Left-corner Minimalist parsing of mixed word-order preferences

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The presentation for busy people:

- Languages exhibit mixed word order preferences, including short-before-long, long-before-short, and no preference.
- The syntactic structures underlying preferred word orders are memory-efficient for a left-corner parser for Minimalist Grammars; no memory cost difference is found for structures with no word order preference.
- The results support the viability of left-corner Minimalist parsing as a psycholinguistically plausible model for offline human sentence processing.

Outline

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1. Introduction
   - Mixed word-order preferences
   - Left-corner Minimalist parsing
2. Modeling mix word-order preferences
   - English heavy NP shift
   - Japanese transitive
   - Mandarin PPs
3. Conclusion

Introduction

Mixed word-order preferences

- Short-before-long preference
  - English heavy NP shift (HNPS) — arm-chair judgement

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

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

  - English post-verbal PP adjuncts — Universal Dependencies (UD) (Liu 2020)
  - Mandarin *ba*-construction and its alternative — Penntree bank (Liu 2022)
- Long-before-short preference
  - Japanese di/transitive — Self-paced reading (Yamashita and Chang 2001)

    (3) SOV

    [keezi-ga] [Se-ga takakute gassiri sita hanni-o] oikaketa
    detective-nom height-nom tall-and big-boned suspect-acc chased

    (4) OSV (preferred w/ long object)

    [Se-ga takakute gassiri sita hanni-o] [keezi-ga] oikaketa
    height-nom tall-and big-boned suspect-acc detective-nom chased

    'The detective chased the suspect who is tall and big-boned.'

Mixed word-order preferences

- Short-before-long preference
  - English heavy NP shift (HNPS)
  - English post-verbal PP adjuncts
  - Mandarin *ba*-construction and its alternative
- Long-before-short preference
  - Japanese transitive
  - Korean PP dative
- No preference
  - Mandarin preverbal PPs
  - Japanese preverbal PPs

Our processing model captures all of the above!

Minimalist processing modeling

- Three components of Minimalist processing modeling
  - formal characterization of structural analysis
    - syntactic analyses for mixed word orders
    - Standard Minimalist Grammars (MGs) (Stabler 1997; 2011)
  - implementation of formalisms to parsing models
    - parser: left-corner (LC) arc-eager mover-eager parser for MGs (Stanojević and Stabler 2018, Hunter et al. 2019)
    - metric: tenure-derived
  - modeling results evaluation
    - It works!

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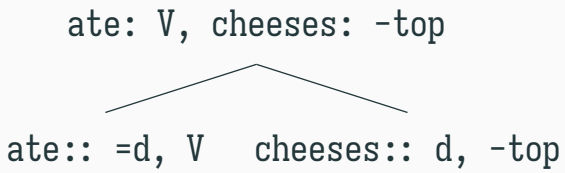
Minimalist Grammars

- Minimalist Grammars: lexicalized grammar formalisms based on the Minimalist Program (Chomsky 2014).
  - lexical items
    - feature bundles
    - phonetics, category, selection, movement
  - operations
    - merge, move

Minimalist Grammars

1. `cheeses:: d, -top`
2. `the:: =n, d, -k`
3. `rat:: n`
4. `ate:: =d, V`
5. `v:: =V, =d, v`
6. `t:: =v, +k, t`
7. `c:: =t, +top, c`

$\Rightarrow$ Cheeses, the rat ate.



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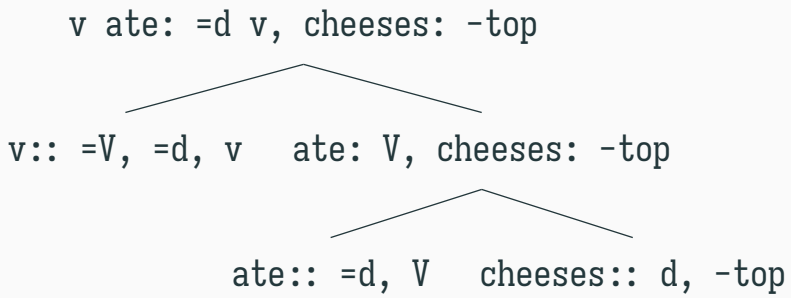

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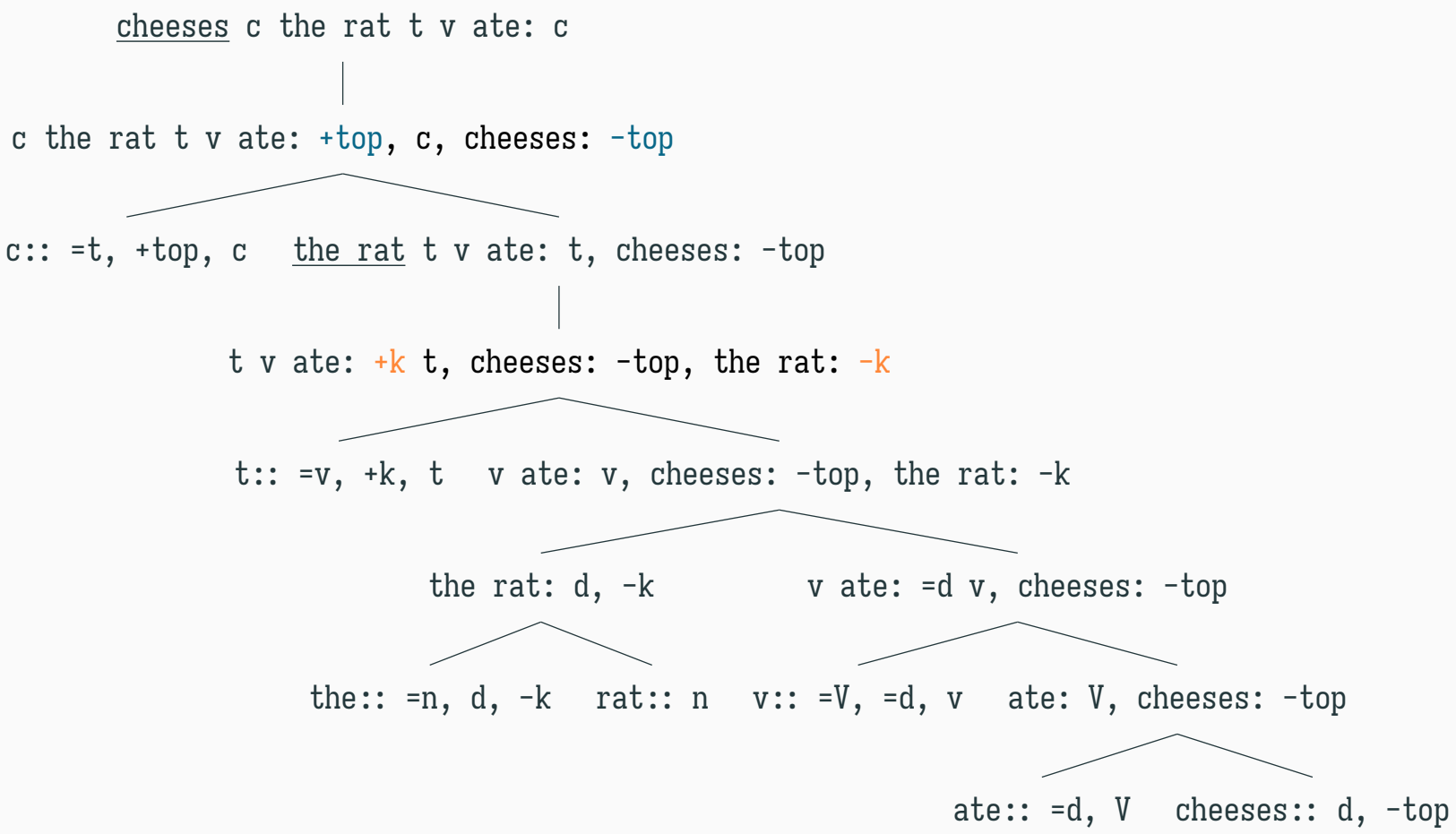

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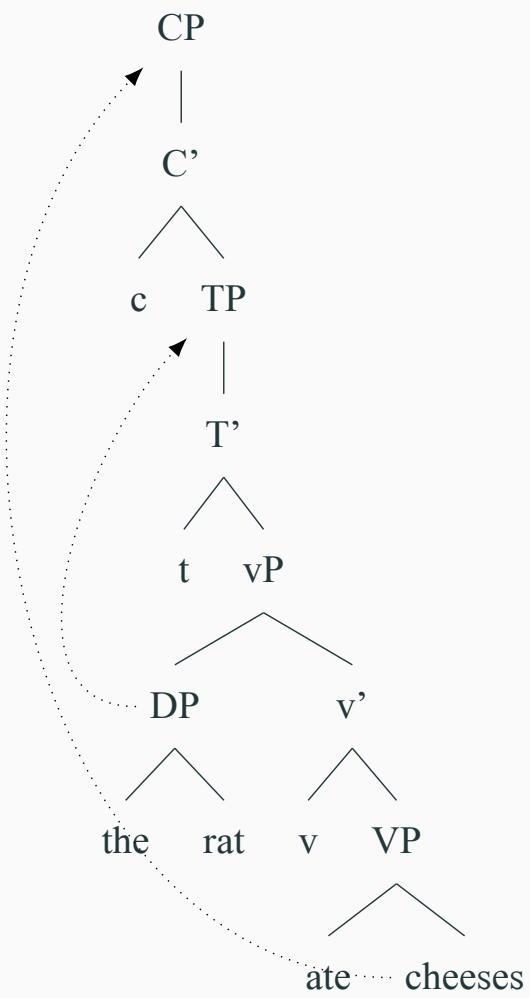

- Easy-to-read derivation tree
  - phrase and leave nodes
  - movement arrows

LC Minimalist parsing

- LC MG parser for modeling
  - input string $\rightarrow \frac{\text{grammar}}{\text{algorithm}} \rightarrow$ structure
    - input string: pronounced and unpronounced words
    - grammar: MGs
    - algorithm: left-corner, arc-eager, move-eager
    - structure: derivation trees
  - additional assumption for processing modeling:
    - perfect oracle

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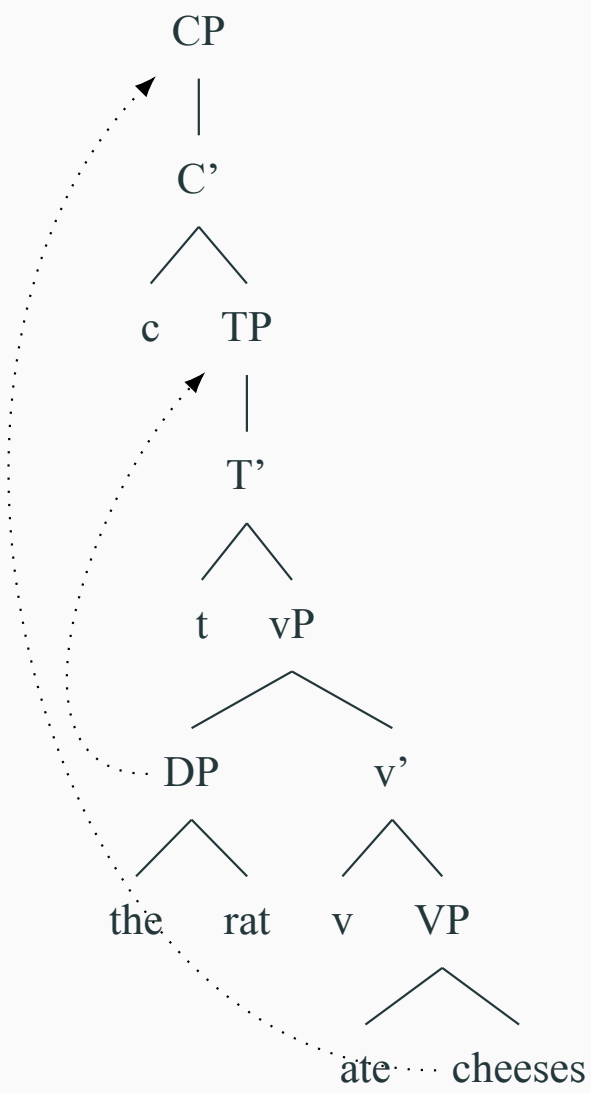

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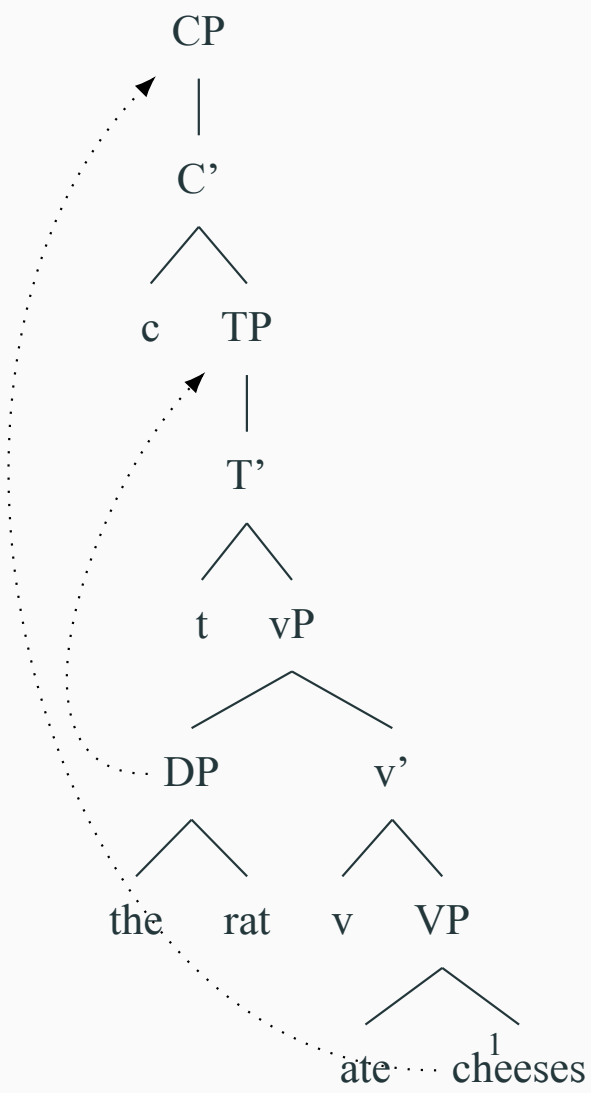

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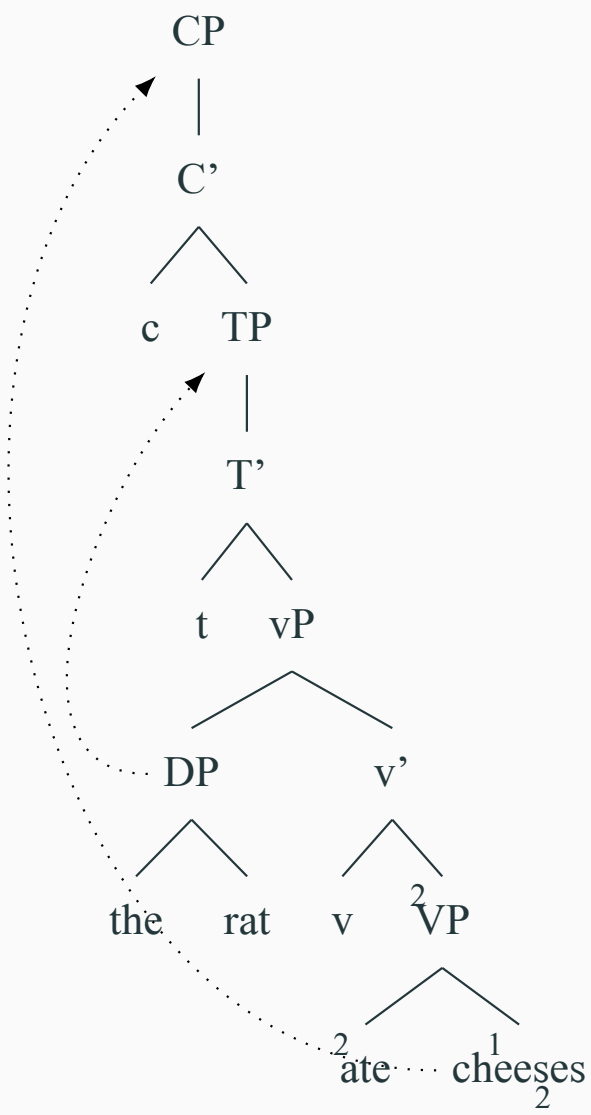

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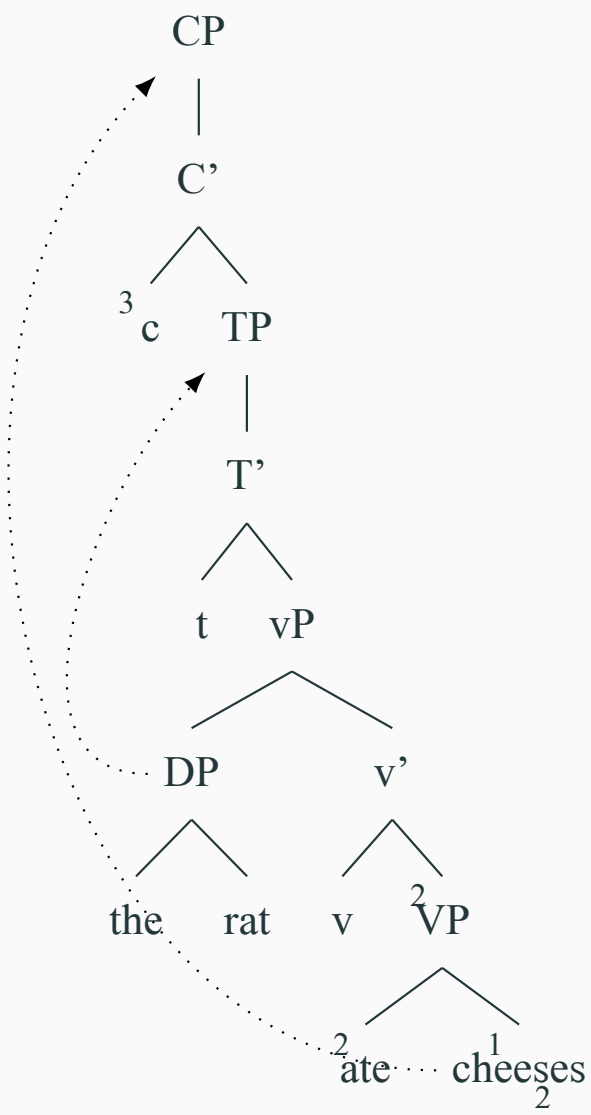

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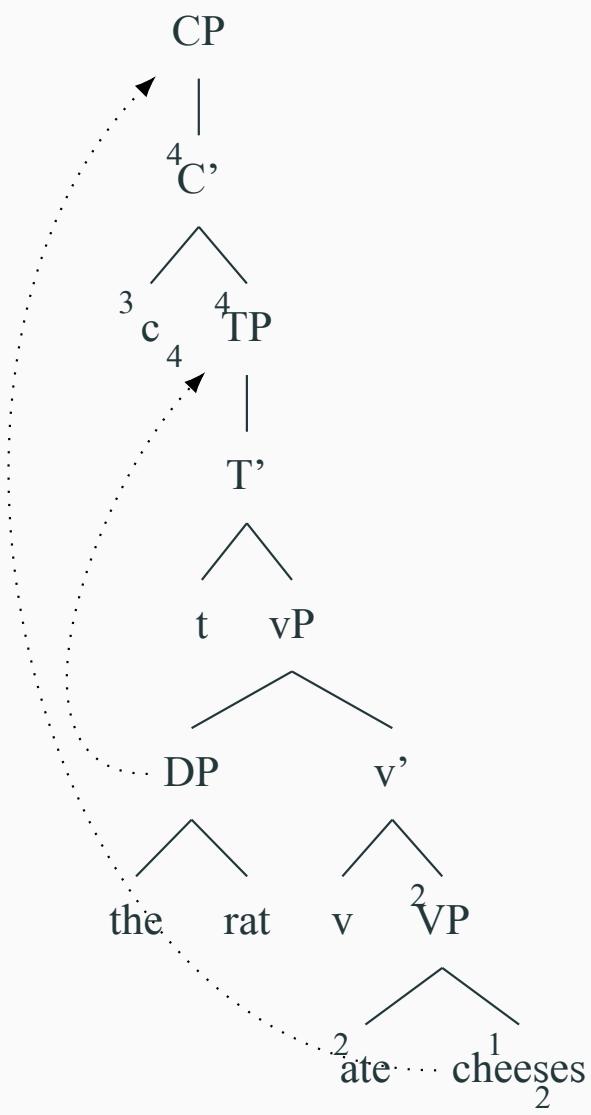

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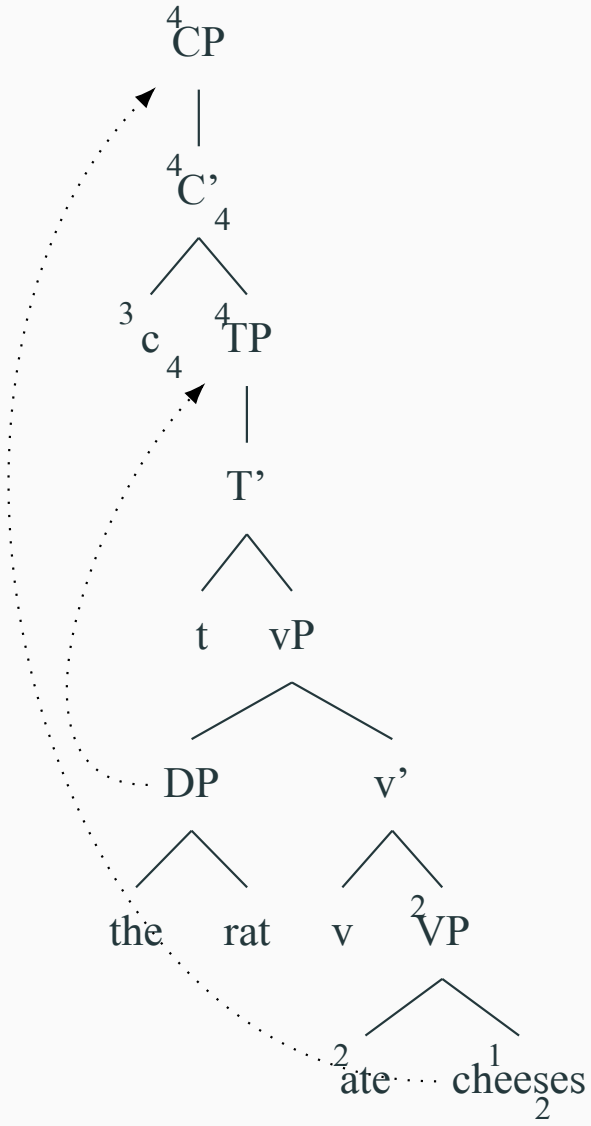

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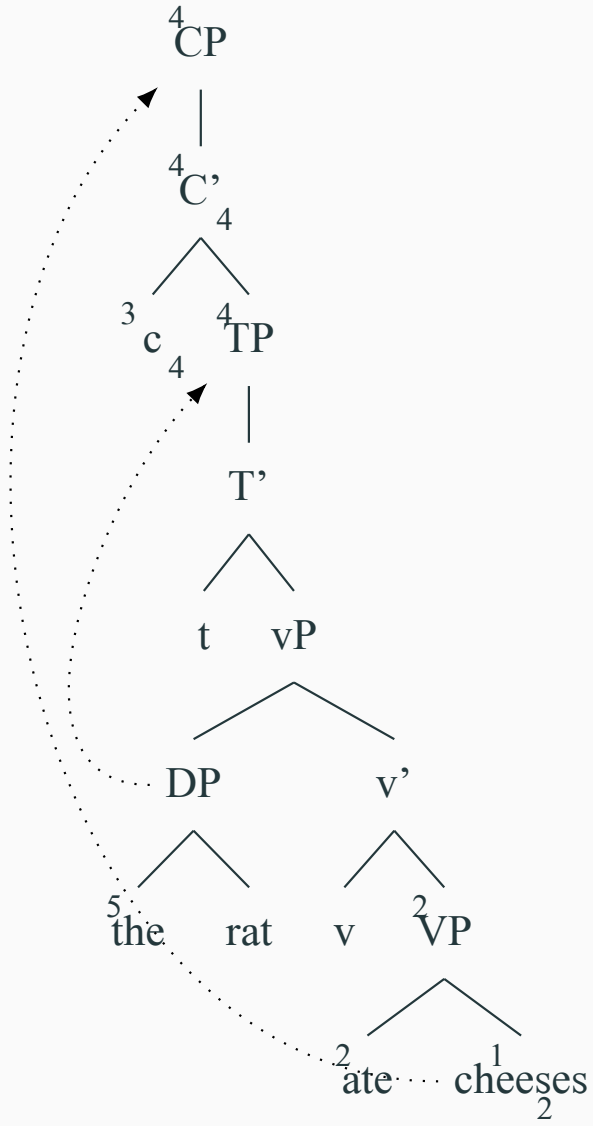

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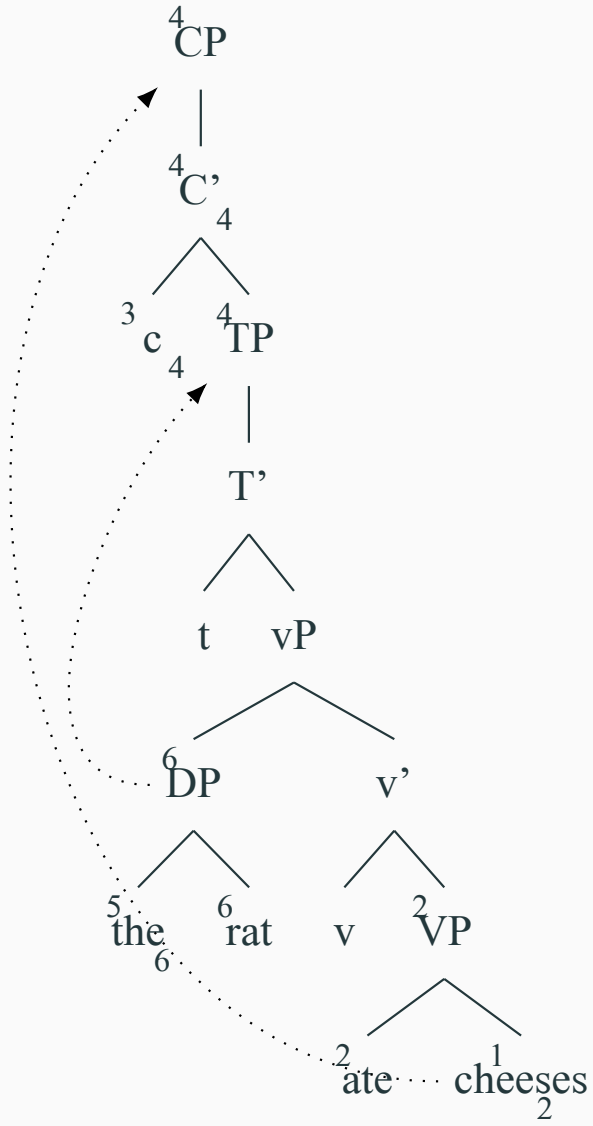

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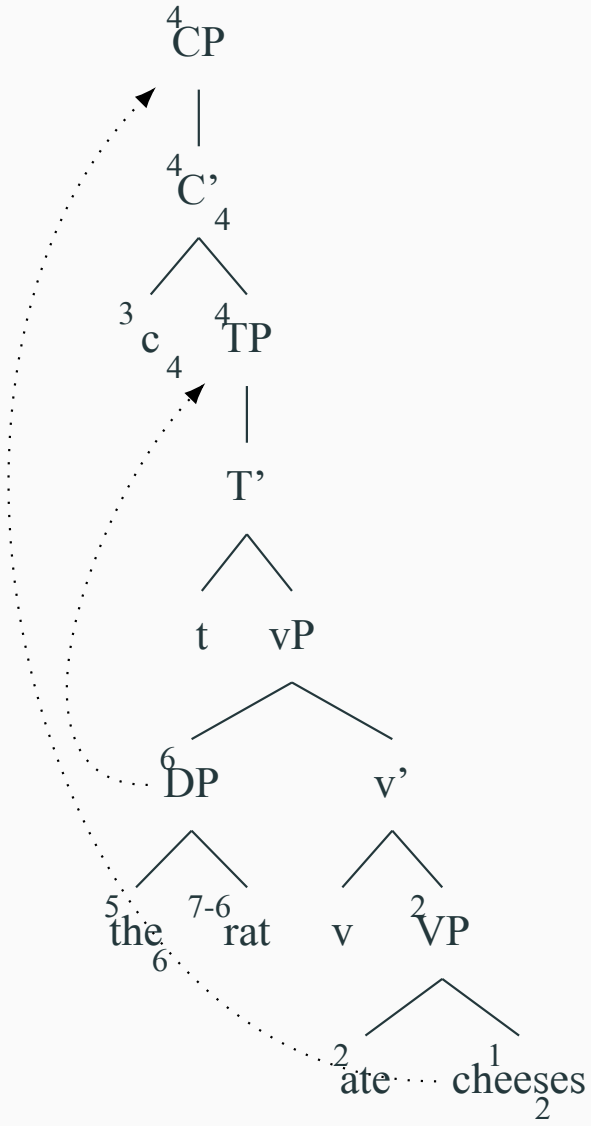

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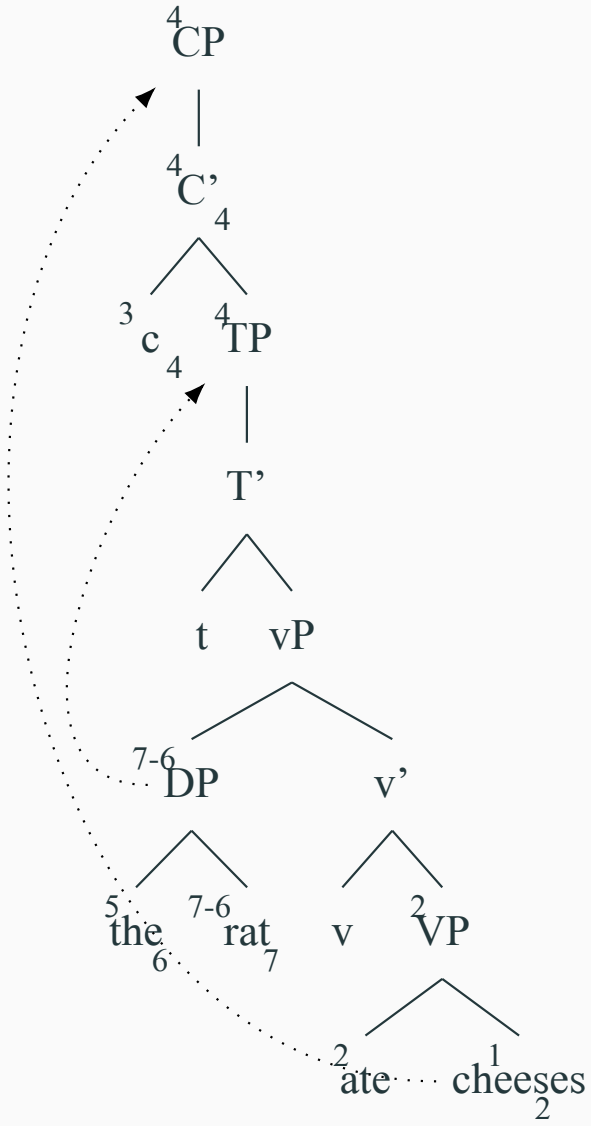

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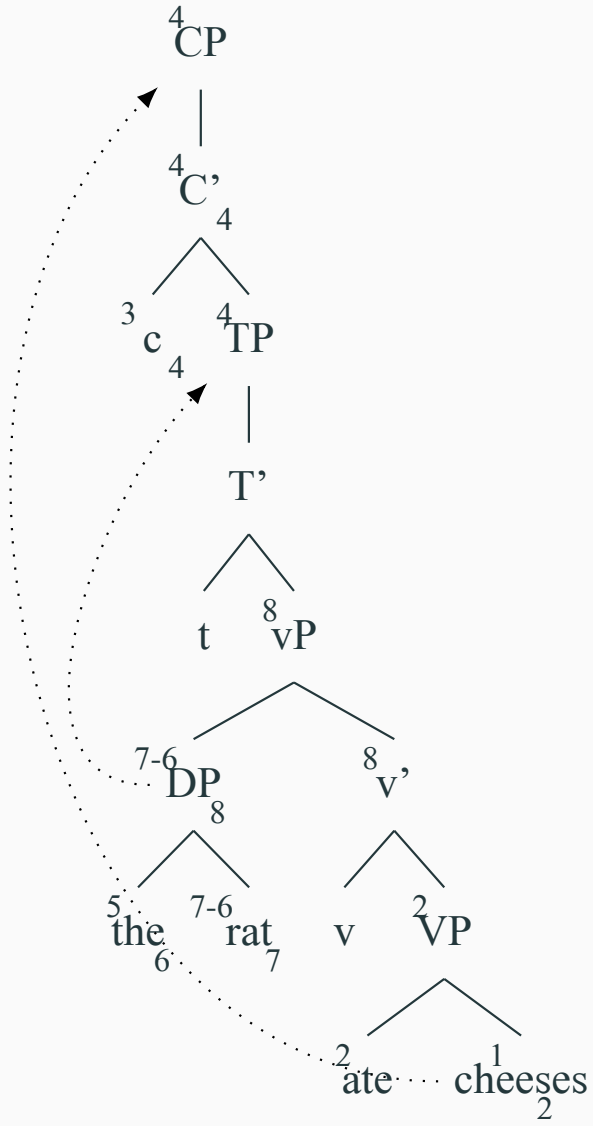

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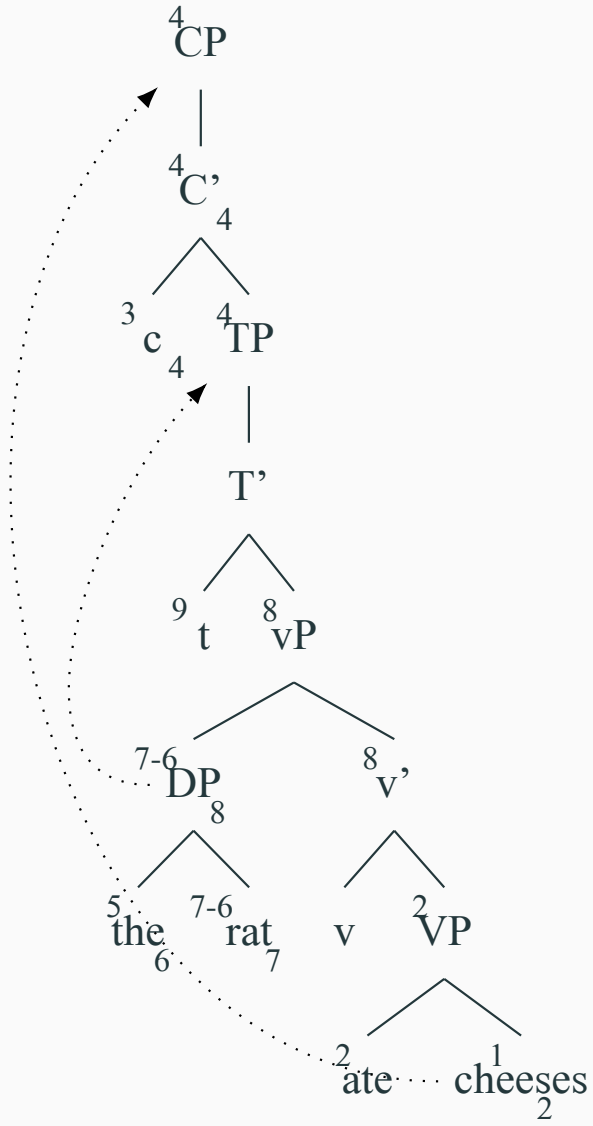

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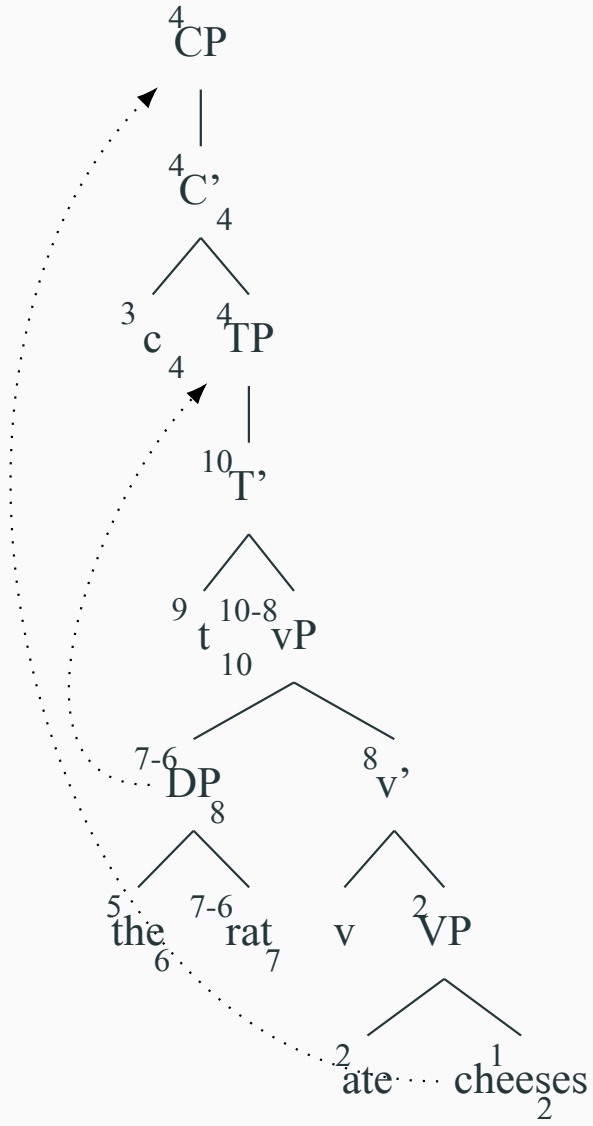

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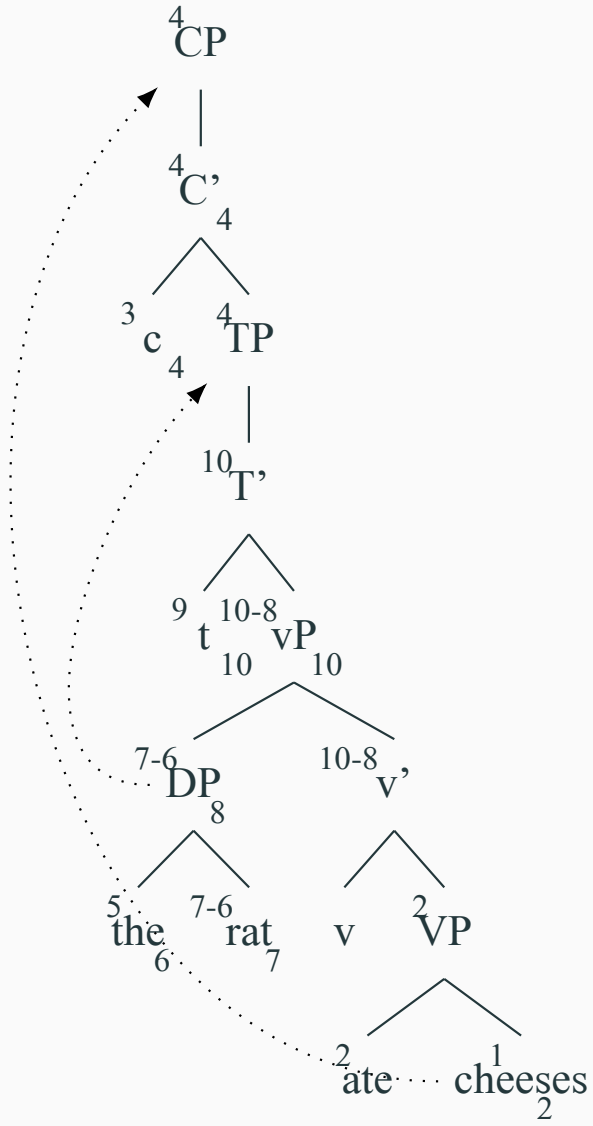

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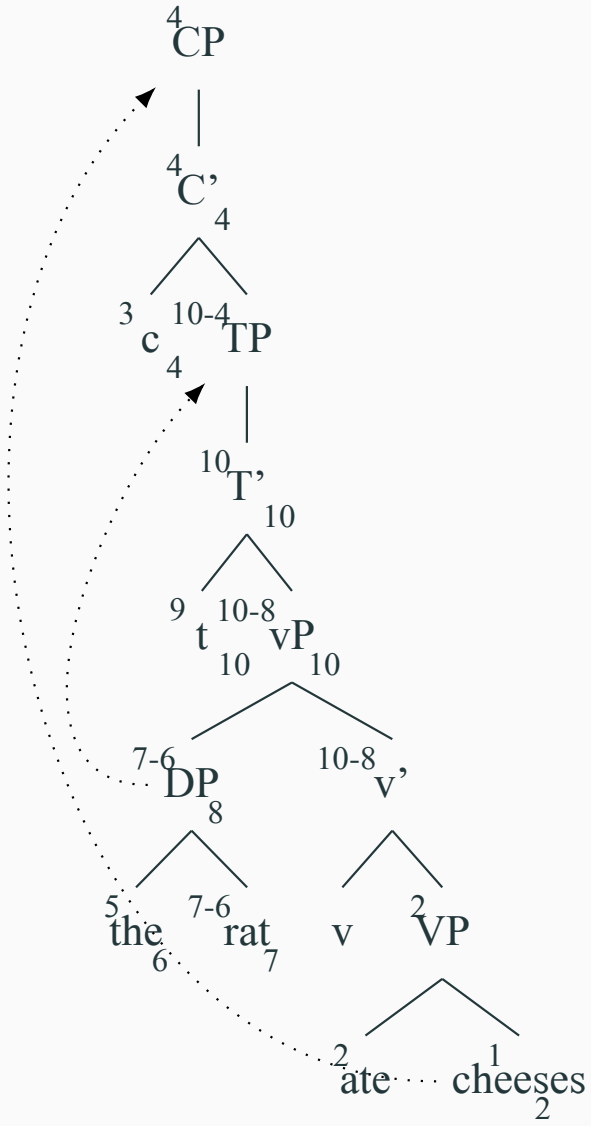

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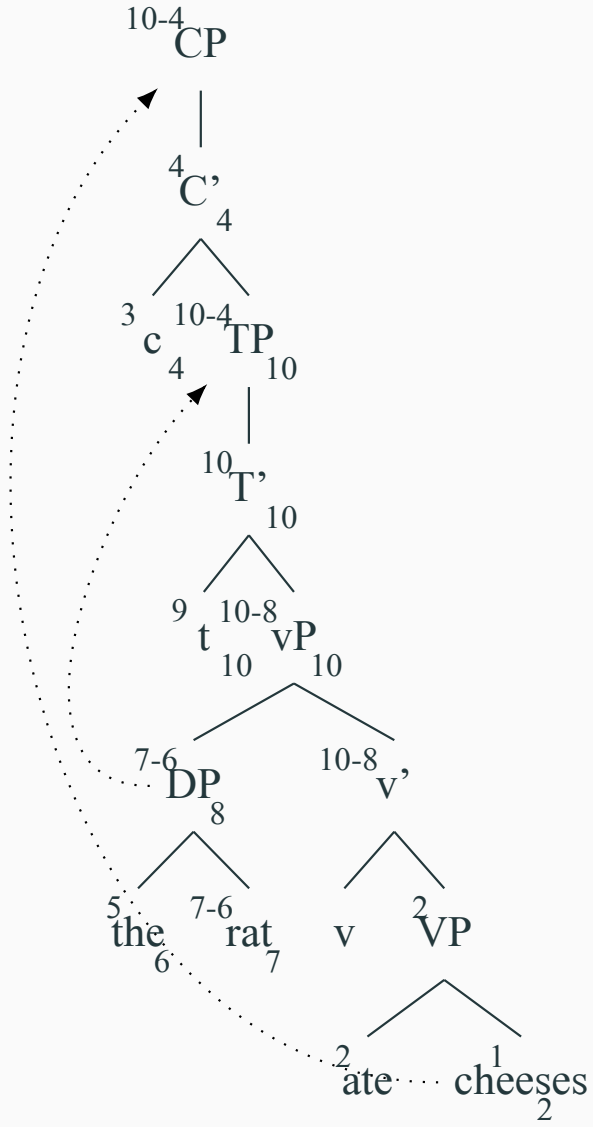

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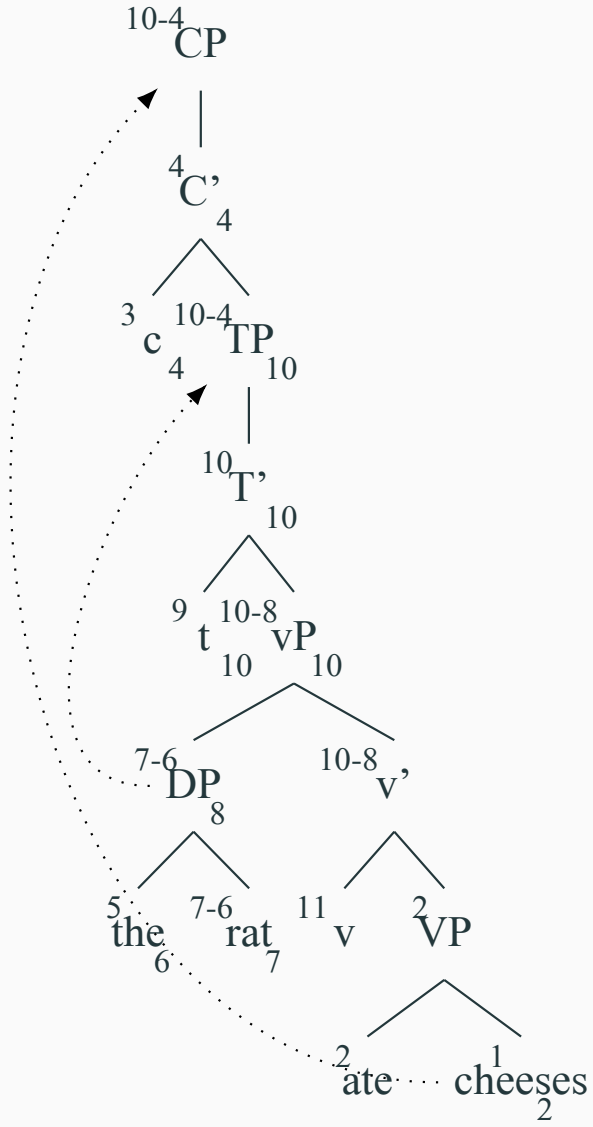

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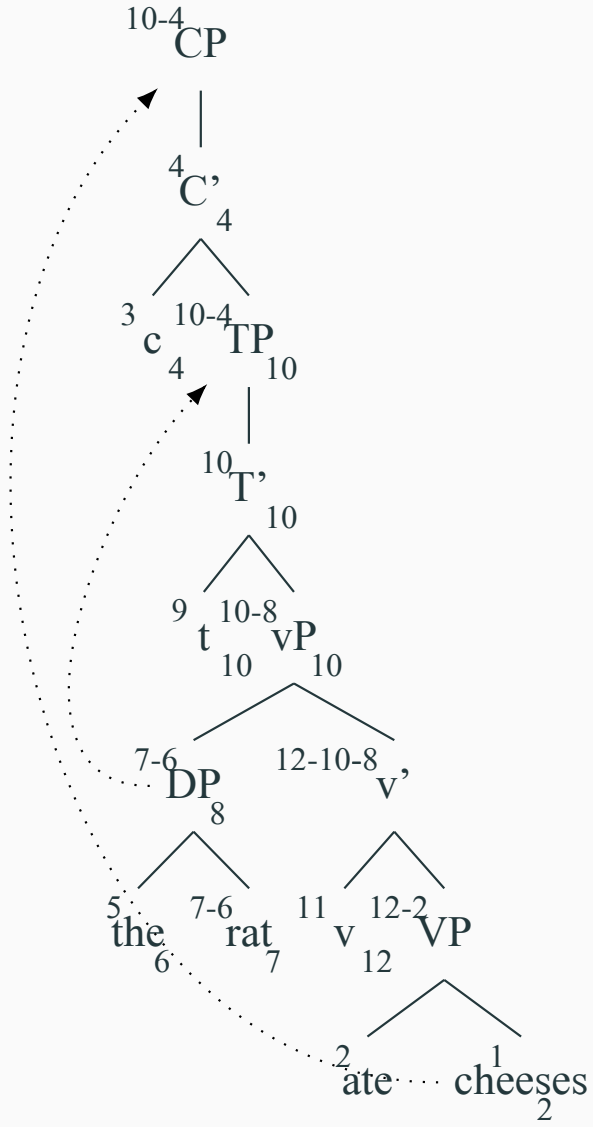

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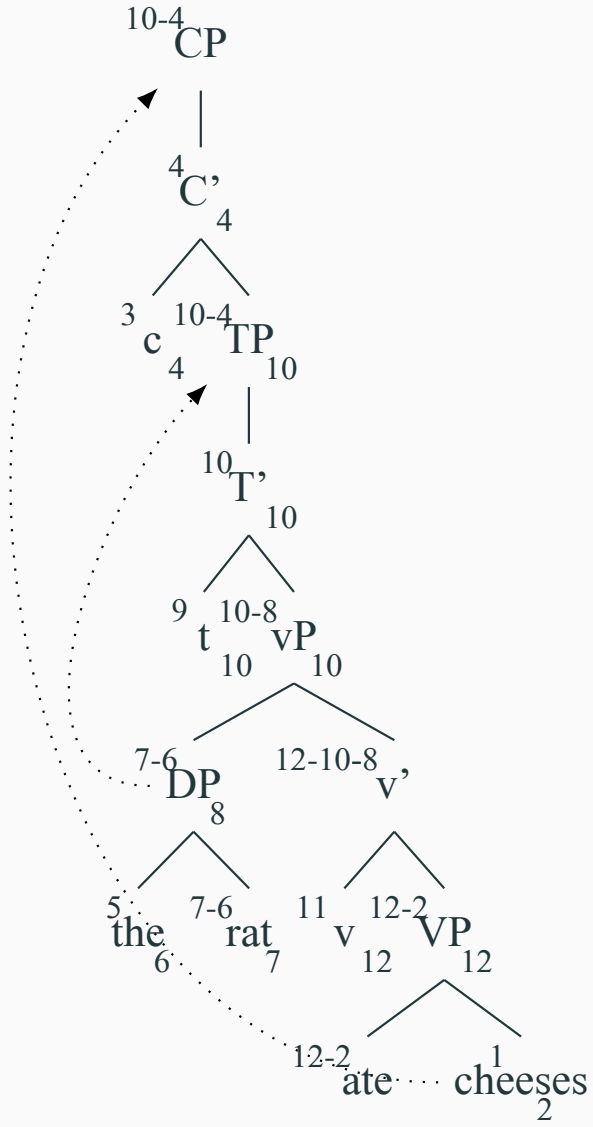

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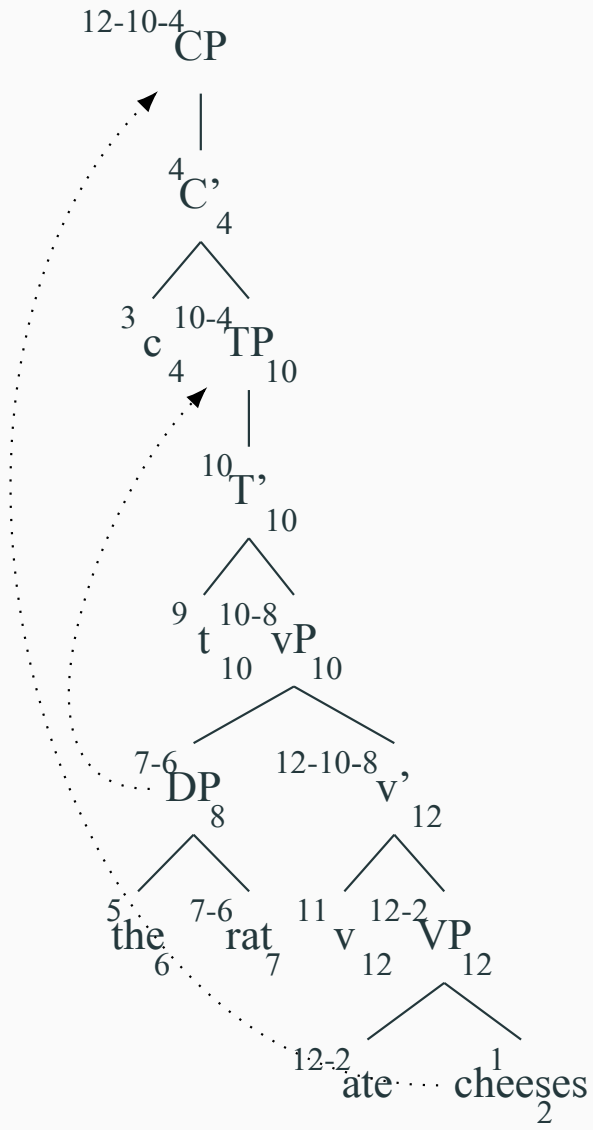

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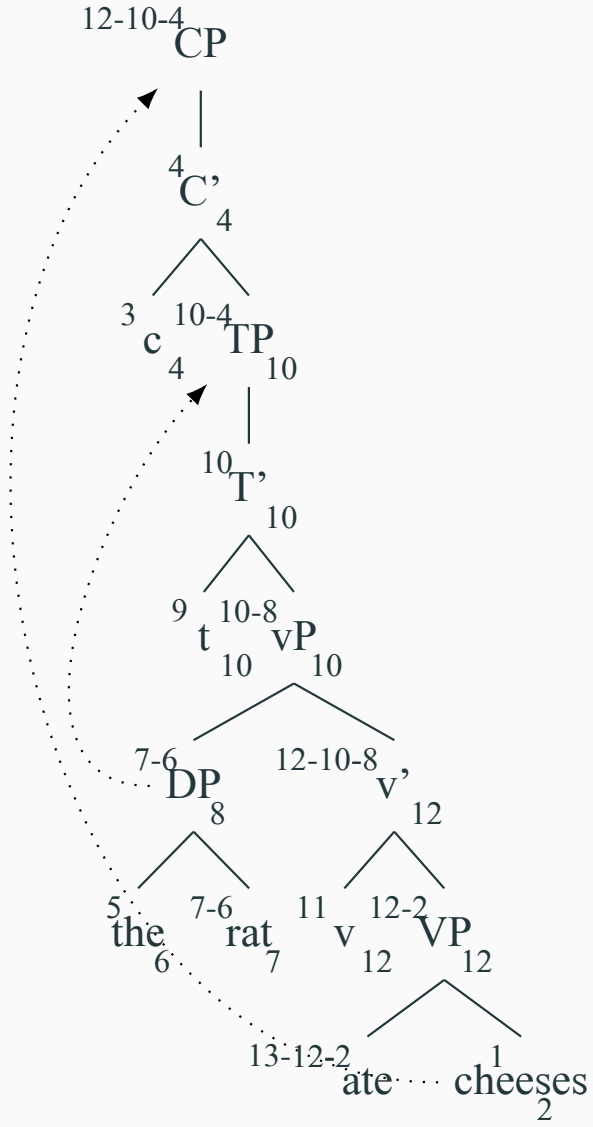
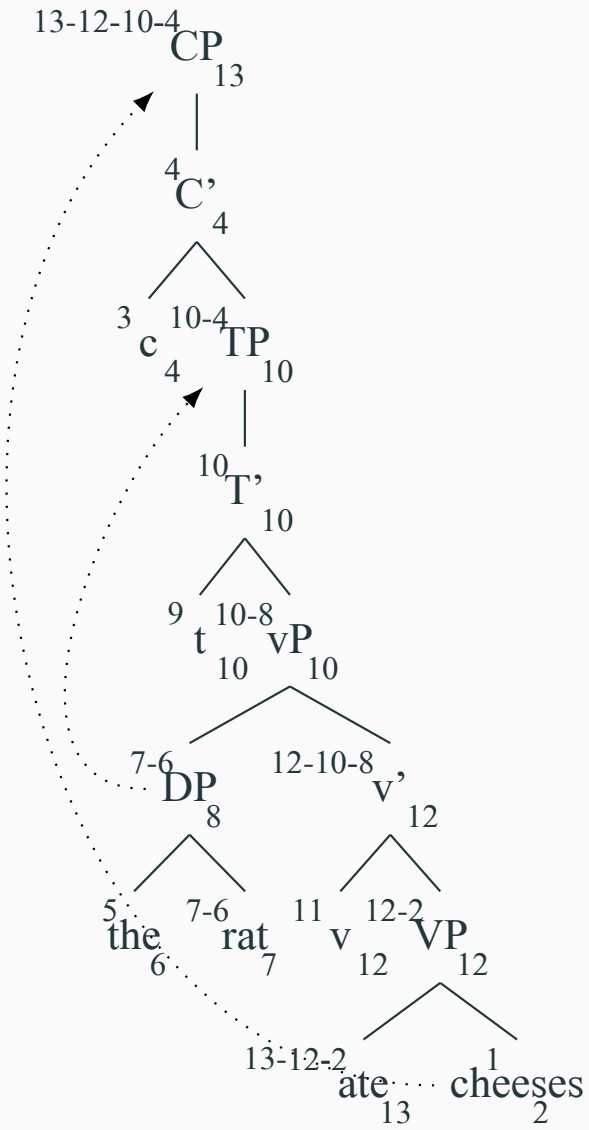
Step 11 read v
Step 12 predict VP, v'
Step 12' connect down
Step 12" connect up
Step 13 read ate
Step 13' complete CP



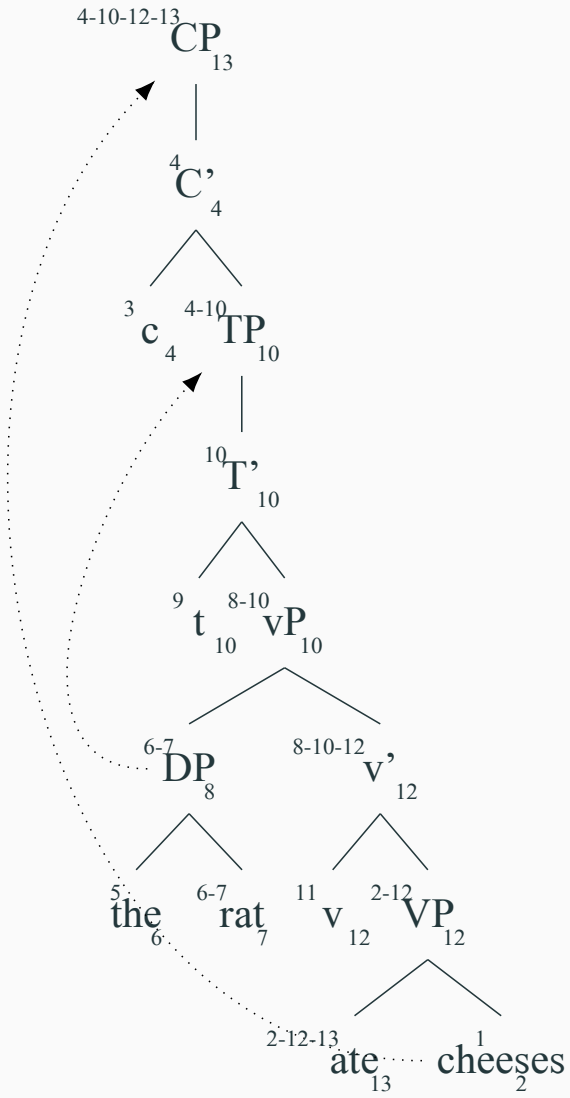
LC Minimalist parsing

(5) Cheeses, c the rat t v ate •

Step 1 read cheeses
Step 2 predict ate, VP
Step 3 read c
Step 4 predict TP, C'
Step 4' unmove C'
Step 5 read the
Step 6 predict rat, DP
Step 7 read rat
Step 7' complete DP
Step 8 predict v', vP
Step 9 read t
Step 10 predict vP, T'
Step 10' connect down
Step 10" unmove T'
Step 10"' connect up
Step 11 read v
Step 12 predict VP, v'
Step 12' connect down
Step 12" connect up
Step 13 read ate
Step 13' complete CP



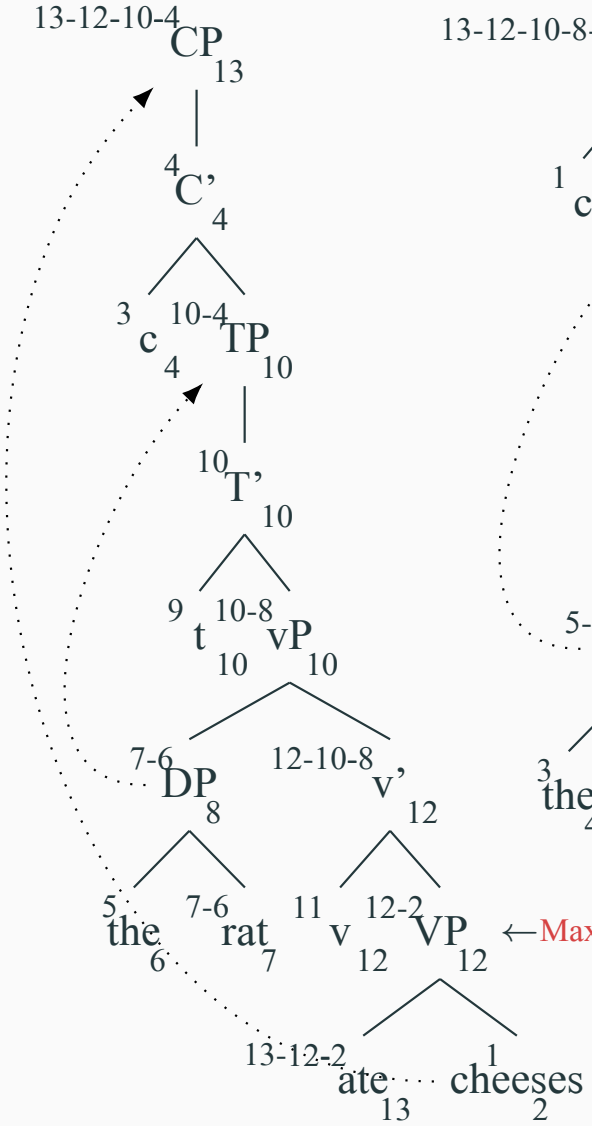
LC Minimalist Parsing



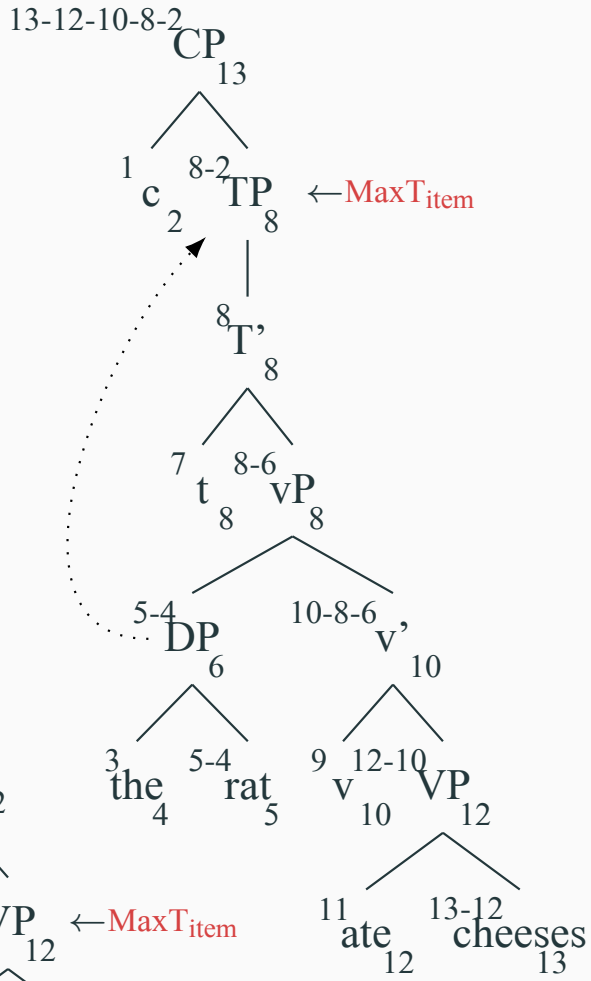
- $^{2\text{-}12}\text{VP}_{12}$
  - index: when the parser updates its memory of the node
    - *LC predict* based on "cheeses": V $\Rightarrow$ VP
    - *LC predict* based on v: VP $\Rightarrow$ v'
  - outdex: when the parser throws the node out of the memory
- Memory usage (Kobele et al. 2013, Graf et al. 2015)
  - Tenure: how long a parse item is held in memory
  - $\text{MaxT}_{\text{item}}$: tenure of the longest stored item

LC Minimalist parsing

(6) Cheese, the rat ate.



(7) The rat ate cheeses.



- Larger $\text{MaxT}_{\text{item}}$, harder to process
- Topicalized: $\text{MaxT}_{\text{item}}$ = 10 difficult!
- Canonical: $\text{MaxT}_{\text{item}}$ = 6

Modeling mix word-order preferences

Modeling results

	$\text{MaxT}_{\text{item}}$		
Word order	short-before-long[†]	long-before-short	no preference
	ENG HNPS	JPN transitive	CHN PPs
short-before-long	8	12	14
long-before-short	12	3	14

Table 1: Modeling results based on $\text{MaxT}_{\text{item}}$

[†] typo in paper

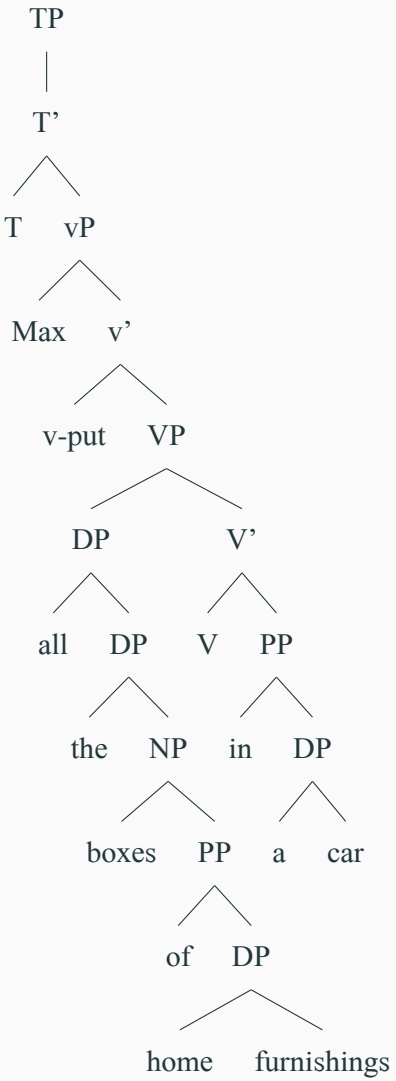
English HNPS: Data

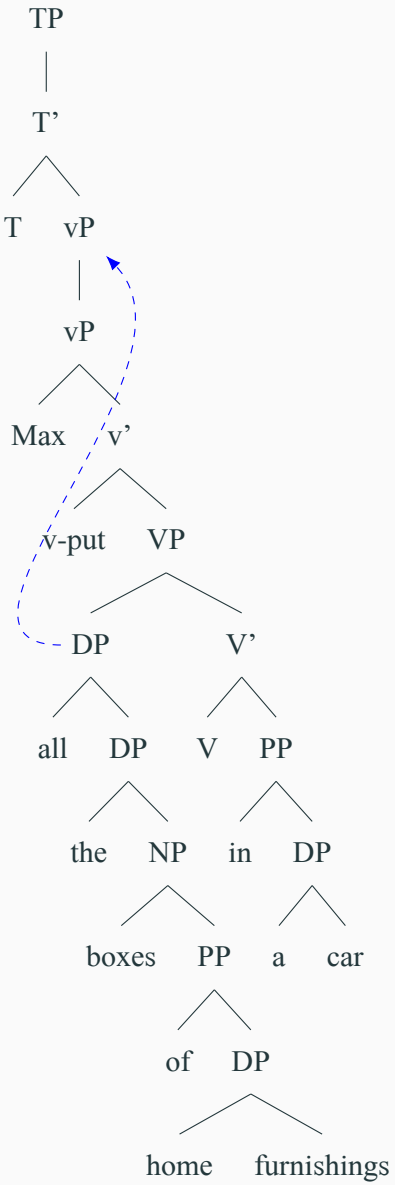
(8) Max put [PP in his car] [DP all the boxes of home furnishings].

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

A shifted order (PP-DP) is preferred when the DP is heavy (e.g. Brown corpus Wasow 1997).

English HNPS: Syntax and modeling results

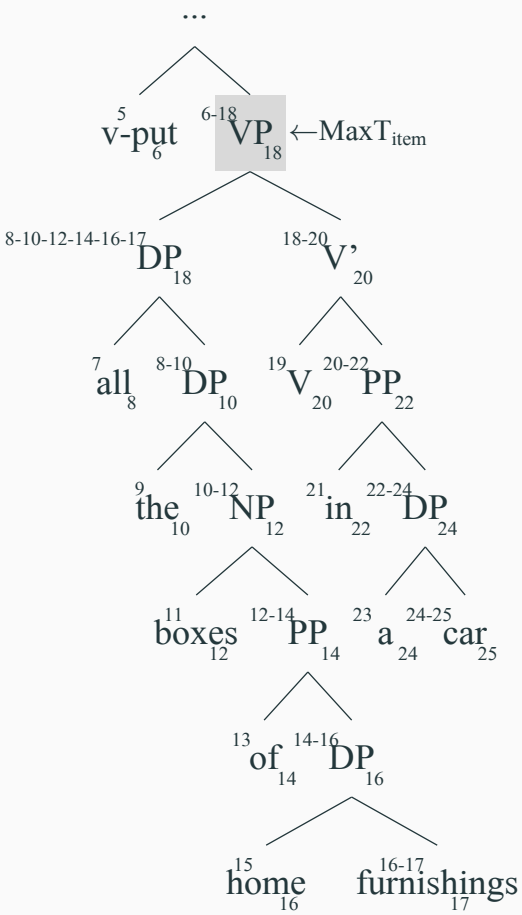




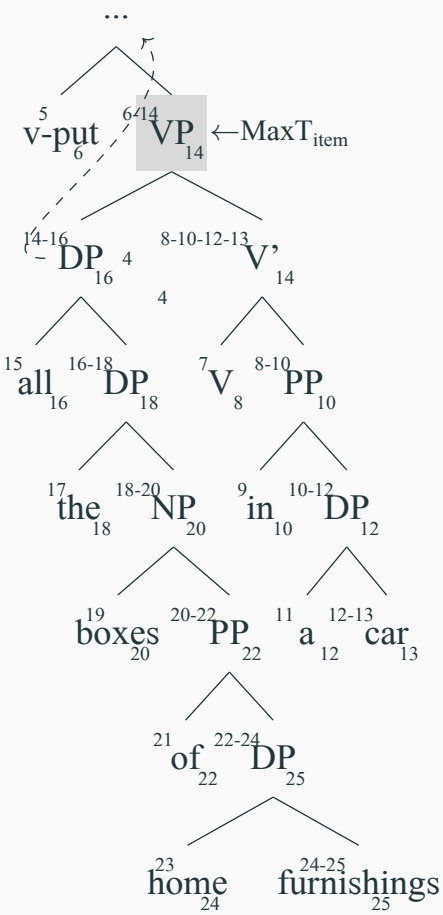
- Shifted order: rightward movement (Ross 1986)
- Ignored: V-to-v movement, ArgO-movement
- Results:
  - canonical order: $MaxT_{item}$ = 12
  - Shifted order: $MaxT_{item}$ = 8

  => Shifted order is easier to process

English HNPS: Annotation



(a) HNPS - Canonical order



(b) HNPS - Shift order

Japanese transitive: Data

(10) SOV

[short keezi-ga] [long Se-ga takakute gassiri sita hanni-o]
detective-nom height-nom tall-and big-boned suspect-acc
oikaketa
chased

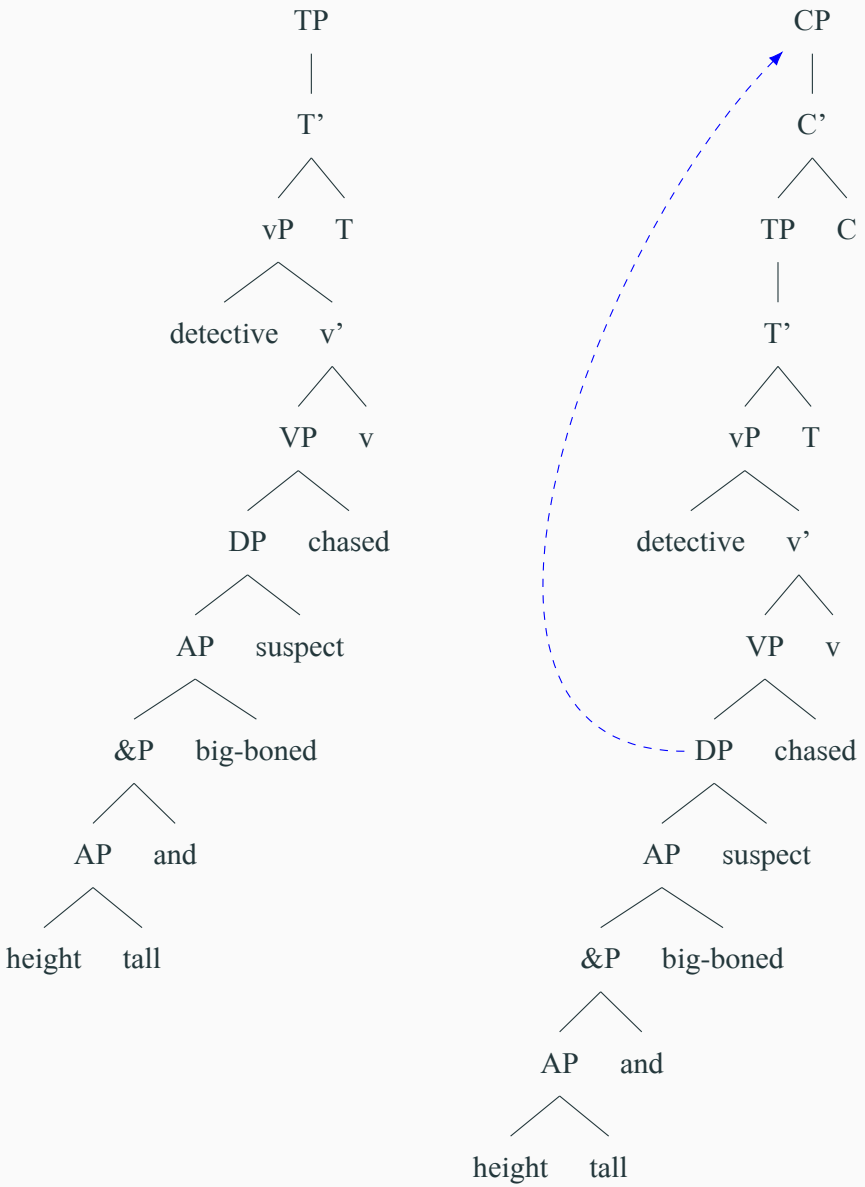
(11) OSV

[long Se-ga takakute gassiri sita hanni-o] [short keezi-ga]
height-nom tall-and big-boned suspect-acc detective-nom
oikaketa
chased

'The detective chased the suspect who is tall and big-boned.'

"Japanese speakers tend to shift long arguments ahead of short ones in an on-line task." (Yamashita and Chang 2001)

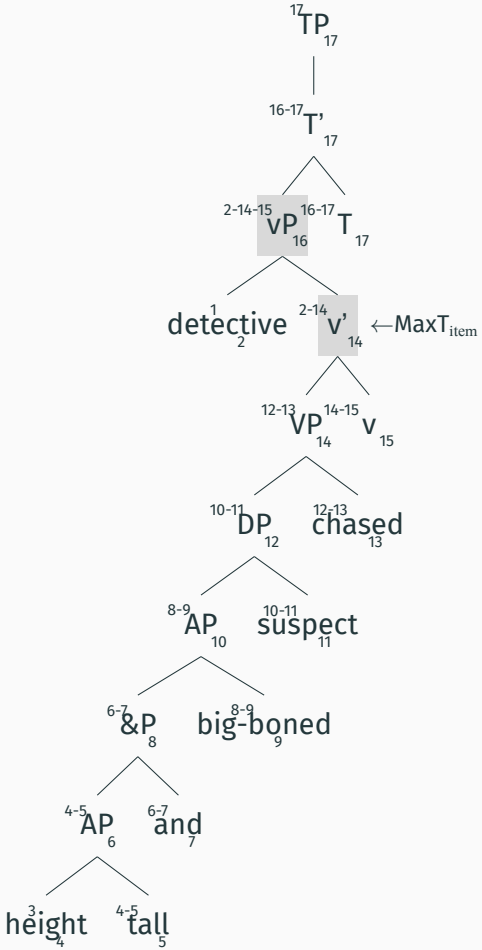
Japanese transitive: Syntax and modeling results



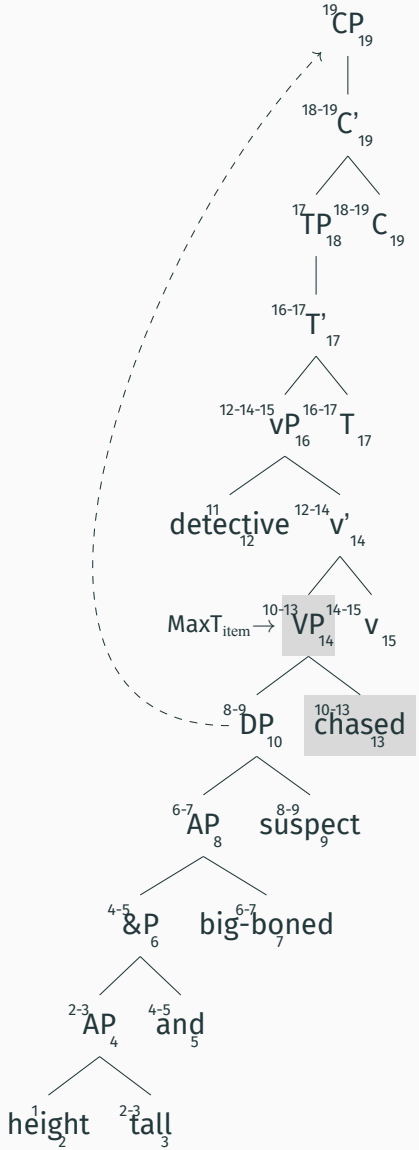
- Shifted order: scrambling to CP (Saito 1992)
- Ignored: V-to-v movement, ArgO-movement
- Results:
  - canonical order: $MaxT_{item}$ = 12
  - Shifted order: $MaxT_{item}$ = 3

  => Shifted order is easier to process

Japanese transitive: Annotation



(a) Japanese - SOV order



(b) Japanese - OSV order

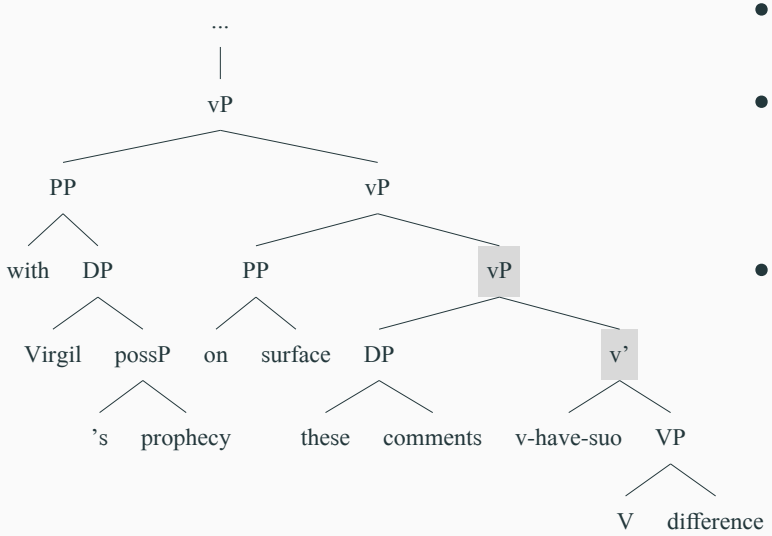
Mandarin PPs: data

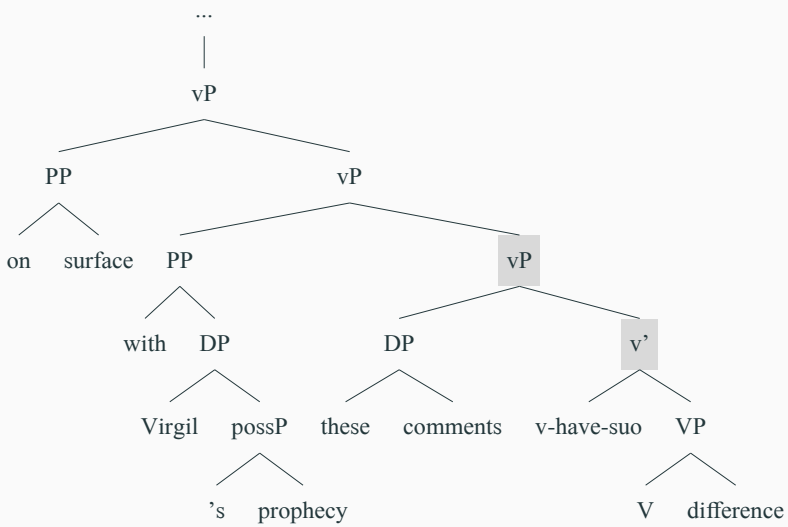
(12) zhexie yanlun T [PP.long he weijier de yuyan] [PP.short zai biaomian]
these comments with Virgil's prophecy on the surface
v-you-suo V churu
have-suo differences

(13) zhexie yanlun T [PP.short [zai biaomian] [PP.long [he weijier de yuyan]
these comments on the surface with Virgil's prophecy
v-you-suo V churu
have-suo differences
'These comments have differences on the surface with Virgil's prophecy.'
(from Liu 2020, silent nodes added)

No word order preference is found between whether ordering the longer PP first (12) or the shorter first (13). (Liu 2020)

Mandarin PPs: : Syntax and modeling results

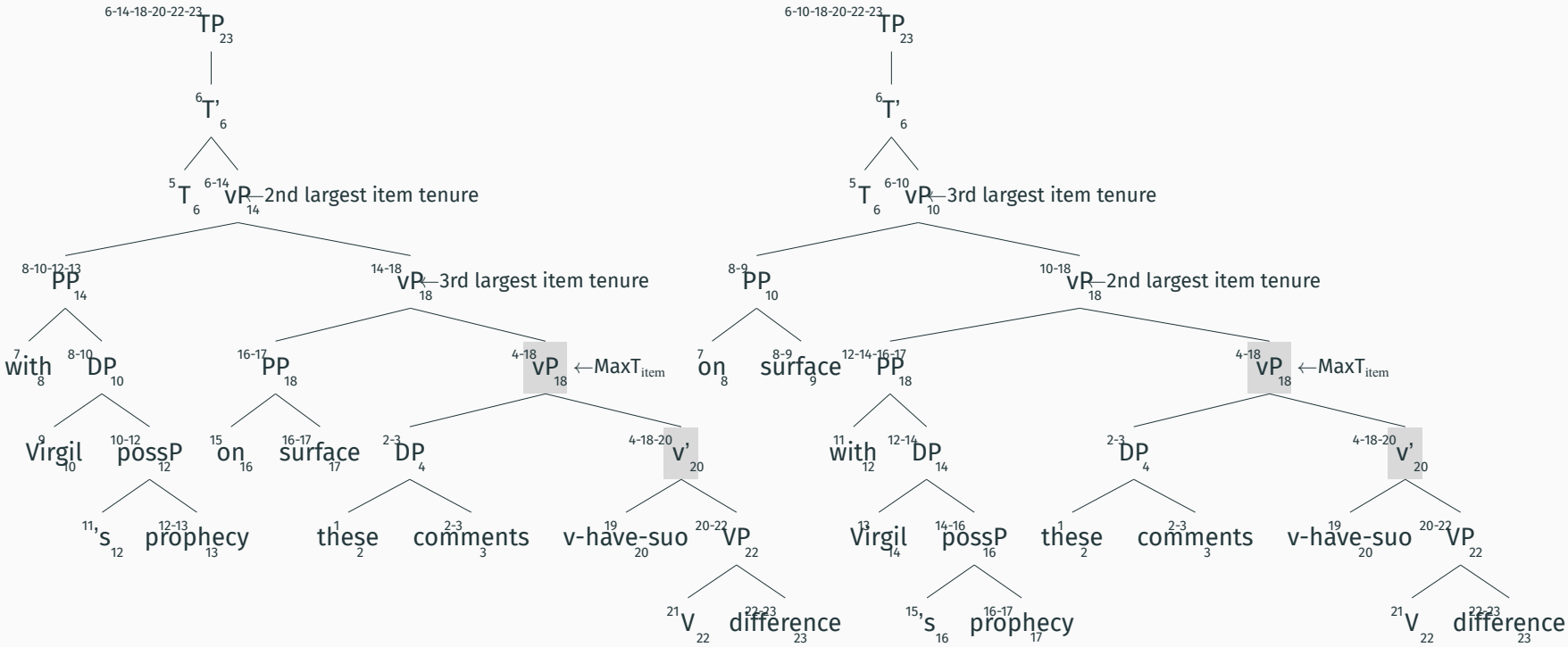




- Syntax: base-gen of adjunct PP
- Ignored: V-to-v movement, ArgO-movement
- Results:
  - long-first
    $MaxT_{item}$ = 14
  - short-first:
    $MaxT_{item}$ = 14

=> no order preference

Mandarin PPs: Annotation



(a) Mandarin Chinese - long first **(b)** Mandarin Chinese - short first

Conclusion

Conclusion

- LC MG parsing as a psycholinguistically adequate model for offline human sentence processing:
  - Current results:

	$\text{MaxT}_{\text{item}}$	...
left-, right-, center-embeddings	✓	...
mixed order preferences	✓	...
...		

  - Next steps:
    - additional metrics
    - empirical coverage
    - incremental processing

I thank Greg Kobele and the audience at the 2024 winter Cyclop Retreat for helpful discussions.

Thank you!

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LC MG parsing: annotation scheme

- index:
  - *shift* new word
  - *complete* new node
  - *update* existing node
    - connect to old index with dash
    - multiple *LC prediction*
    - open node *connect* to existing structure
- outdex:
  - node used in *LC predict*
  - node used in *complete*
  - node used in *connect*