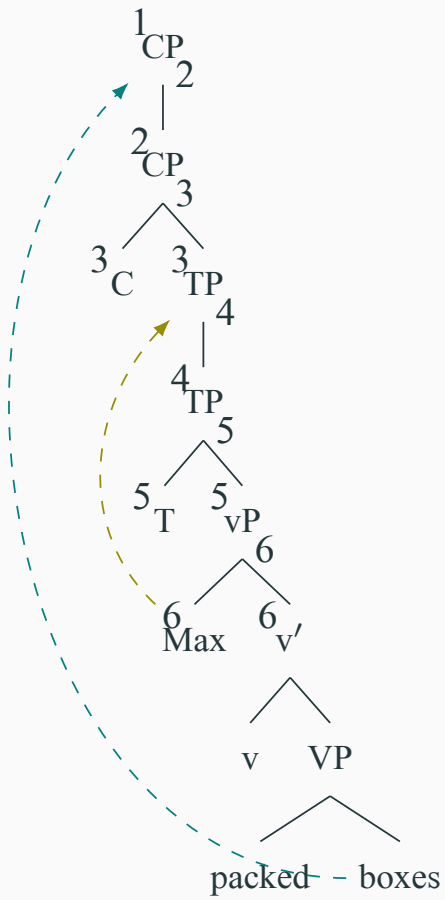
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



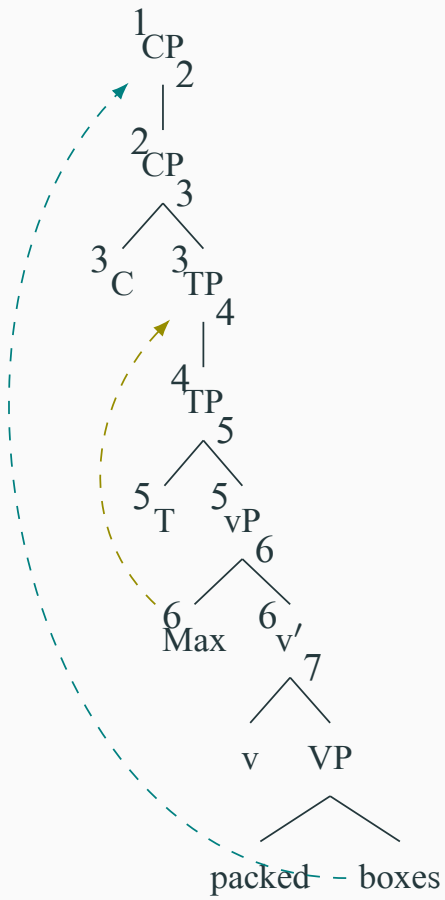
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



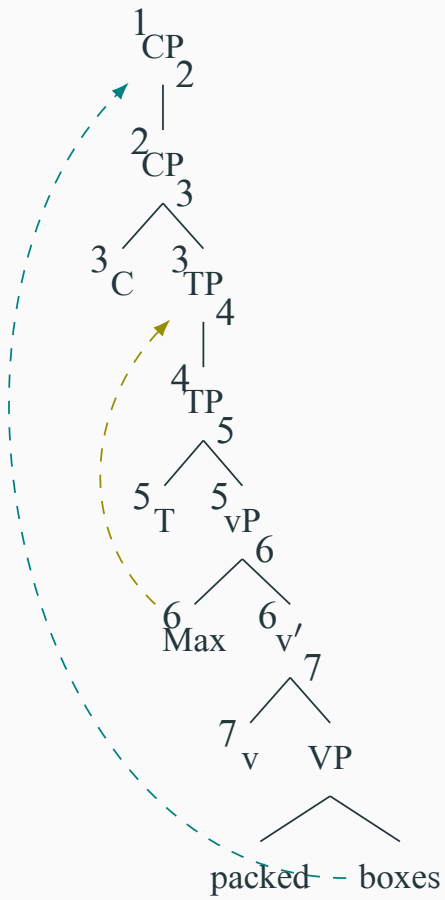
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



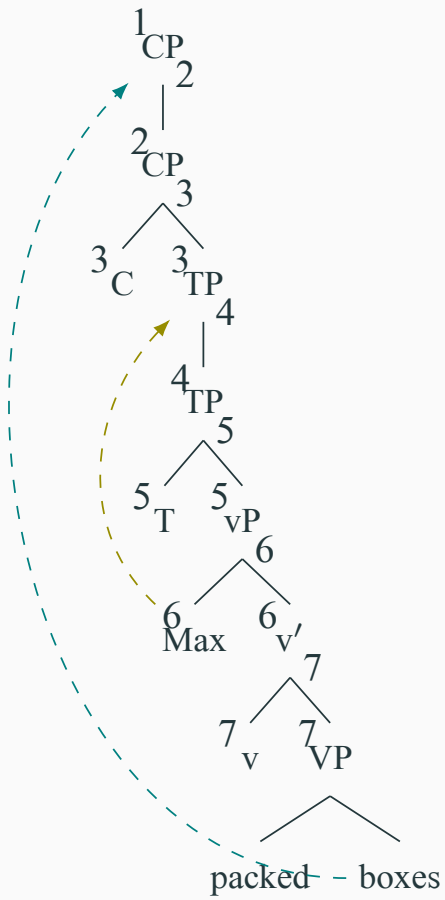
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



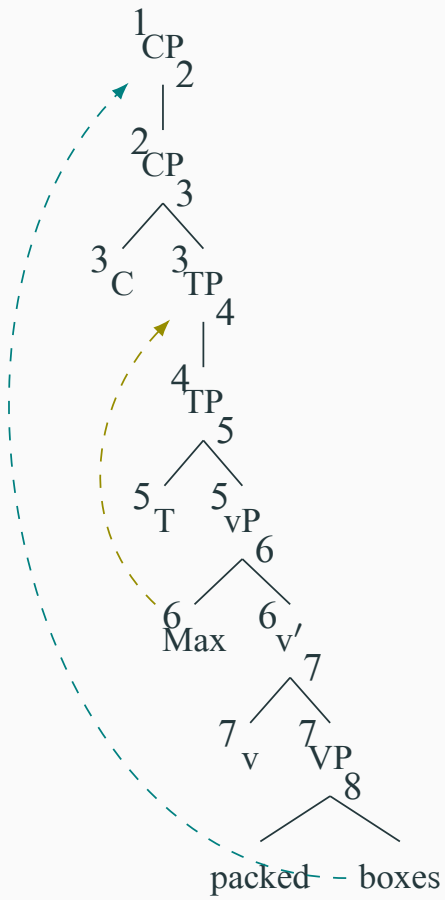
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



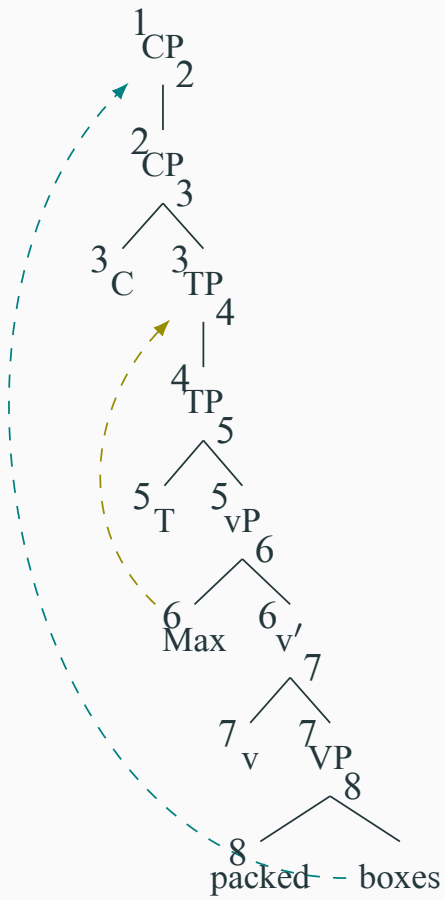
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



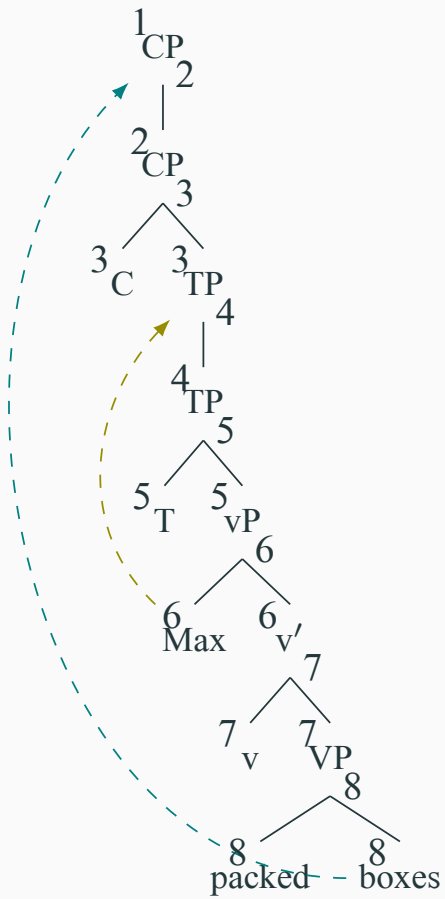
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



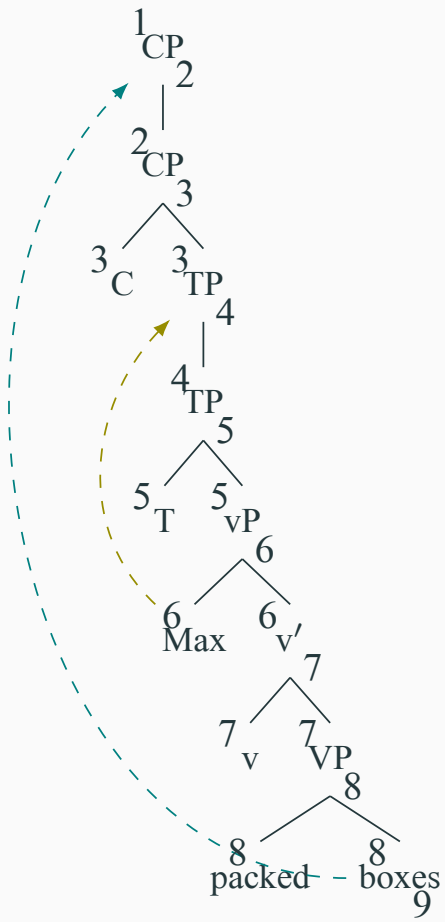
Weight measured in memory cost - toy sentence 2

(10) • Boxes, C Max T v packed.



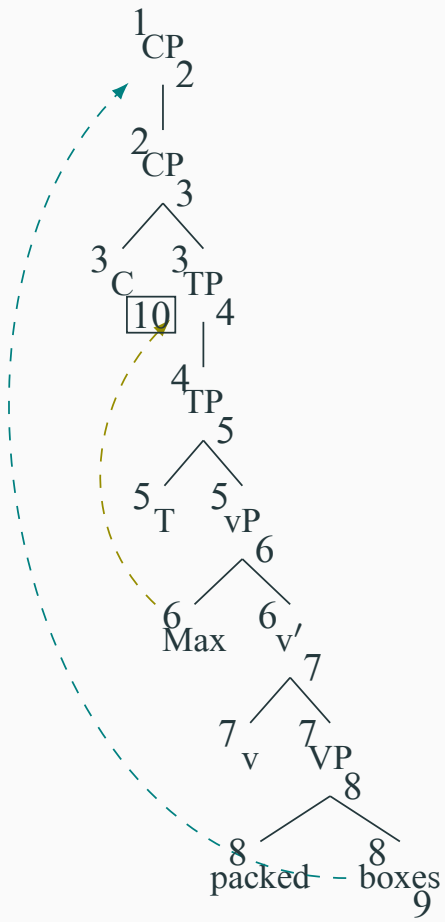
Weight measured in memory cost - toy sentence 2

(10) Boxes, • C Max T v packed.



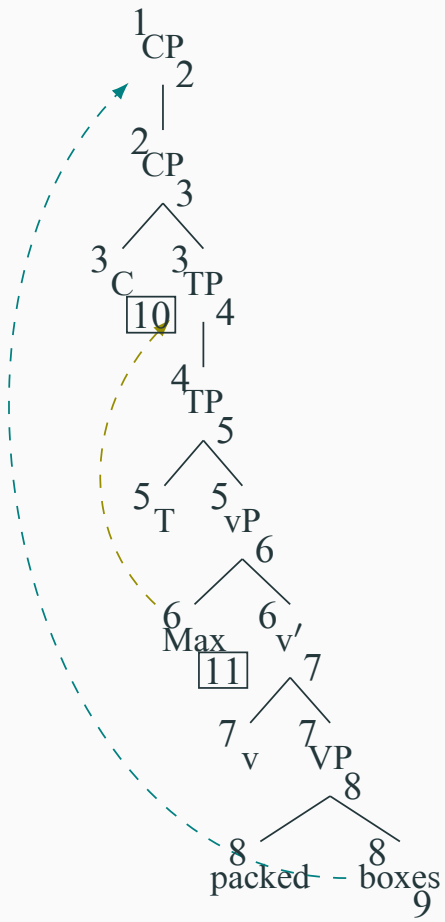
Weight measured in memory cost - toy sentence 2

(10) Boxes, C • Max T v packed.



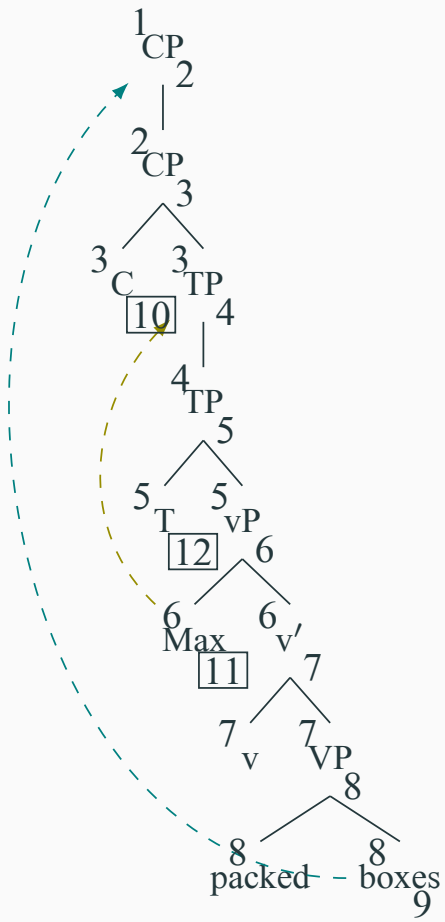
Weight measured in memory cost - toy sentence 2

(10) Boxes, C Max • T v packed.



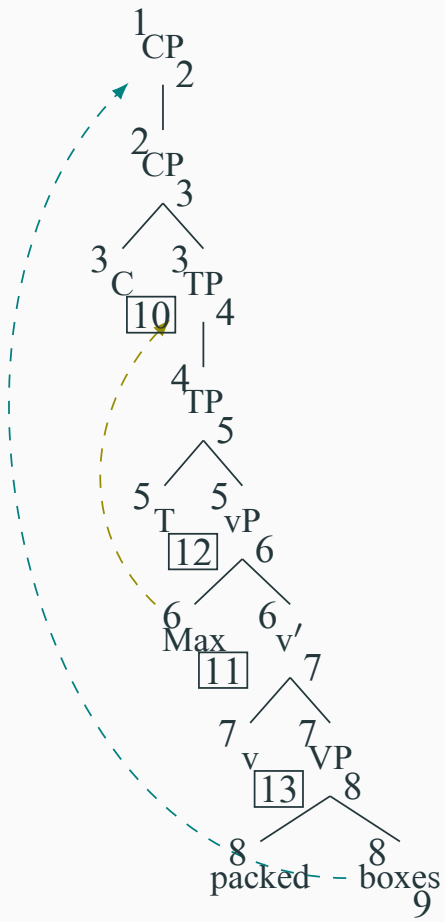
Weight measured in memory cost - toy sentence 2

(10) Boxes, C Max T • v packed.



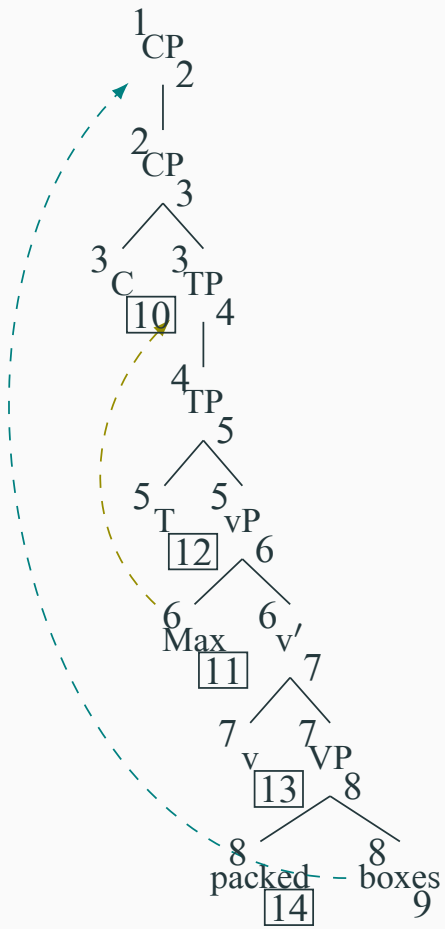
Weight measured in memory cost - toy sentence 2

(10) Boxes, C Max T v • packed.

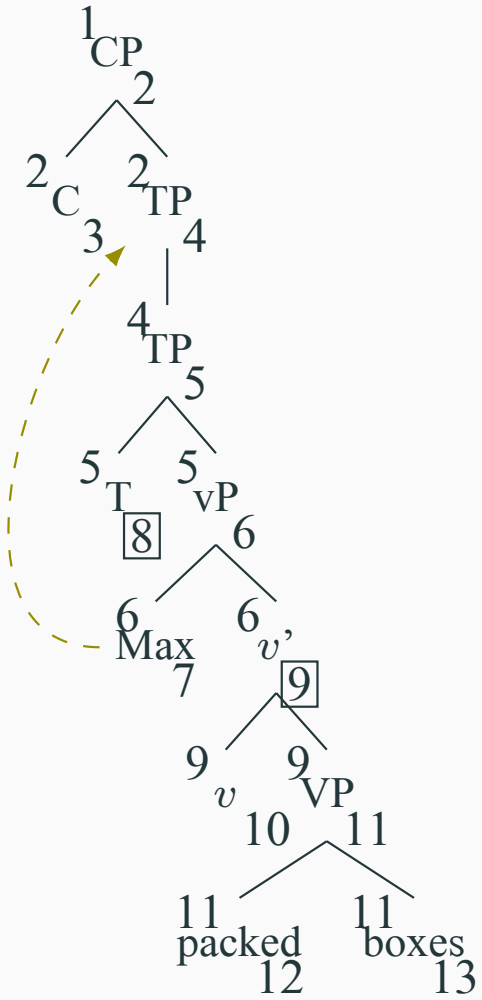


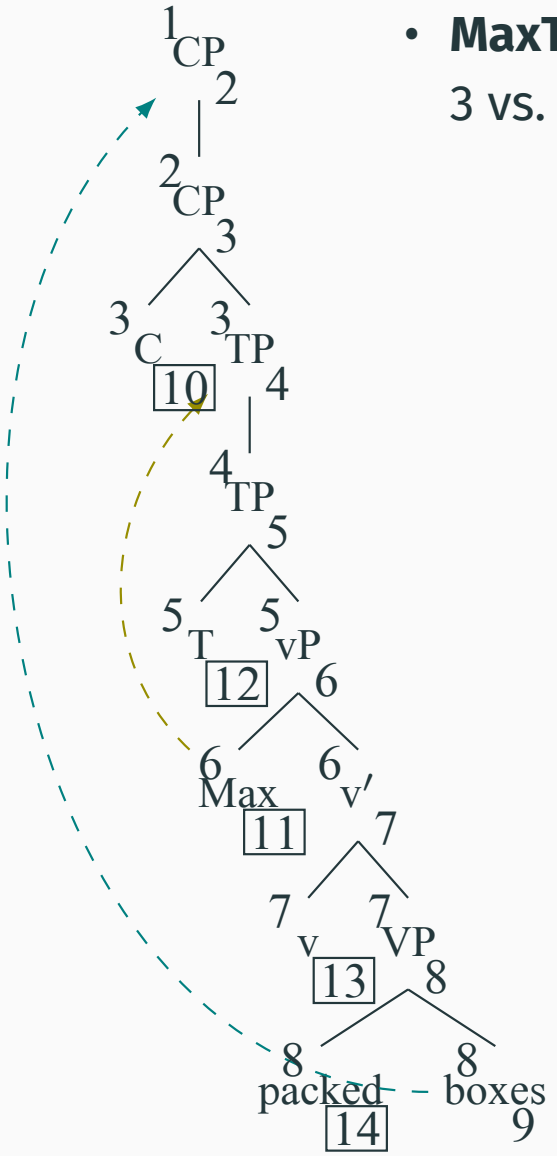
Weight measured in memory cost - toy sentence 2

(10) Boxes, C Max T v packed.⋉



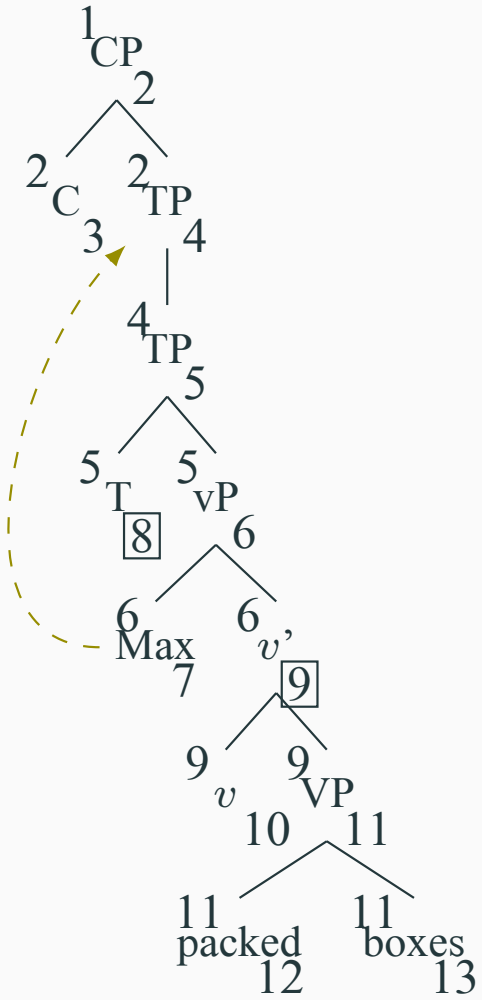
Weight measured in memory cost - complexity metrics

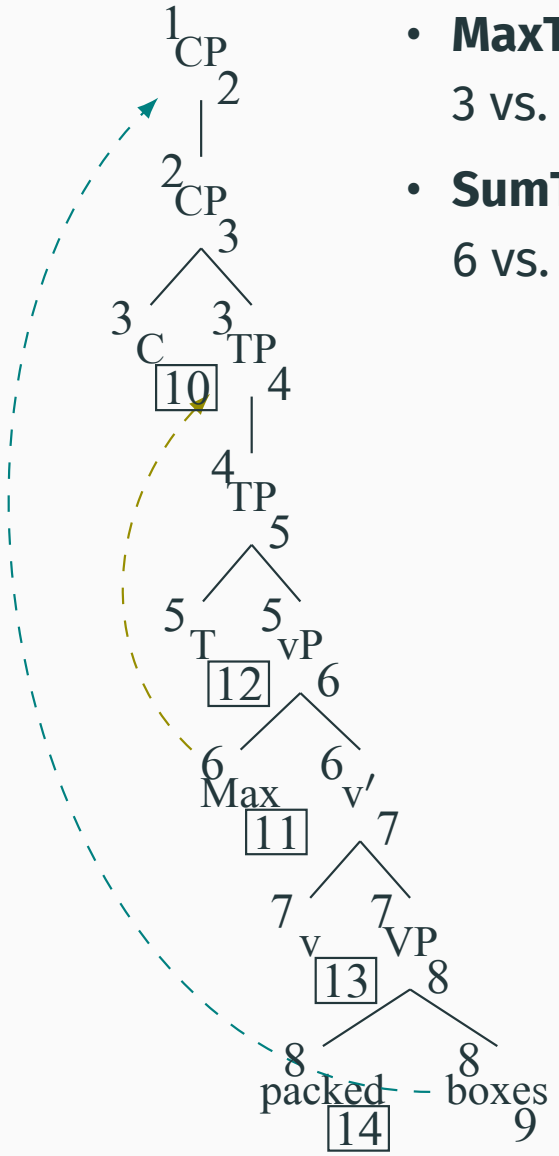




- **MaxT** = max(tenure-of(n)|n ∈ T)
  3 vs. 7

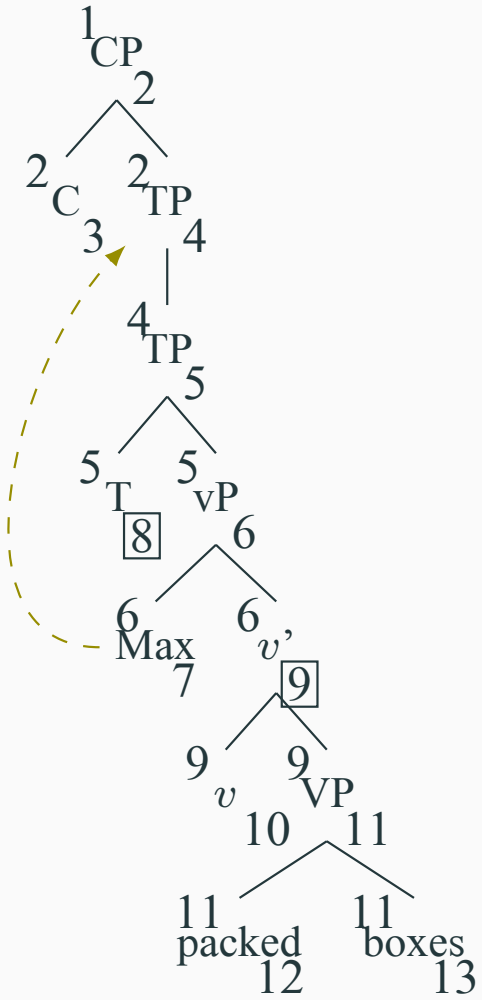
Weight measured in memory cost - complexity metrics

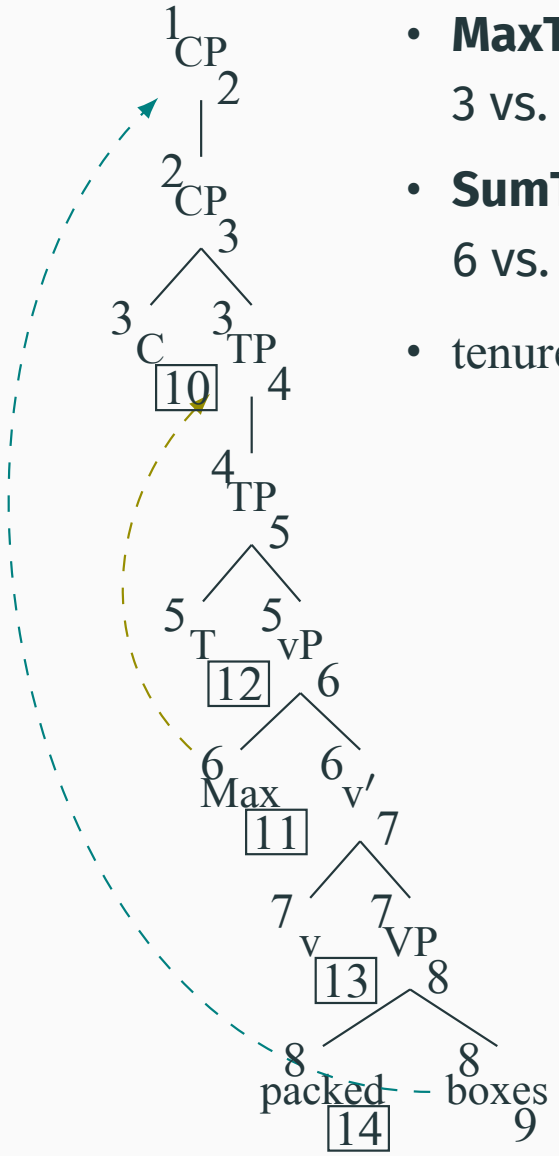




- **MaxT** $= \max(\text{tenure-of(n)} | \text{n} \in \text{T})$
  3 vs. 7
- **SumT** $= \sum_{\text{n} \in \text{T}} \text{tenure-of(n)}$
  6 vs. 31

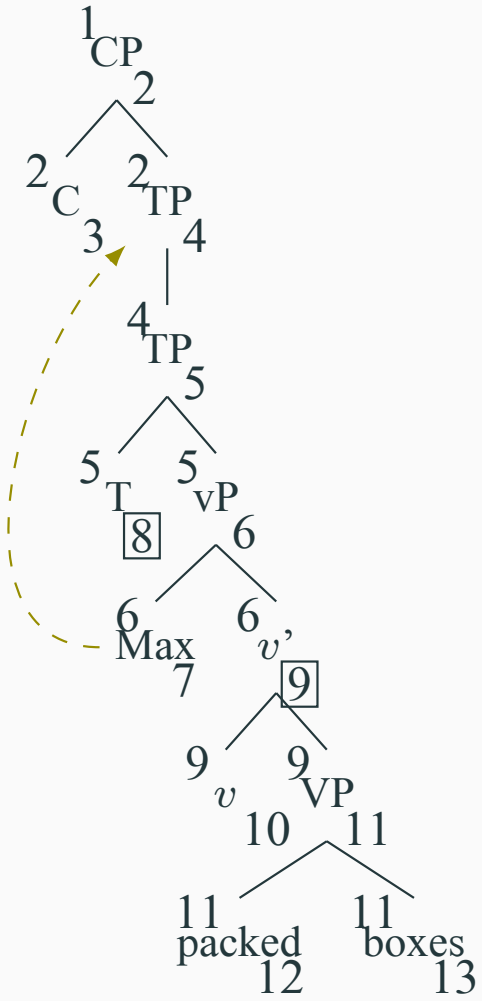
Weight measured in memory cost - complexity metrics

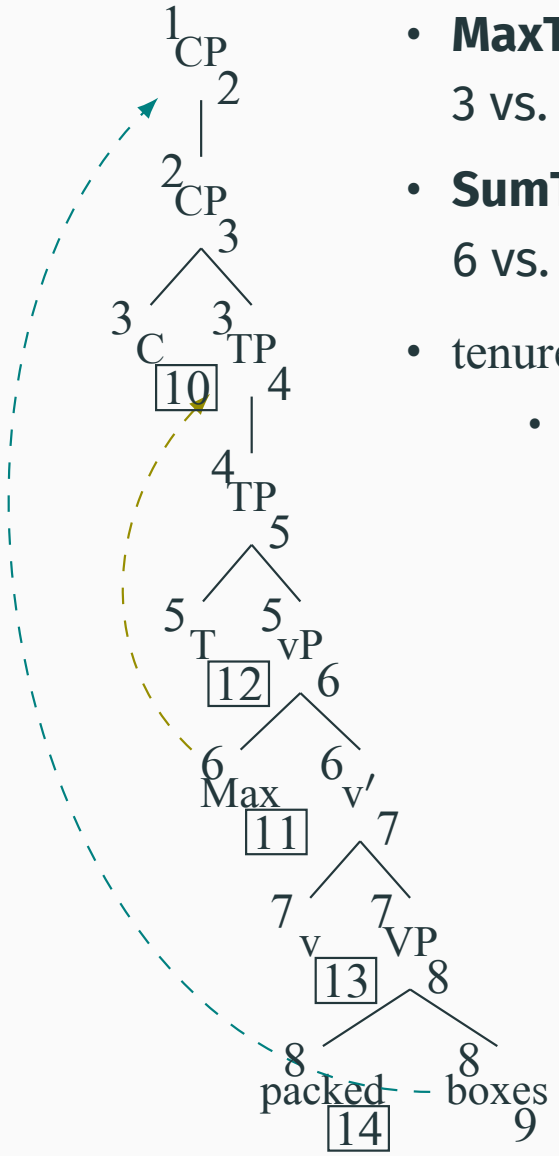




- **MaxT** $= \max(\text{tenure-of(n)} | n \in T)$
  3 vs. 7
- **SumT** $= \sum_{n \in T} \text{tenure-of(n)}$
  6 vs. 31
- $\text{tenure-of(n)} = y - x | {}^{x}n_{y}$

Weight measured in memory cost - complexity metrics

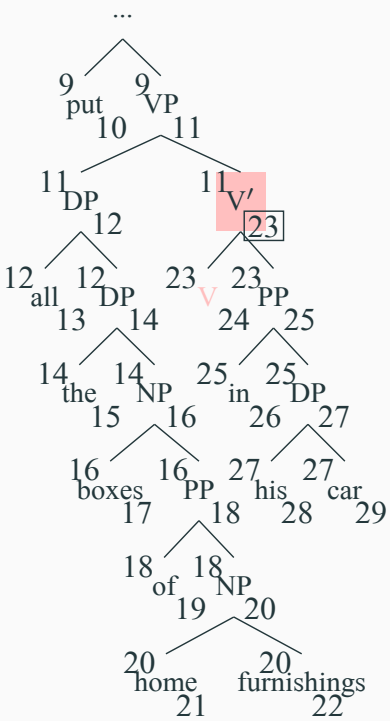




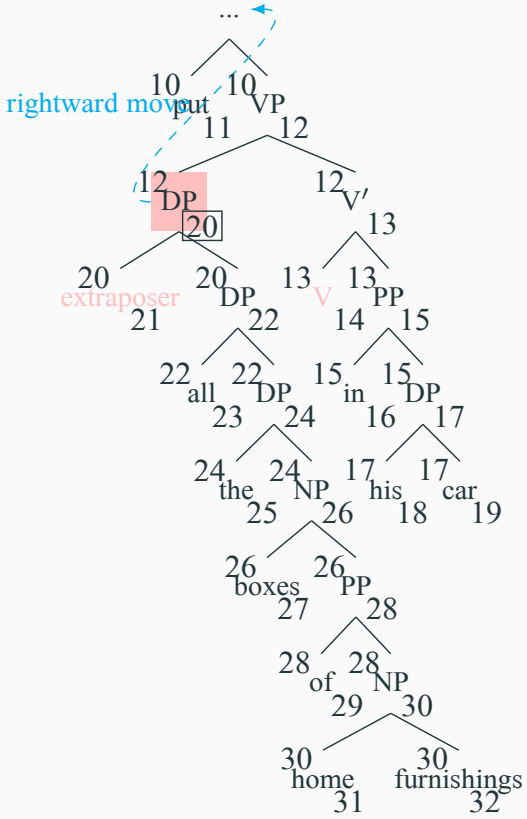
- **MaxT** $= \max(\text{tenure-of(n)} | n \in T)$
  3 vs. 7
- **SumT** $= \sum_{n \in T} \text{tenure-of(n)}$
  6 vs. 31
- $\text{tenure-of(n)} = y - x | {}^{x}n_{y}$
  - steps a node has been kept in memory

Weight measured in memory cost - HNPS

(16) put [DP ...boxes...] [PP in...]
canonical order



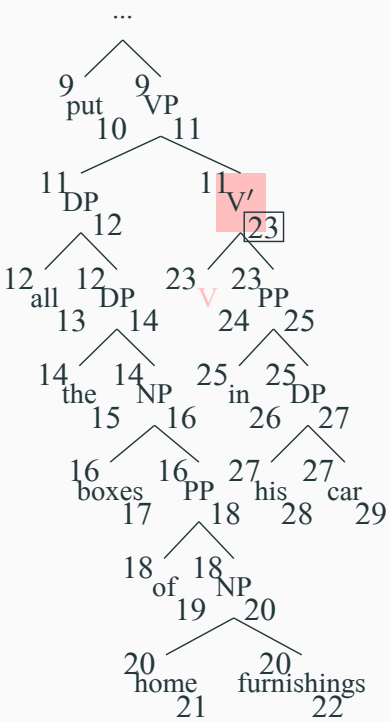
(17) put [PP in...] [DP ...boxes...]
HNPS order



MaxT: 12/v' (canonical)

Weight measured in memory cost - HNPS

(16) put [DP ...boxes...] [PP in...]
canonical order



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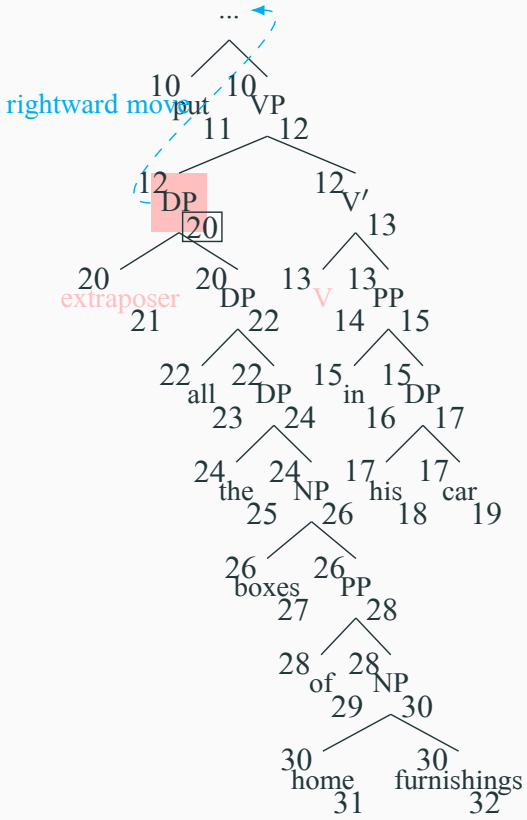
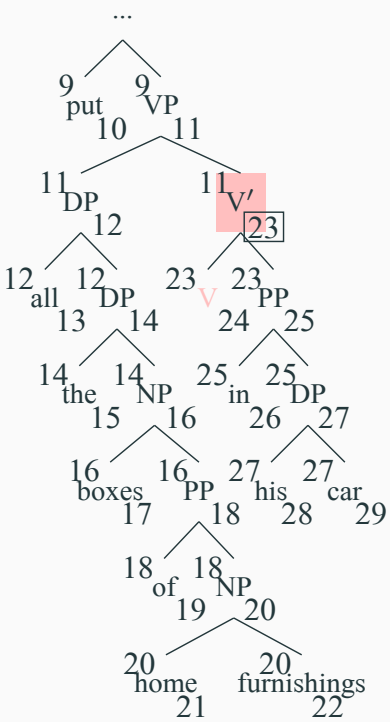
HNPS order



MaxT: 12/v' (canonical) > 8/DP (HNPS)

Weight measured in memory cost - HNPS

(16) put [DP ...boxes...] [PP in...]
canonical order



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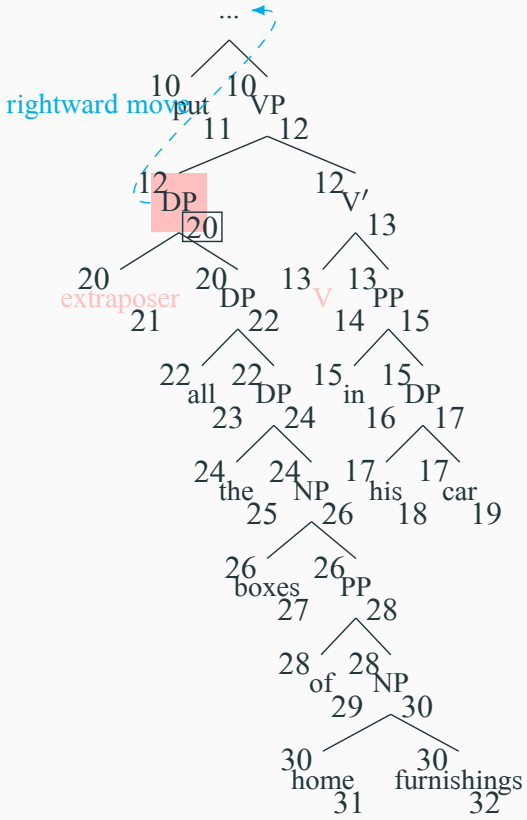

MaxT: 12/v' (canonical) > 8/DP (HNPS) ✓

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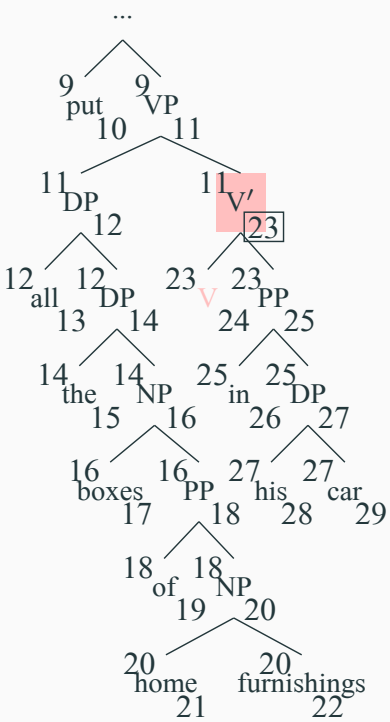

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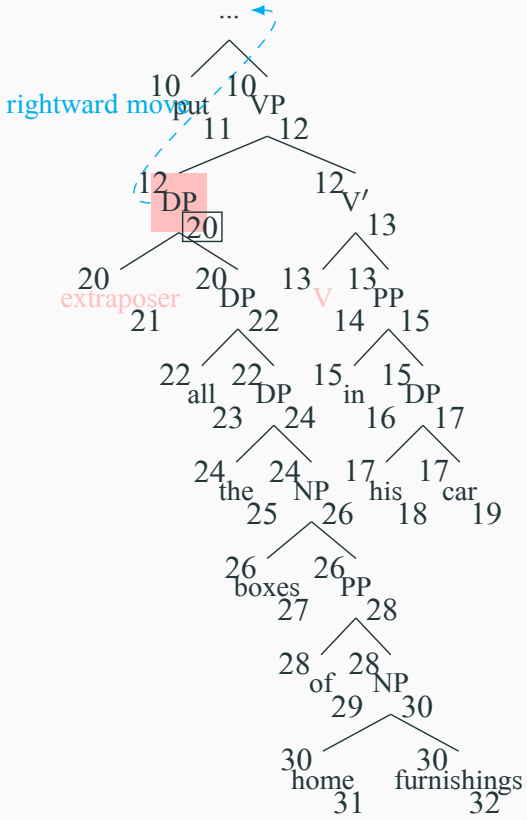

MaxT: 12/v' (canonical) > 8/DP (HNPS) ✓

SumT: 18 (canonical)

Weight measured in memory cost - HNPS

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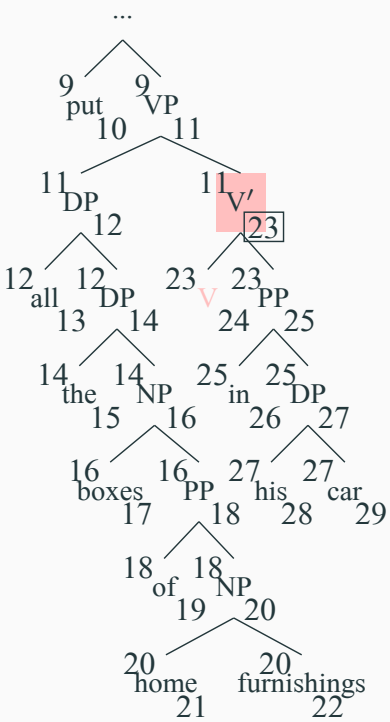

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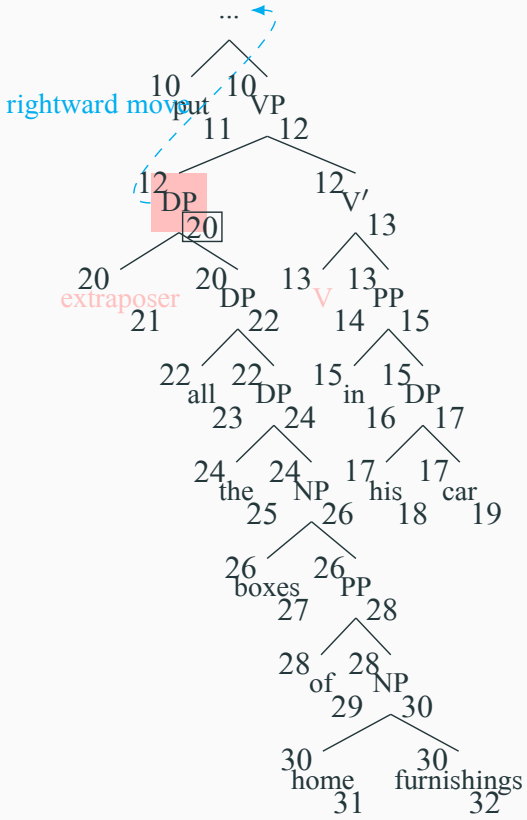

MaxT: 12/v' (canonical) > 8/DP (HNPS) ✓

SumT: 18 (canonical) > 15 (HNPS)

Weight measured in memory cost - HNPS

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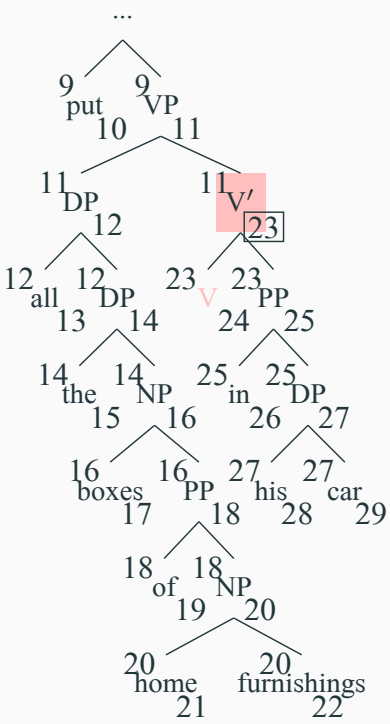

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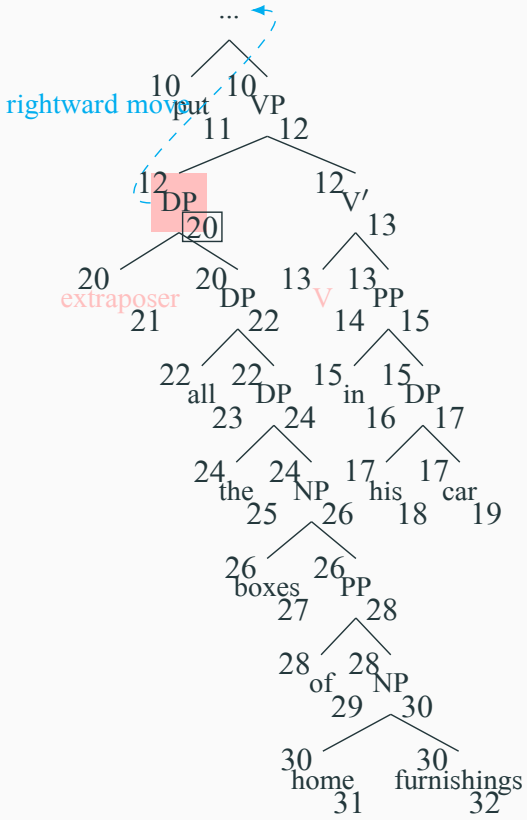

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Weight measured in memory cost - HNPS

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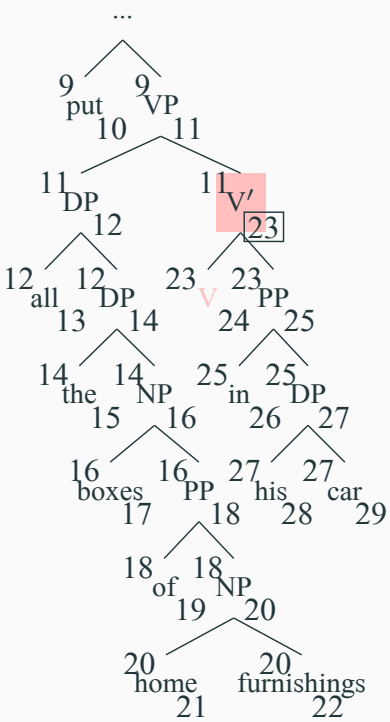

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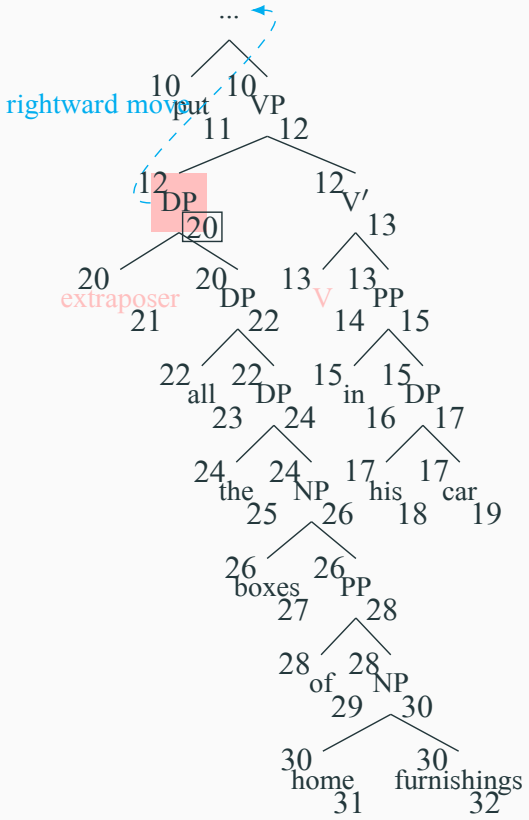

MaxT: 12/v' (canonical) > 8/DP (HNPS) ✓

SumT: 18 (canonical) > 15 (HNPS) ✓

HNPS advantage!

Weight measured in memory cost

- Structural simplicity accounts for word order preferences in:
  - English heavy NP shift (HNPS)

    (18) Max put [PP in his car] [DP all the boxes of home furnishings].

    (19) Max put [DP all the boxes of home furnishings] [PP in his car].

  - English particle verb construction (PV)

    (20) Chris put on [DP a hat which Alex made with merino wool].

    (21) Chris put [DP a hat which Alex made with merino wool] on.

  - Mandarin *ba* construction

    (22) Zhangsan ba [DP daocha] fang (le) [PP zai yong tanmu zhizuo
    Z. ba knife.fork put (LE) on use sandalwood make
    de zhuozi-shang]
    DE table-top

    (23) Zhangsan [PP zai yong tanmu zhizuo de zhuozi-shang] fang (le)
    Z. on use sandalwood make DE table-top put (LE)
    [DP daocha]
    knife.fork
    'Z put a set of knife and fork on the table that is made of sandalwood.'

Why light-before-heavy after all?

- *Focus Last*: reserving the more important information at the end (amo Krifka 1998)

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- *Focus Last*: reserving the more important information at the end (amo Krifka 1998)
- Incremental production processes: longer, harder-to-process phrases are delayed during utterance planning (Stallings et al. 1998, Stallings and MacDonald 2011)
- Memory efficiency: a short-before-long structure is more memory efficient to parse. (Liu 2022)

Heavy before light - Japanese

(24) Japanese OSV and SOV order (adapted from Yamashita and Chang (2001))

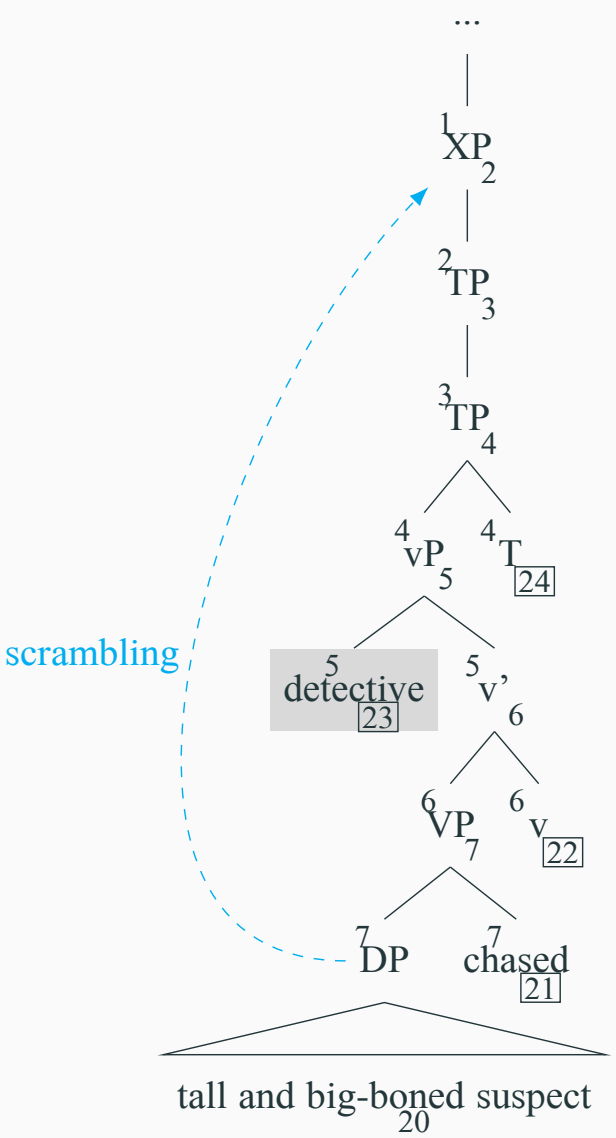
a. [$_{obj.}$ Se-ga takakute gassiri sita hanni-o]$_i$ [$_{subj.}$ Keezi-ga] t_i
height-nom tall-and big-boned suspect-acc detective-nom
Oikaketa.
chased
'The detective chased the suspect who is tall and big-boned.' Shift order, preferred

b. [$_{subj.}$ Keezi-ga] [$_{obj.}$ Se-ga takakute gassiri sita hanni-o] Oikaketa.
detective-nom height-nom tall-and big-boned suspect-acc chased
'The detective chased the suspect who is tall and big-boned.'

c. C.f., [$_{subj.}$ Keezi-ga] [$_{obj.}$ hanni-o] Oikaketa.
detective-nom suspect-acc chased
'The detective chased the suspect.'

Heavy before light - Japanese

(25)



Morphology invading syntax

(26) From Sören's retreat presentation

ke-tidak adil-an
NMLZ-NEG just-NMLZ

'injustice' Indonesia

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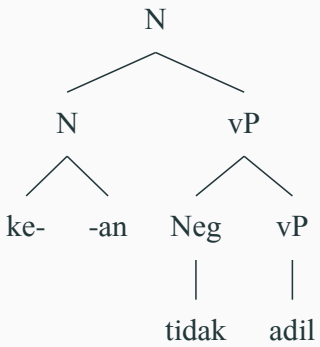

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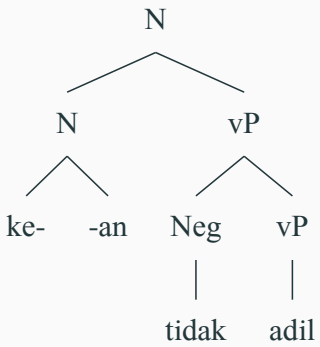
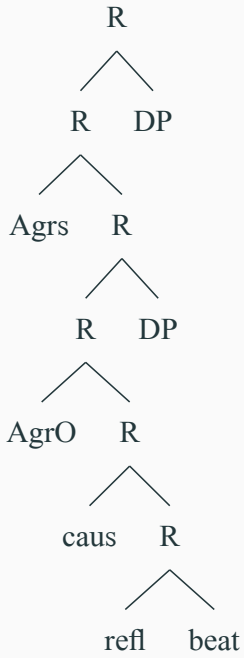


- What about justice?

Verb is everything - Quechua

(28) Maqa -ku -ya -chi -n
beat -refl -dur -caus -3sg
'He$_i$ is causing [him$_j$ to beat himself$_j$].' Quechua

(29) From Greg's retreat presentation



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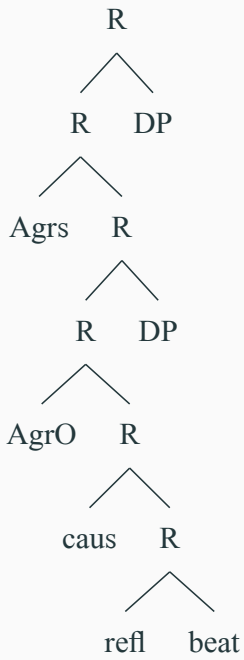
- What about beat as a simple transitive?



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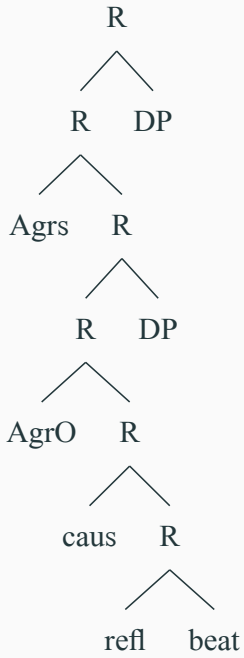

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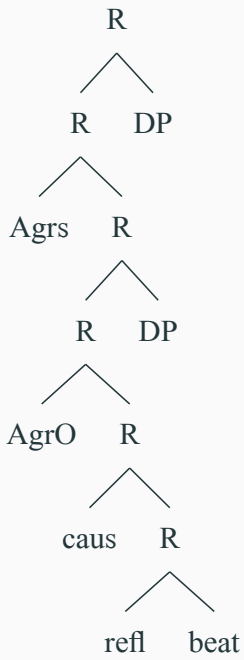

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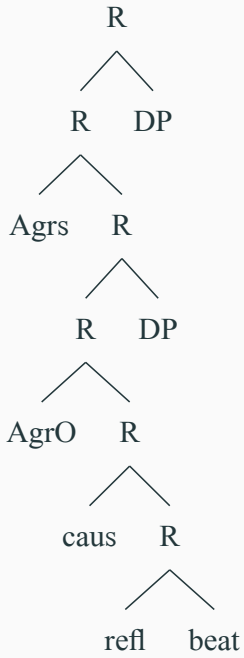

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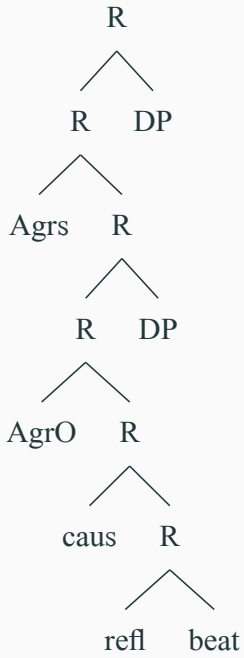

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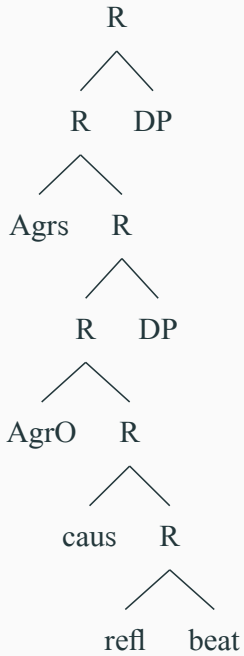

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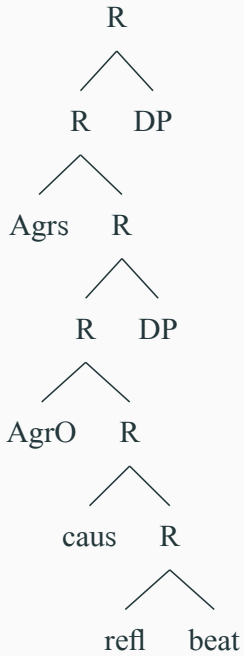

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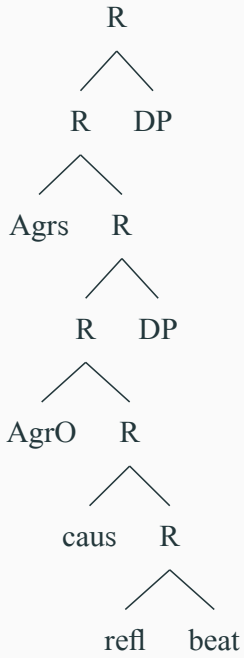

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Memory cost $\leftarrow$ MG parsing $\rightarrow$ Structure

References i

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Weight measured in memory cost - HNPS

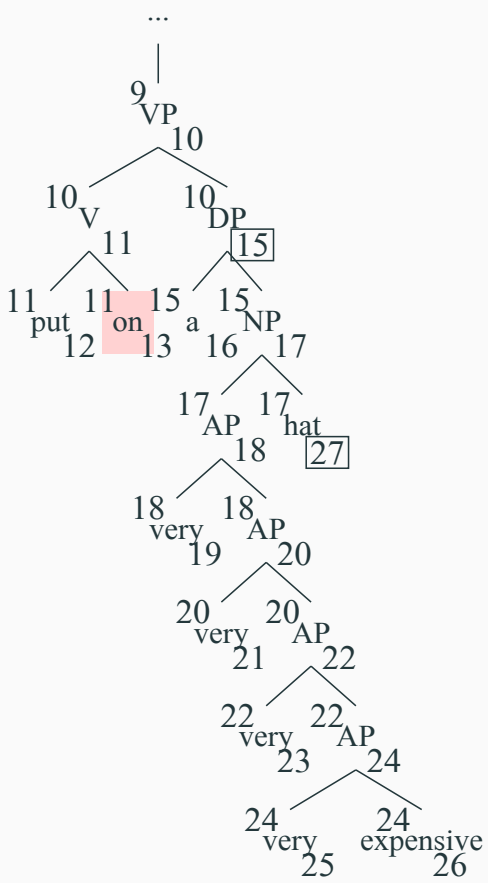
Metric		Metric	
AvgS	**No**	MaxT	**Yes**
AvgS'†	**No**	MaxT'	**Yes**
AvgT	**Yes**	MaxTR	**Yes**
AvgT'	**Yes**	MaxTR'	**Yes**
BoxT	**Tie**	Movers	**No**
BoxT'	**No**	Movers'	**No**
MaxS	**No**	SumS	**No**
MaxS'	**No**	SumS'	**No**
MaxSR ‡	**No**	SumT	**Yes**
MaxSR'	**No**	SumT'	**No**
MaxT	**Yes**	SumT'	**No**

† Primed (') metrics are metrics that do not ignore trivial ($\leqslant 2$) memory load.
‡metrics suffixed with "R" apply recursively until a difference is found.

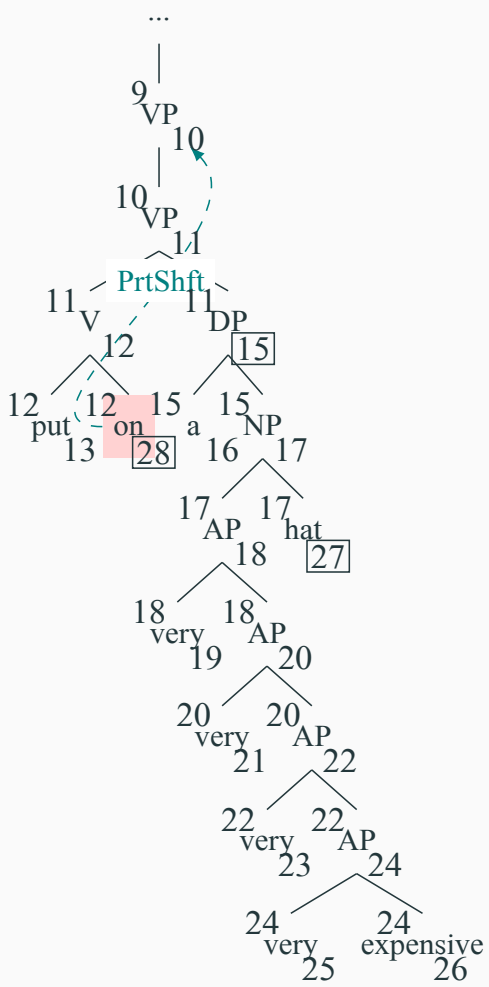
Table 2: Complexity metrics predictions for HNPS - Rightward movement

Weight measured in memory cost - English PV

(30) put on [a very very...hat]



(31) put [a very very...hat] on



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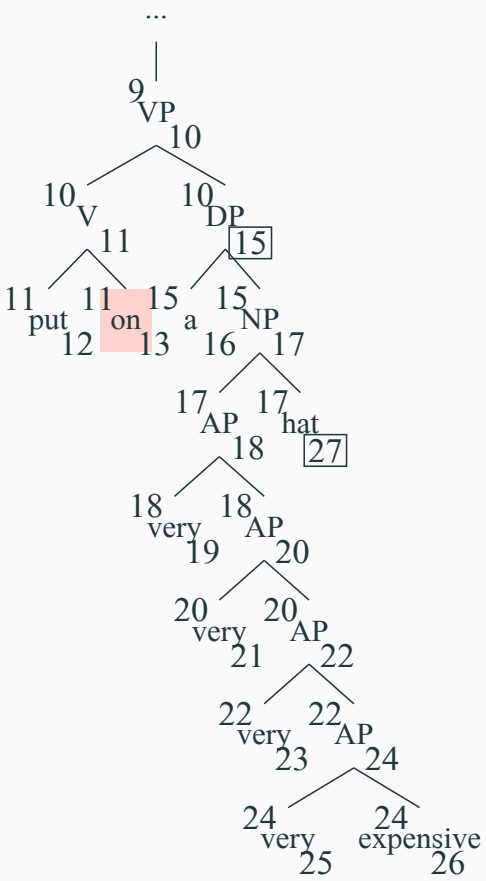
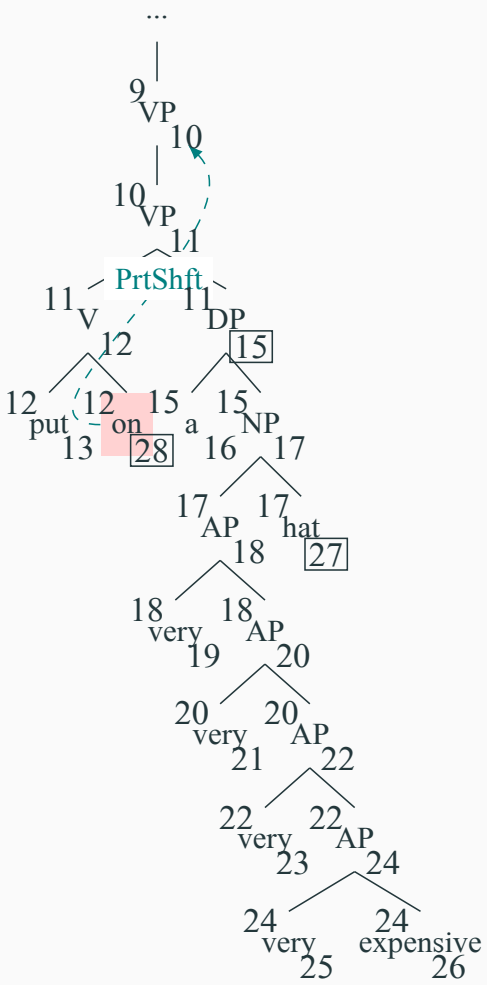


(31) put [a very very...hat] on

MaxT: 10/hat (join)

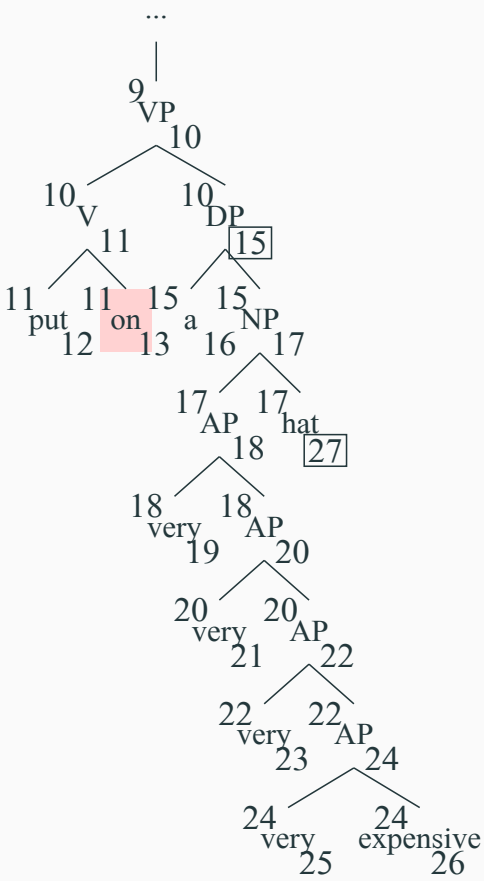


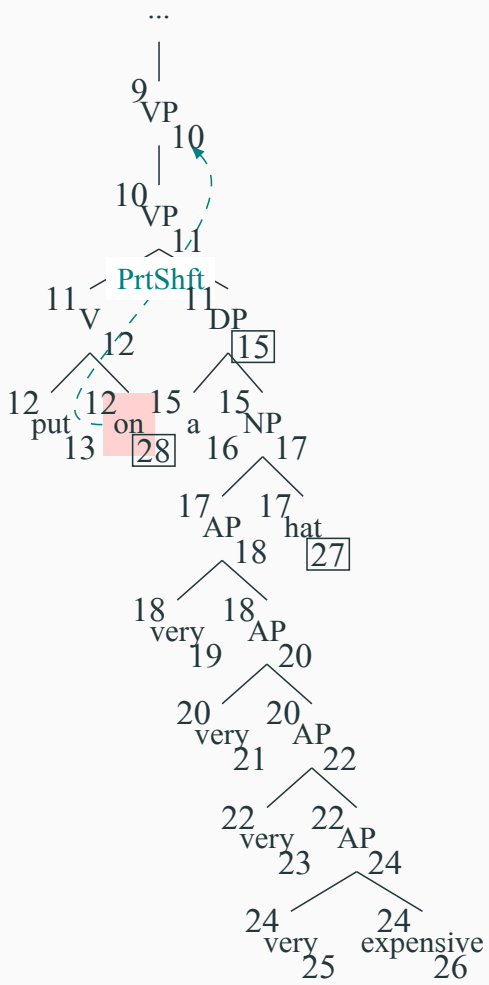
Weight measured in memory cost - English PV

(30) put on [a very very...hat]

(31) put [a very very...hat] on

MaxT:
10/hat (join) < 16/on (sep.)





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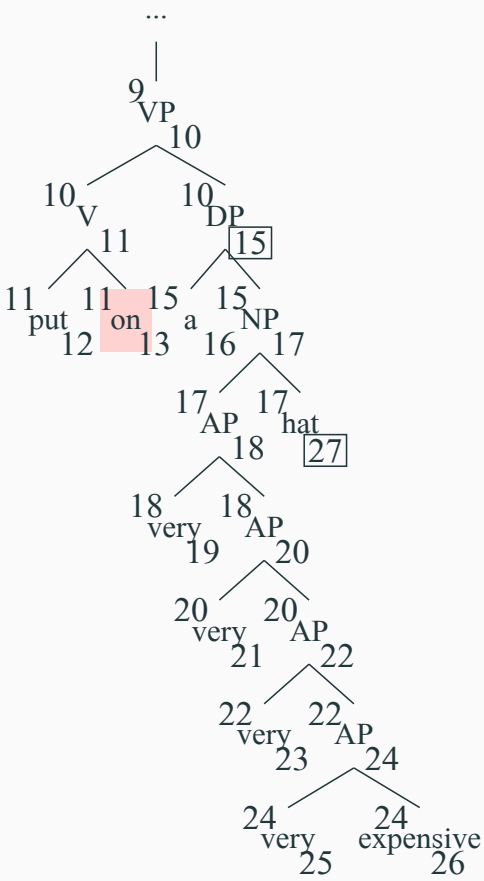

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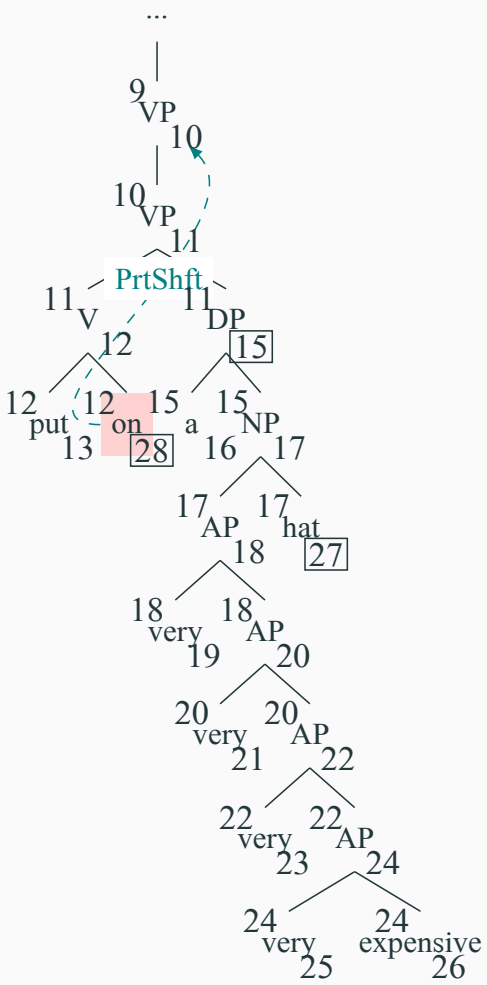

MaxT:
10/hat (join) < 16/on (sep.) ✓

Weight measured in memory cost - English PV

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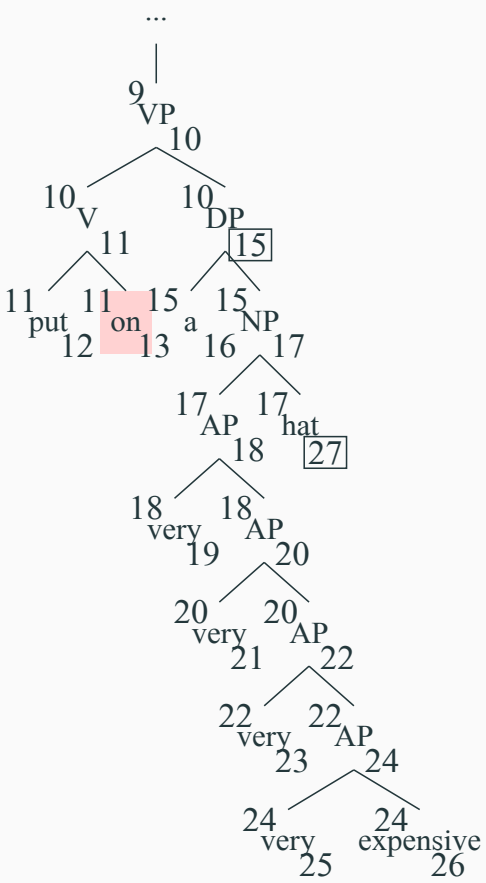

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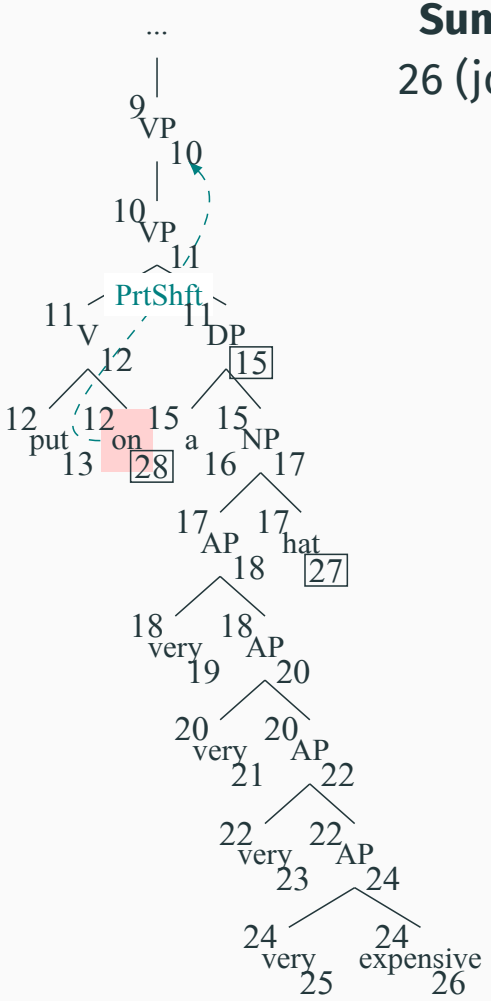


MaxT:

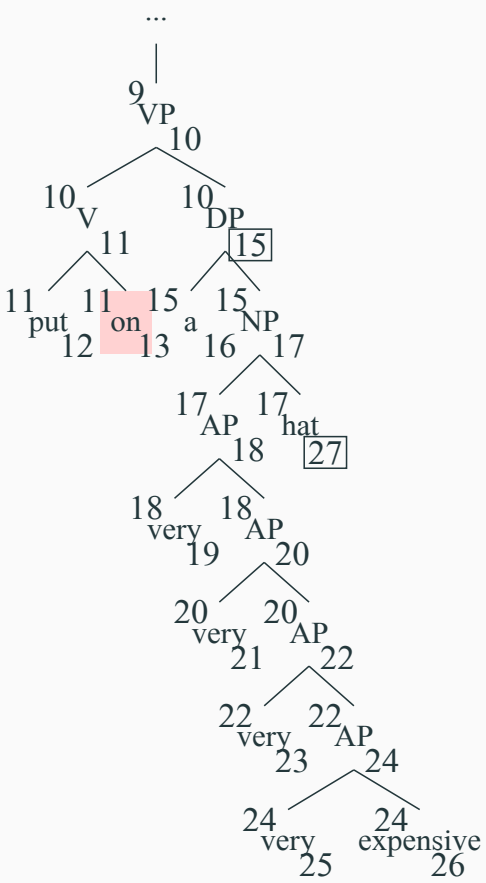
10/hat (join) < 16/on (sep.) ✓

SumT:

26 (join)

Weight measured in memory cost - English PV

(30) put on [a very very...hat]



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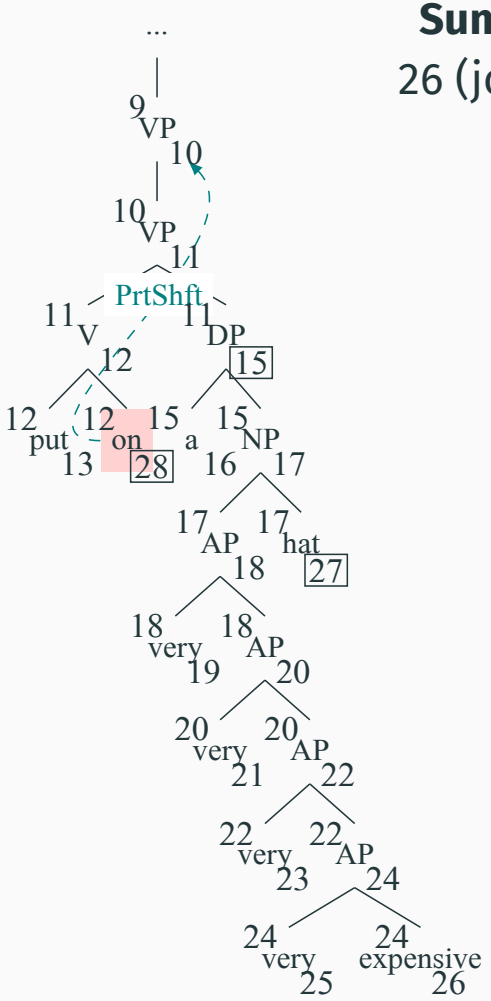


MaxT:

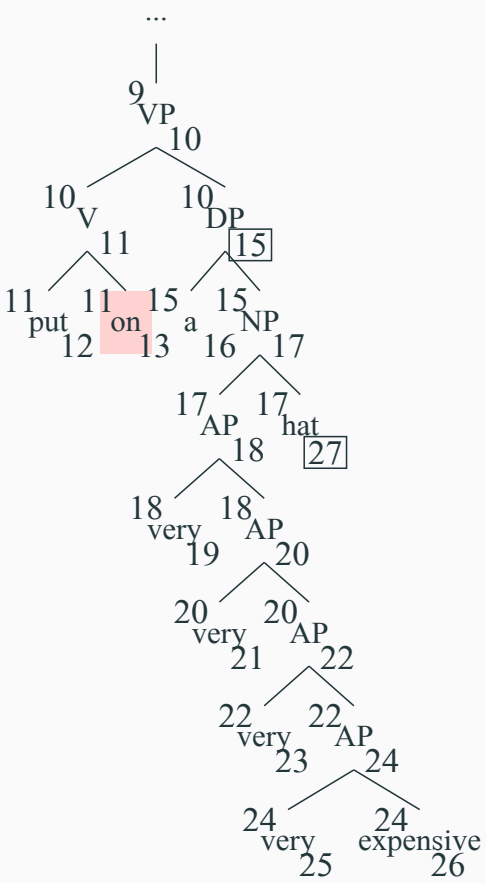
10/hat (join) < 16/on (sep.) ✓

SumT:

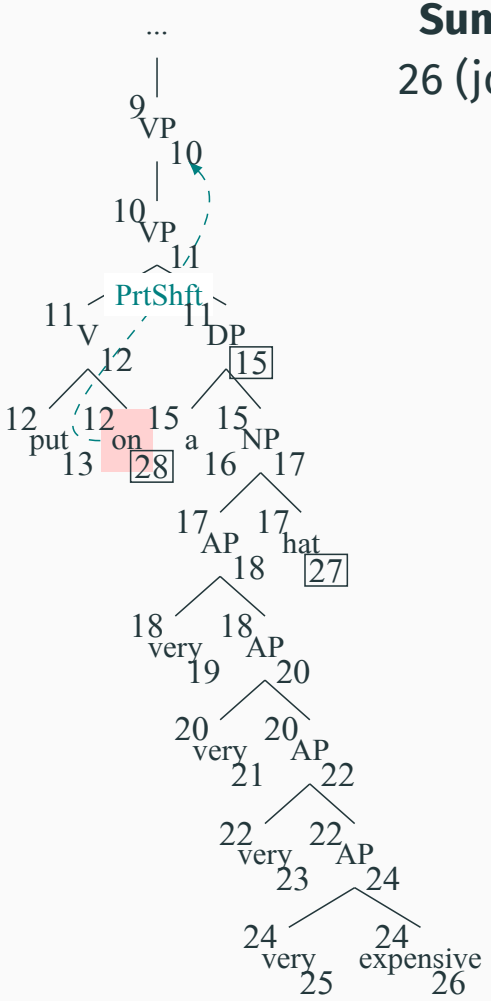
26 (join) < 41 (sep.)

Weight measured in memory cost - English PV

(30) put on [a very very...hat]



(31) put [a very very...hat] on



MaxT:

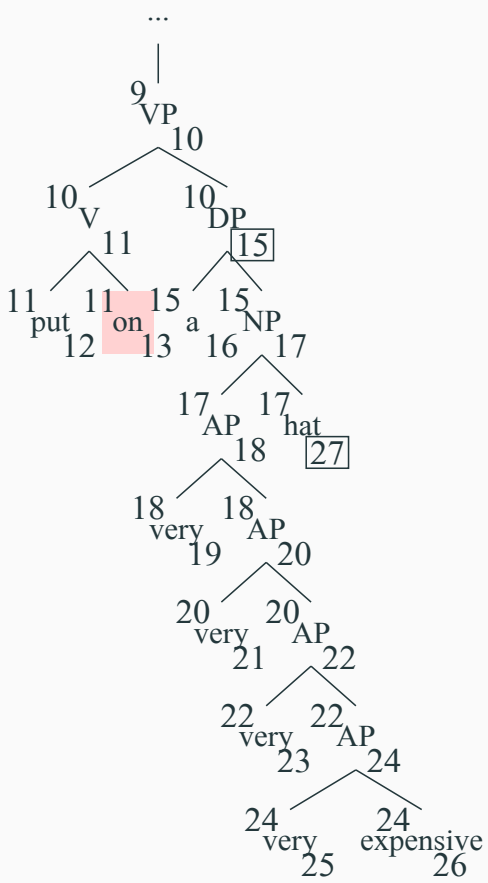
10/hat (join) < 16/on (sep.) ✓

SumT:

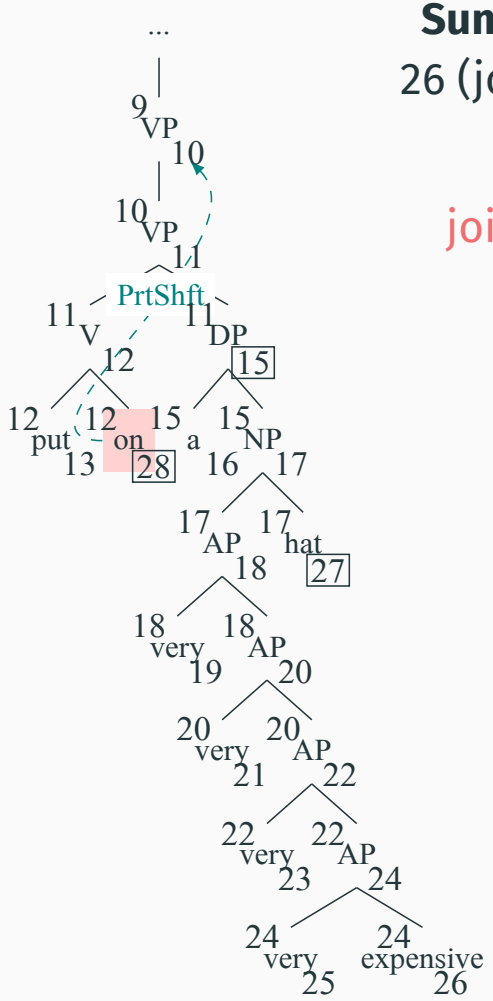
26 (join) < 41 (sep.) ✓

Weight measured in memory cost - English PV

(30) put on [a very very...hat]



(31) put [a very very...hat] on



MaxT:

10/hat (join) < 16/on (sep.) ✓

SumT:

26 (join) < 41 (sep.) ✓

joined order advantage!