Syntactic constraints: Strings are more insightful than trees

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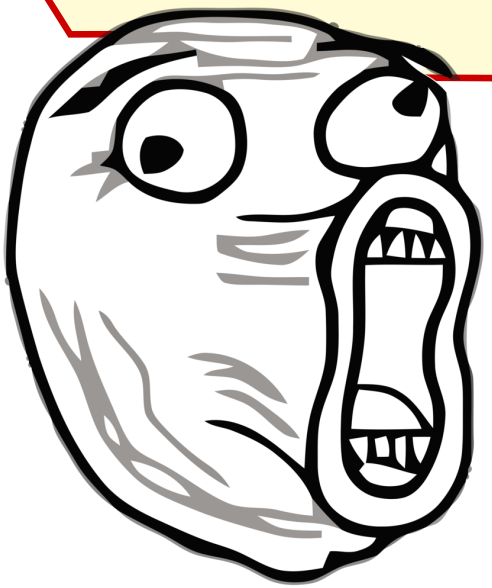
The talk in a nutshell

lol trees are so 1990 what
r linguists evne dooing u
only need sstringws u dummies!!!1!!!11!



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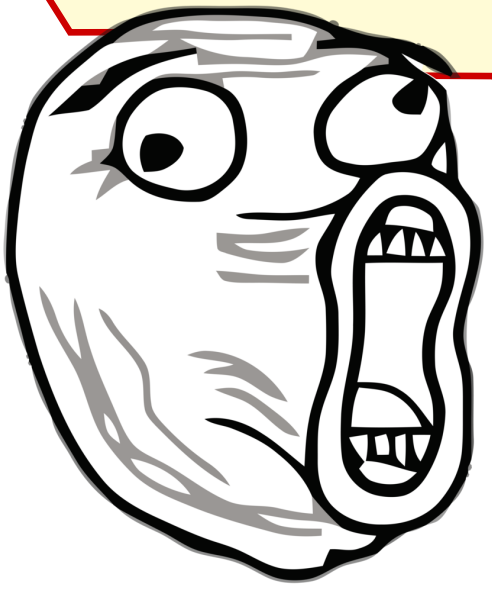

But now that I've rage baited you into paying attention,
let's be (just a bit) more serious.

The talk in a nutshell [real version]

- Syntax may well build trees.
  Perhaps due to interface demands?
- **But:** Syntactic computations don't exploit the power of trees. They operate on strings that track certain **derivational paths**.
- Why does that matter?
  - Attested syntactic constraints form a **natural class**.
    movement, islands, relativized minimality, binding of reflexives, extraction morphology, freezing, ...
  - Surprising patterns become expected.
    typology of extraction morphology, German wh-copying
  - Learnability
  - Parallels to phonology and morphology
  - Building bridges to psycho- and neurolinguistics

This will be abstract, and that's a good thing

The critical link between disciplines should come from computation, specifically, from computational models that are made explicit at the appropriate level of **abstraction** *to create an interface for linguistics and neurobiology.*

(Poeppel and Embick 2005)

David Poeppel

David Embick

Outline

Syntax: Computation, not structures

Which talk might upset the audience?

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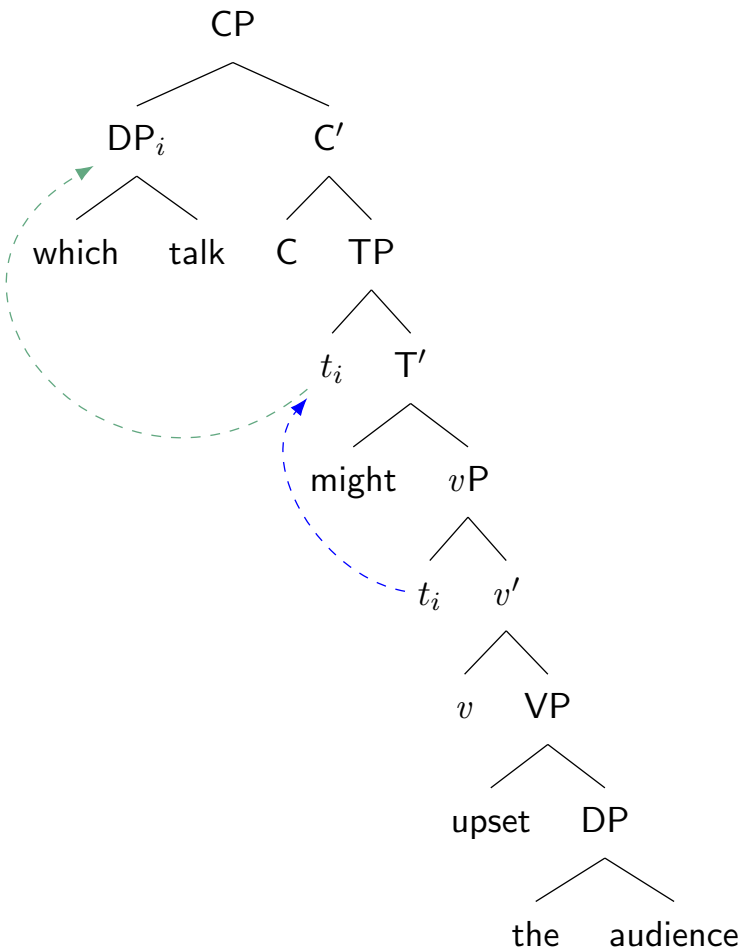

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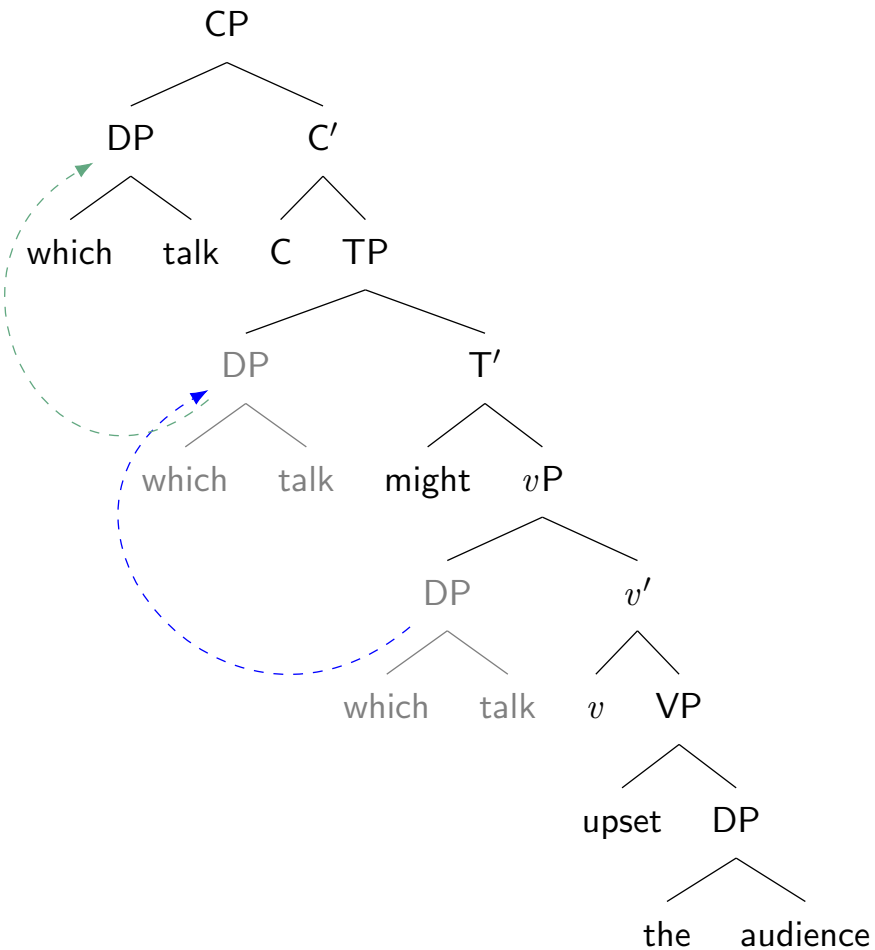

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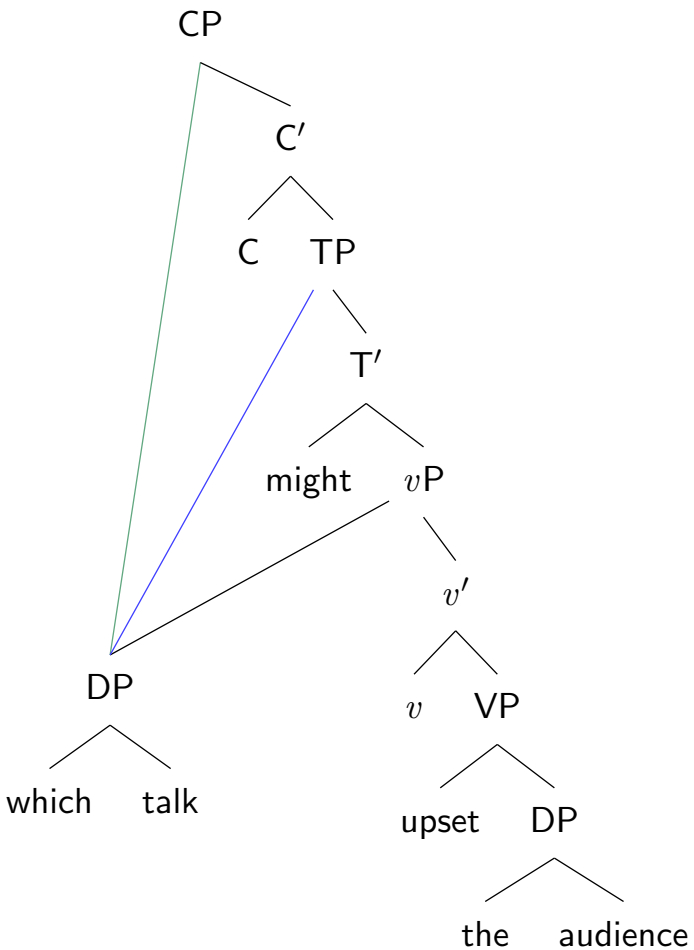

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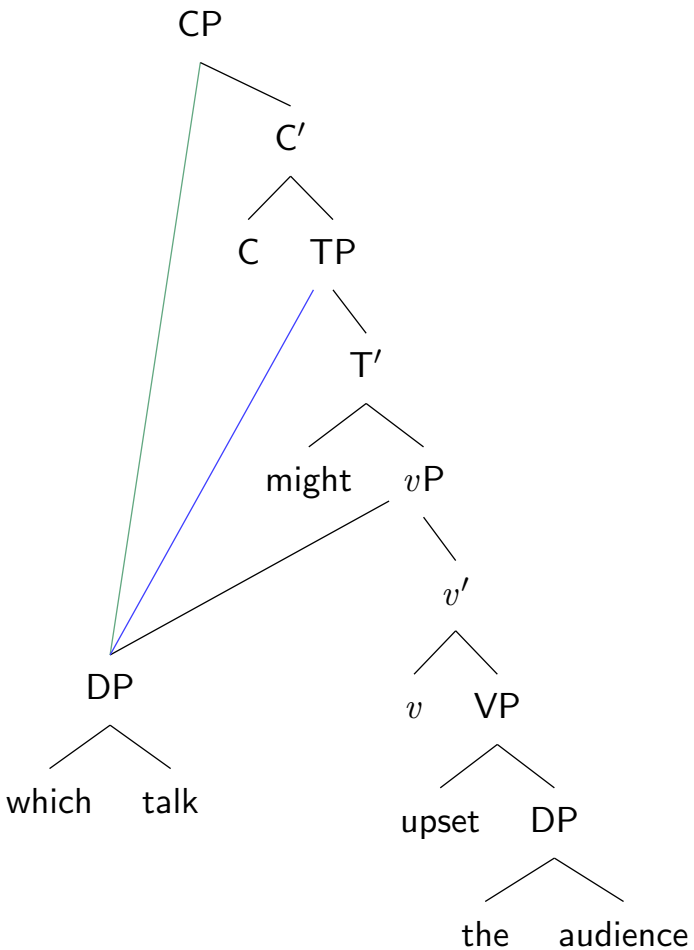

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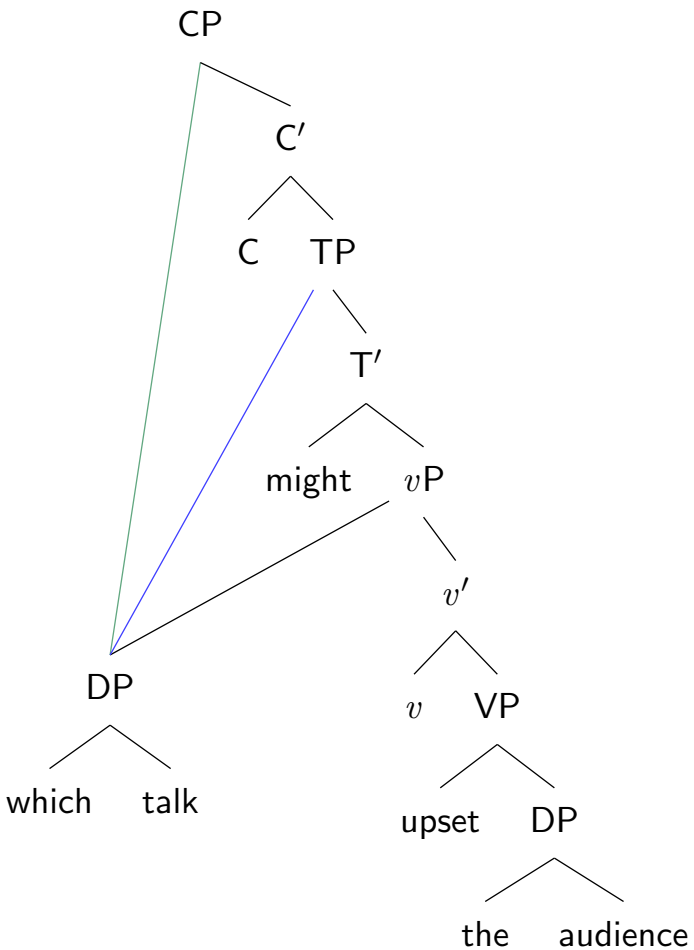

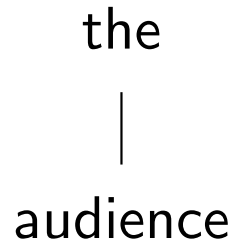

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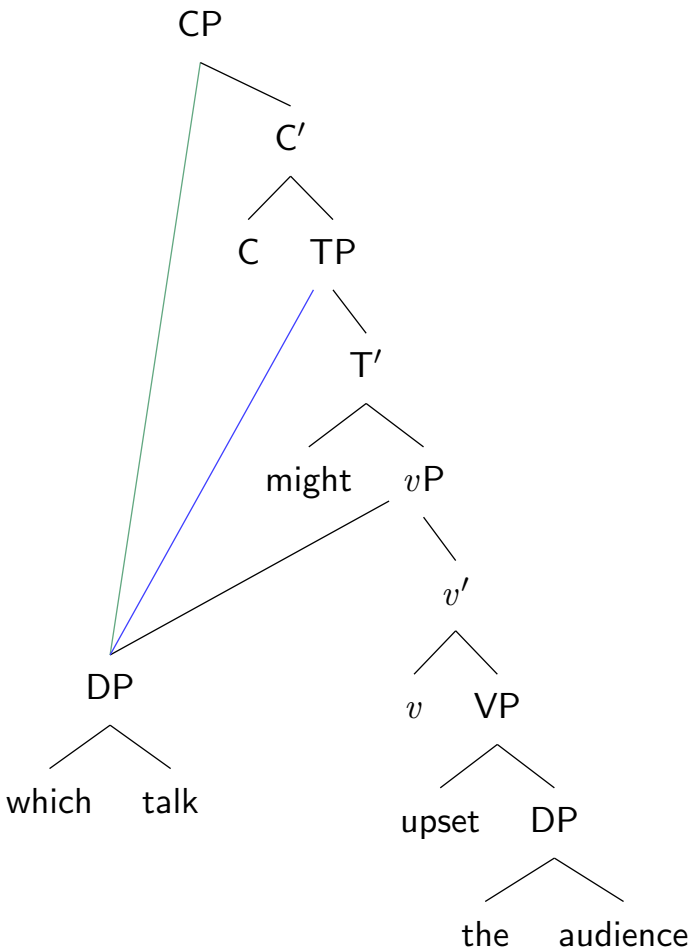

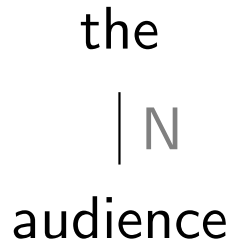

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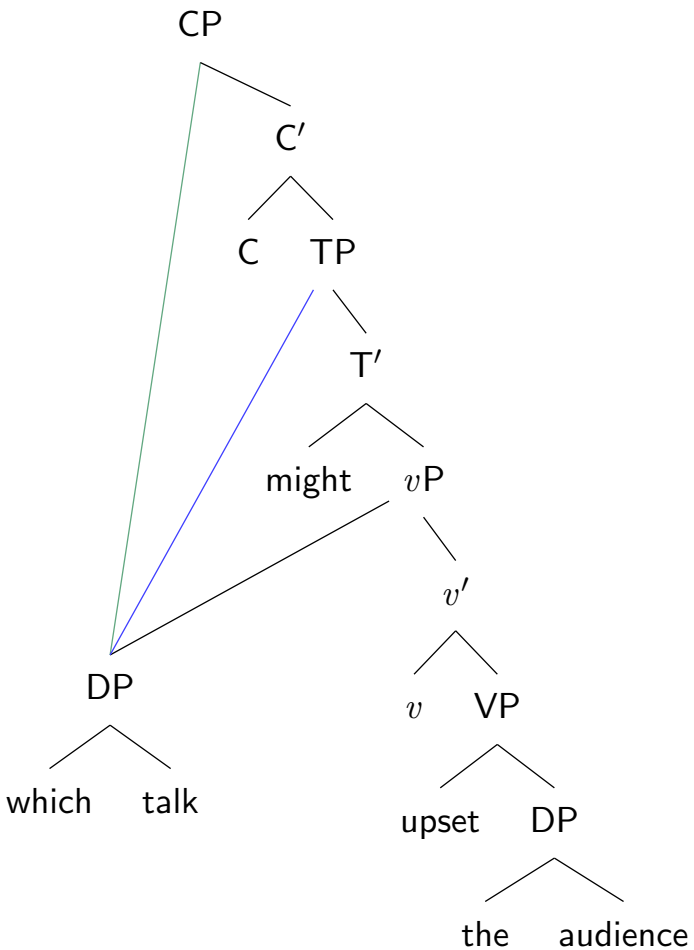

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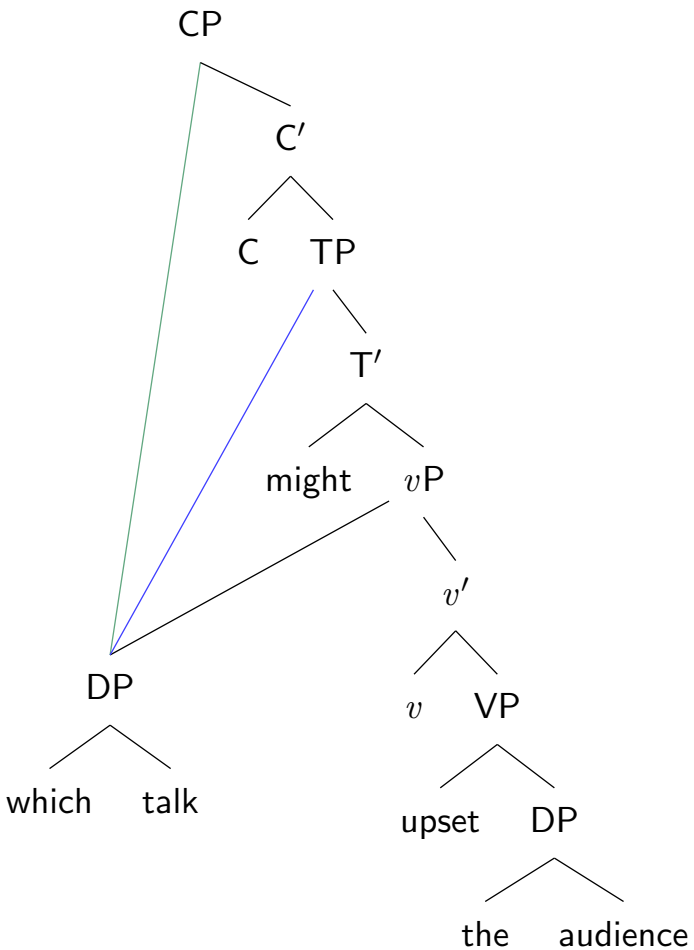

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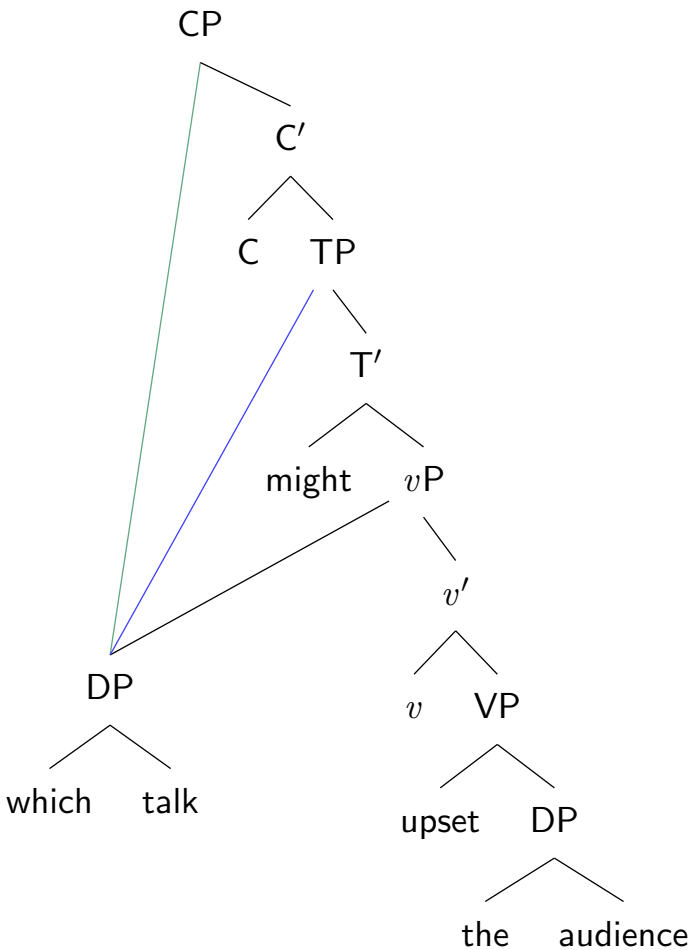

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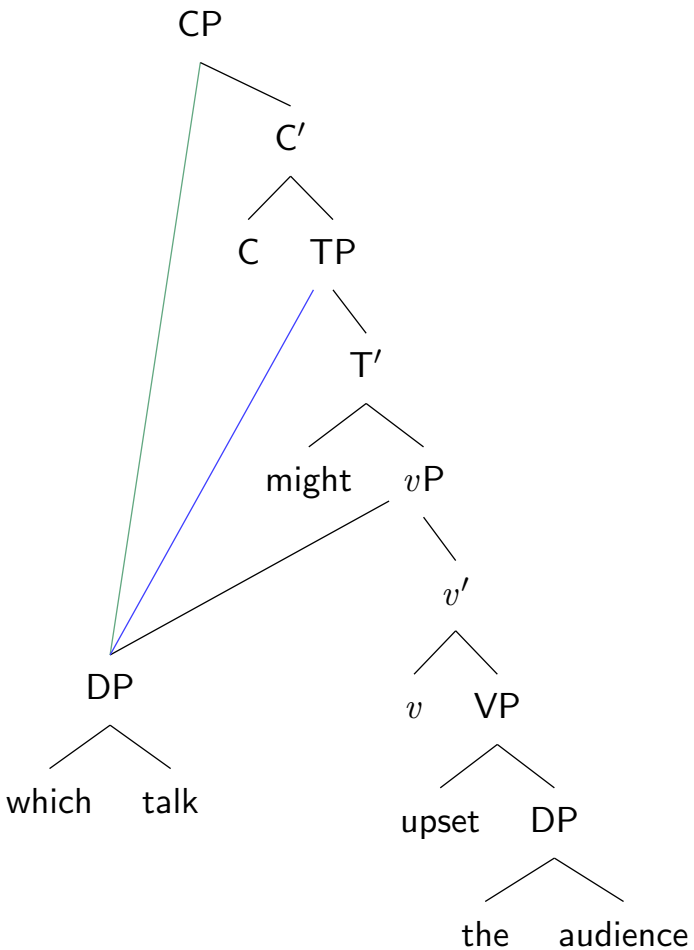

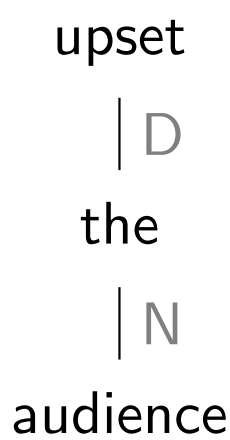

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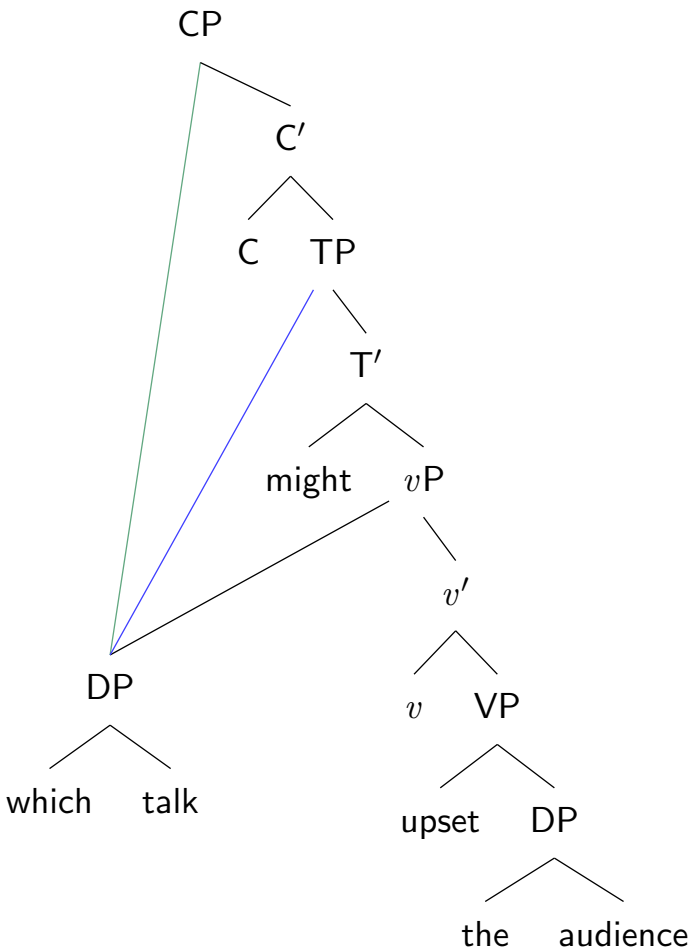

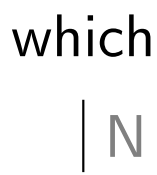

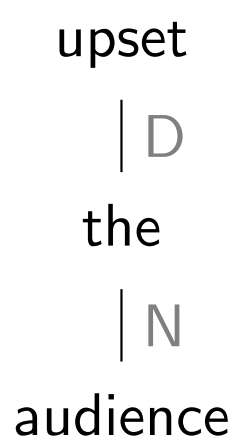

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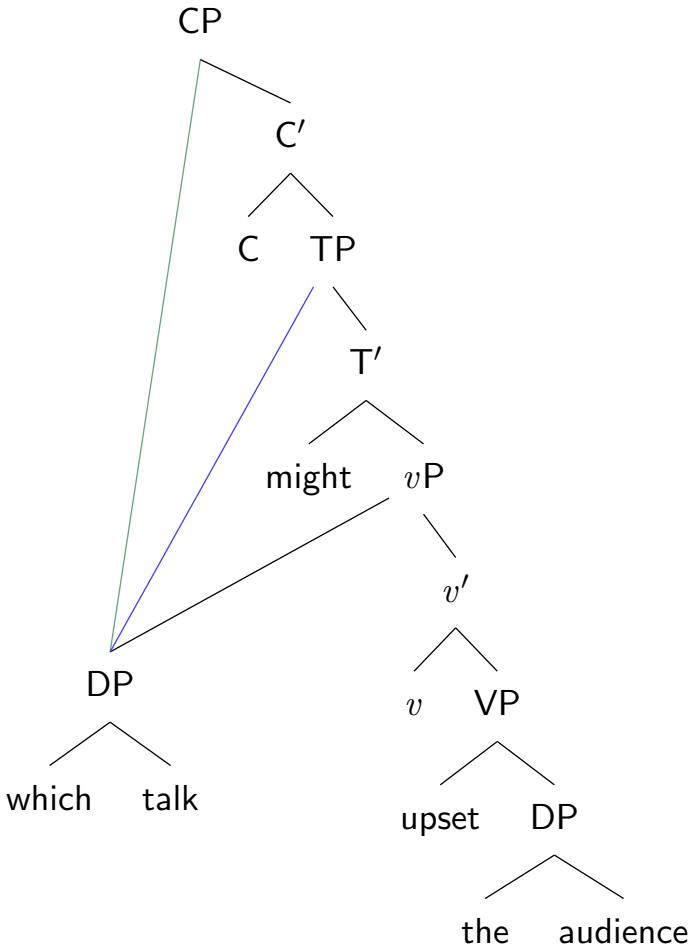

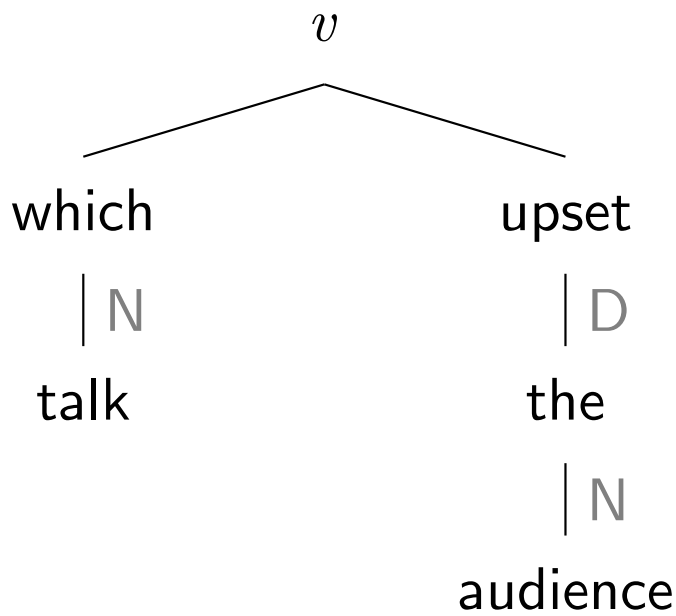

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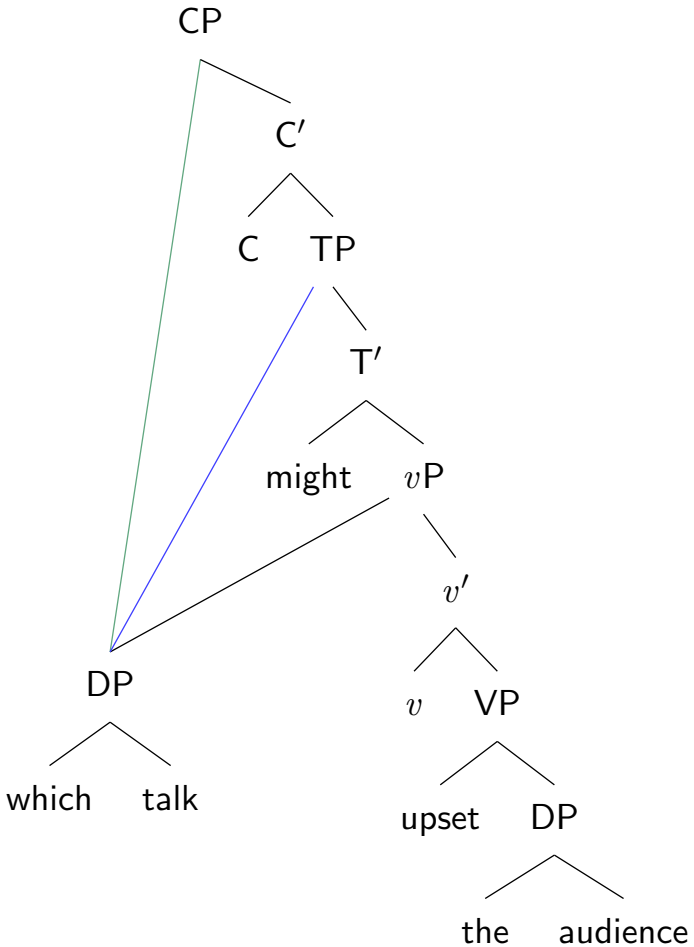

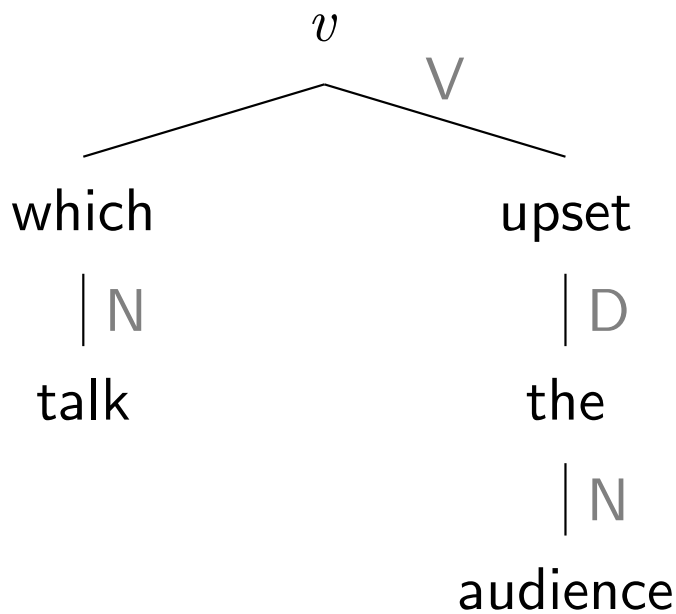

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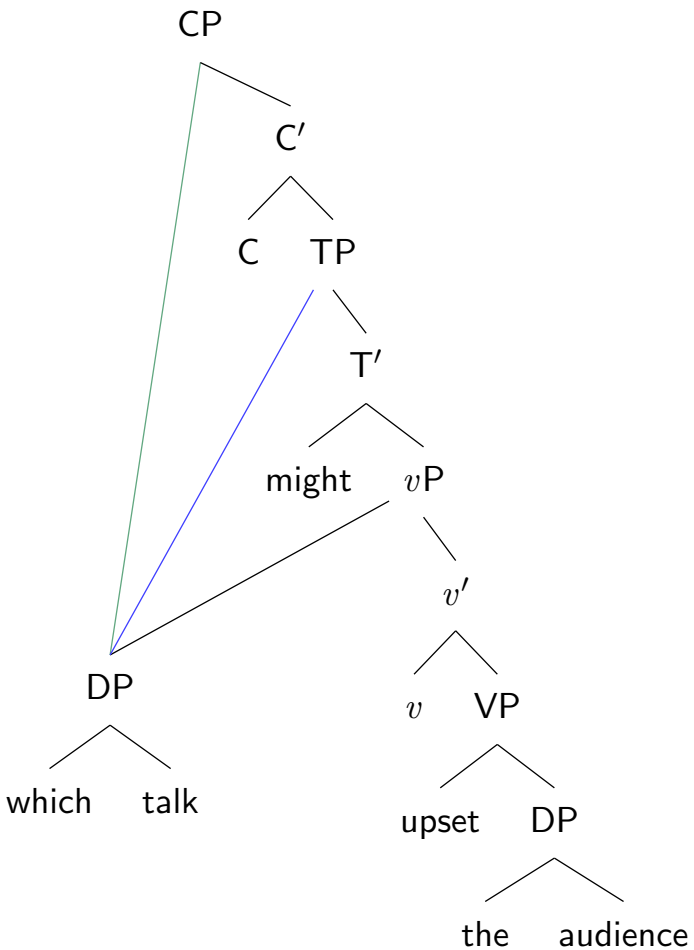

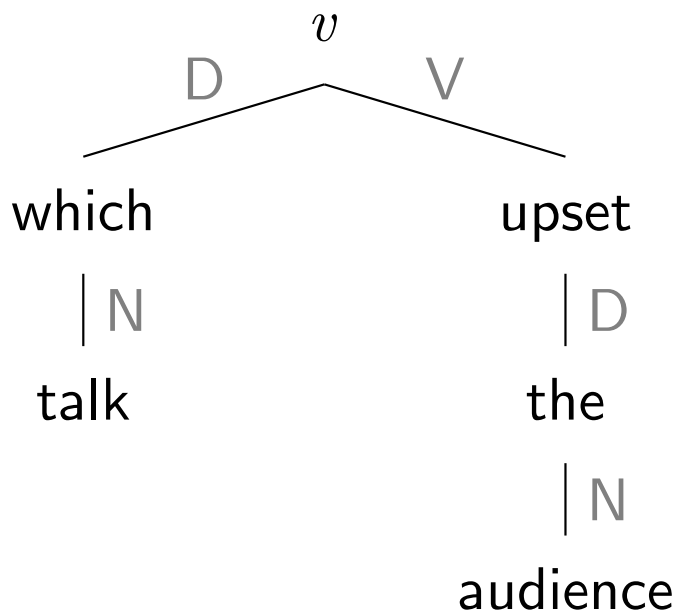

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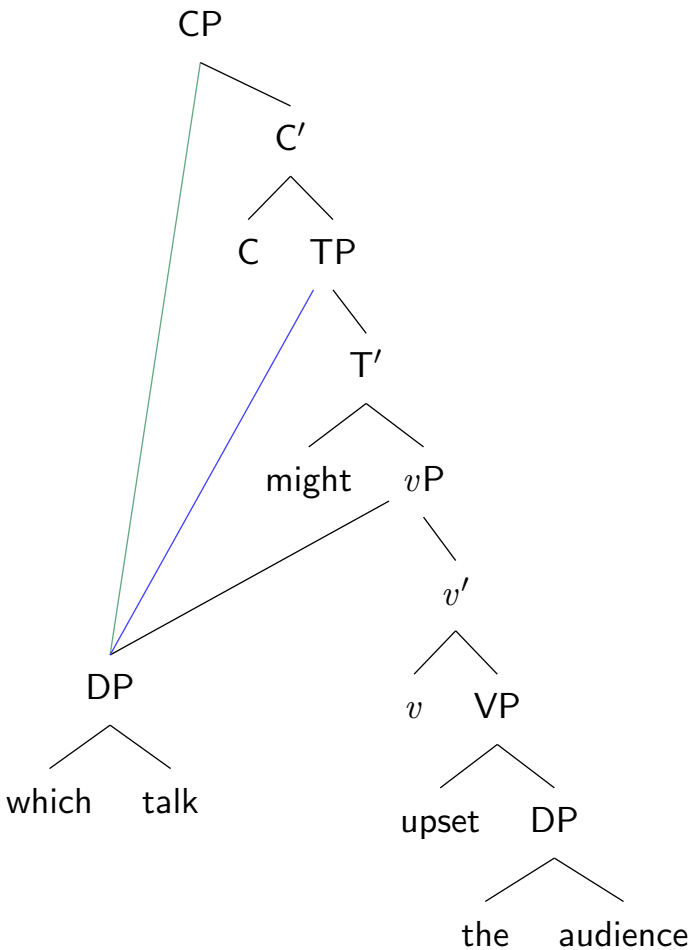

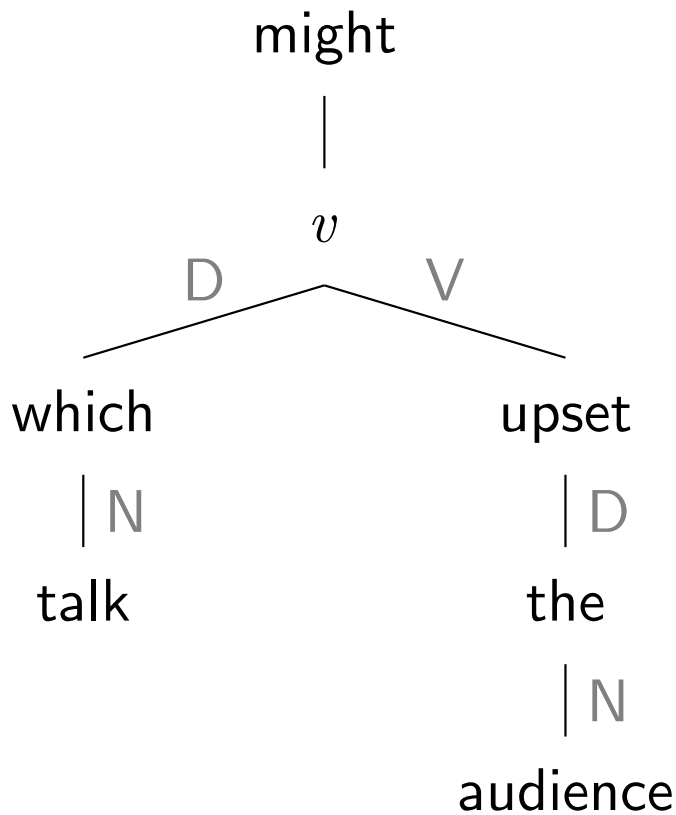

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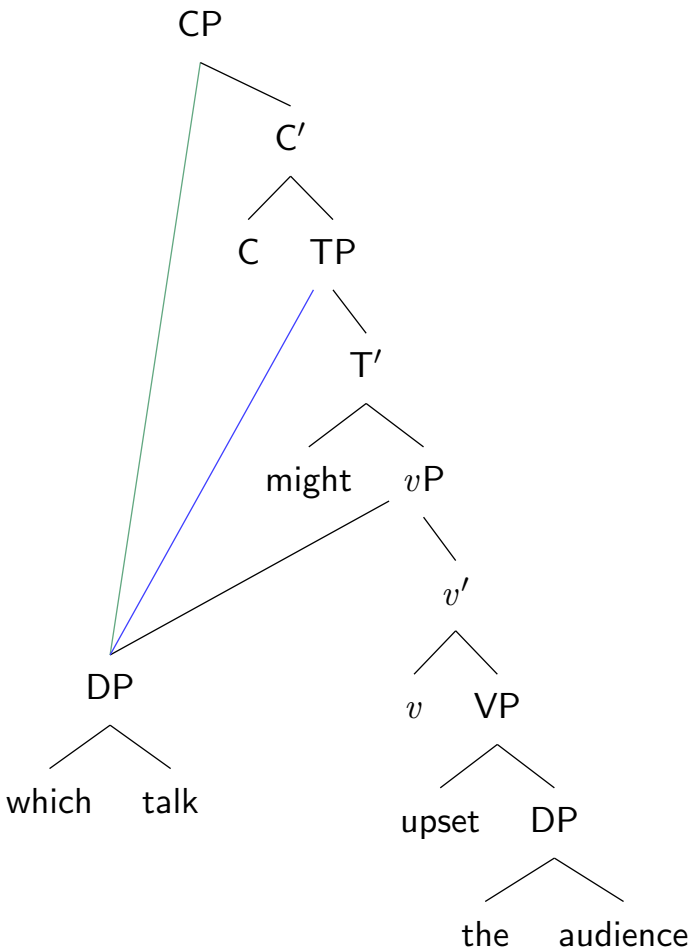

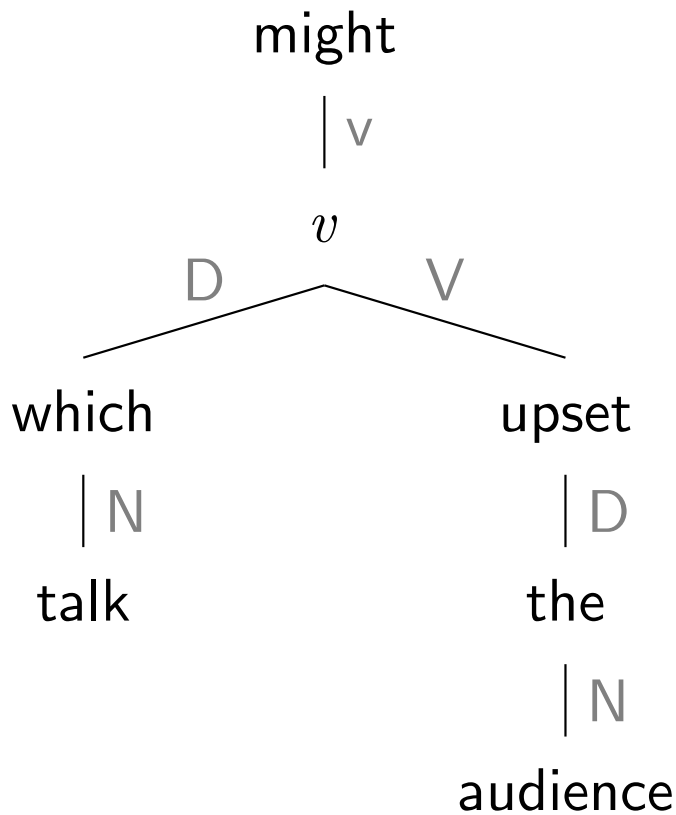

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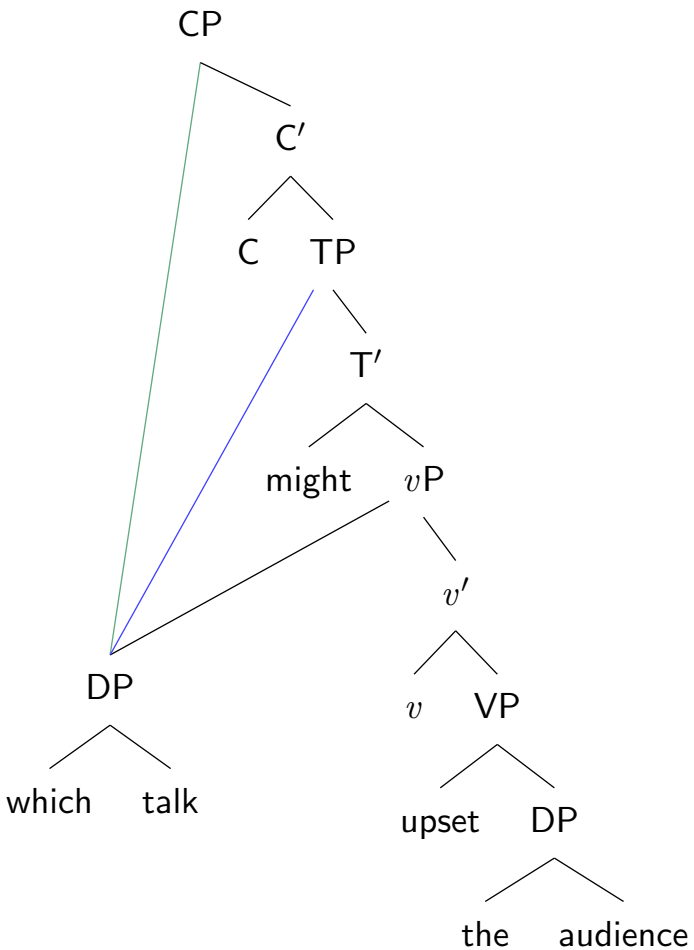

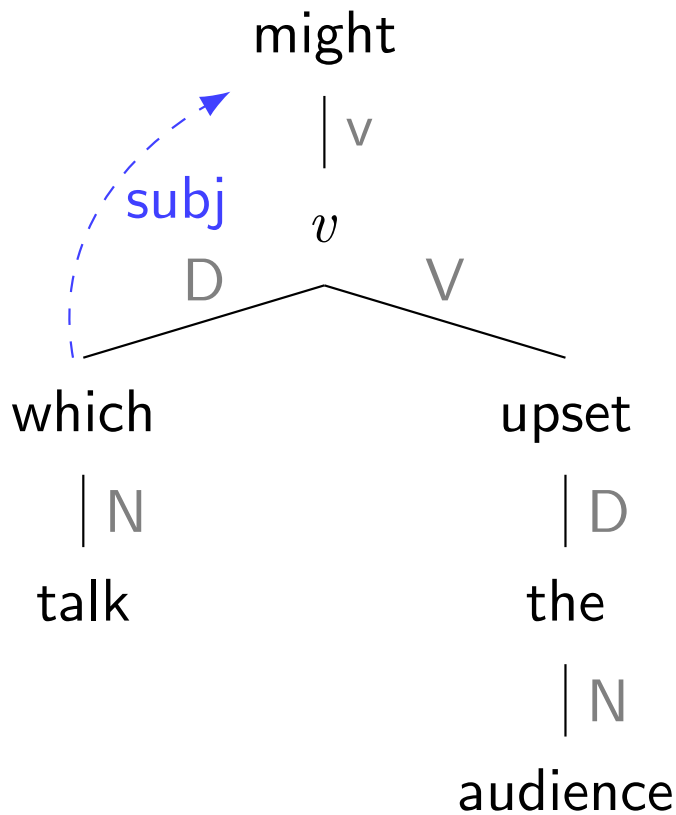

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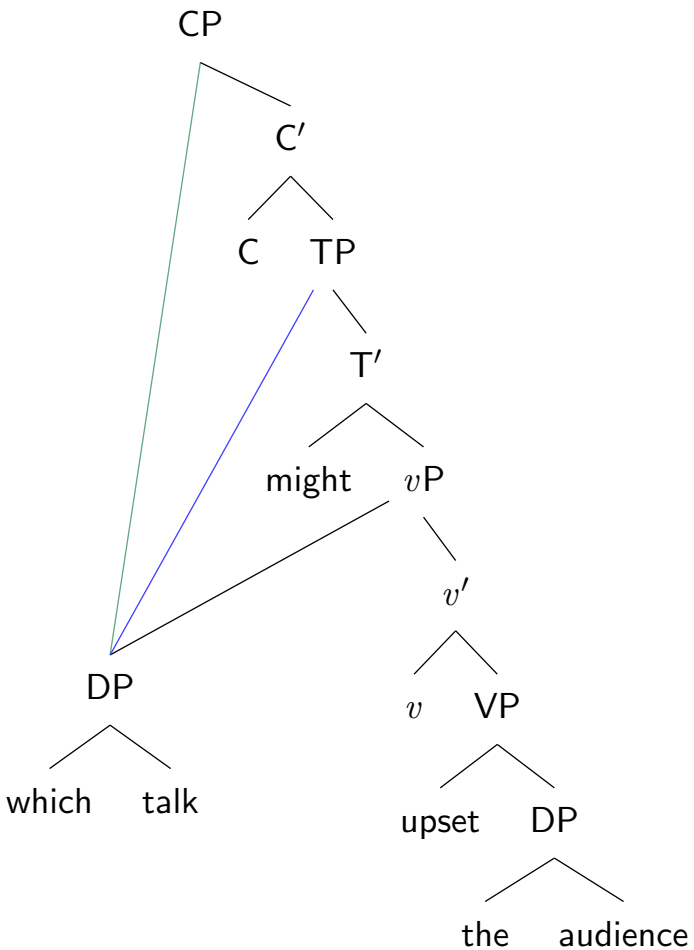

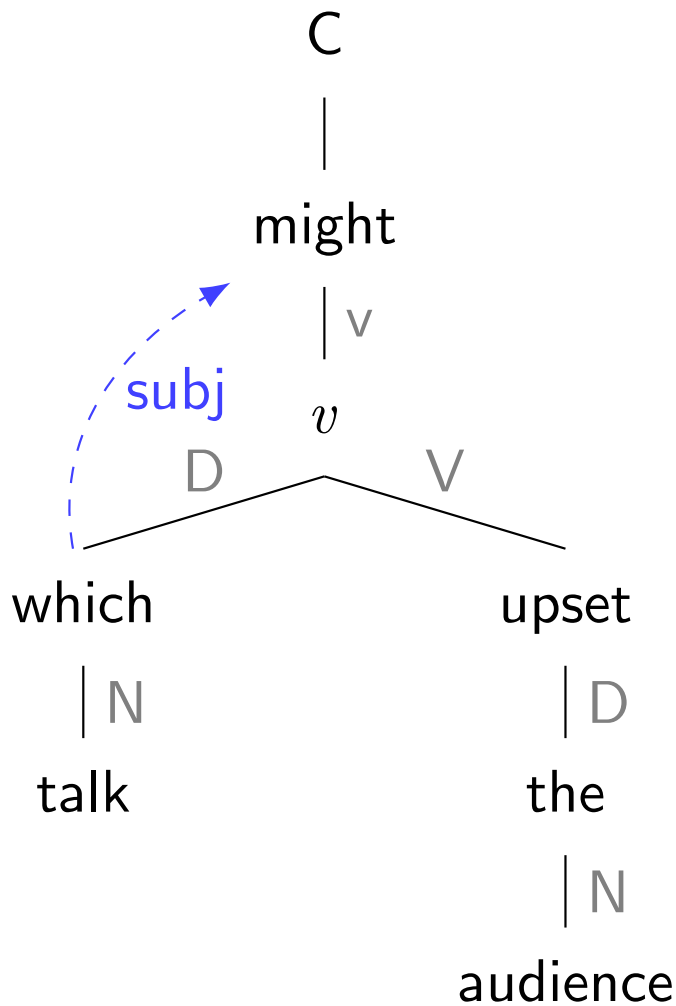

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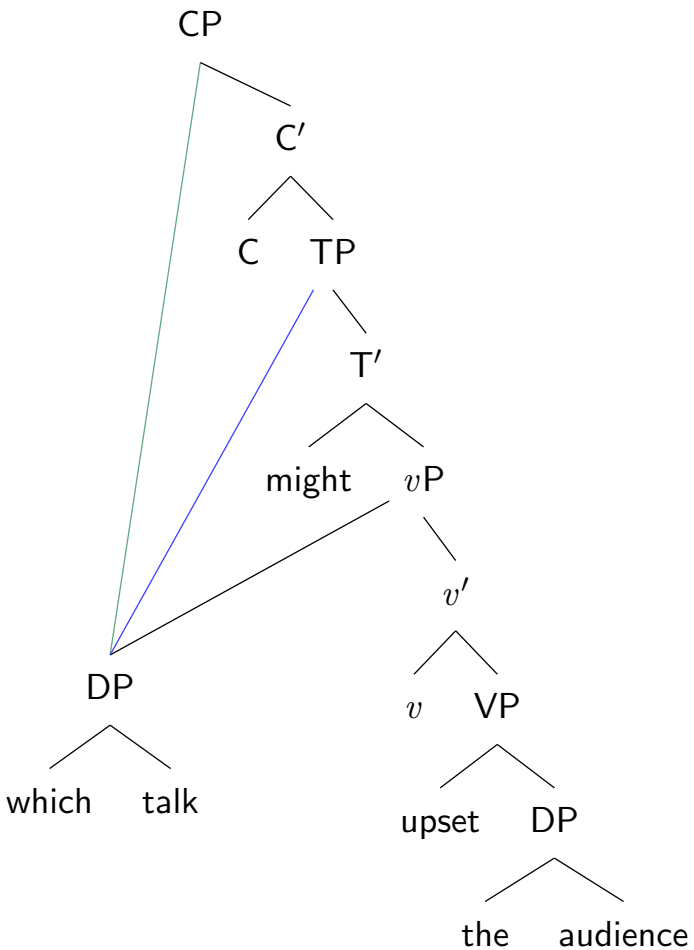

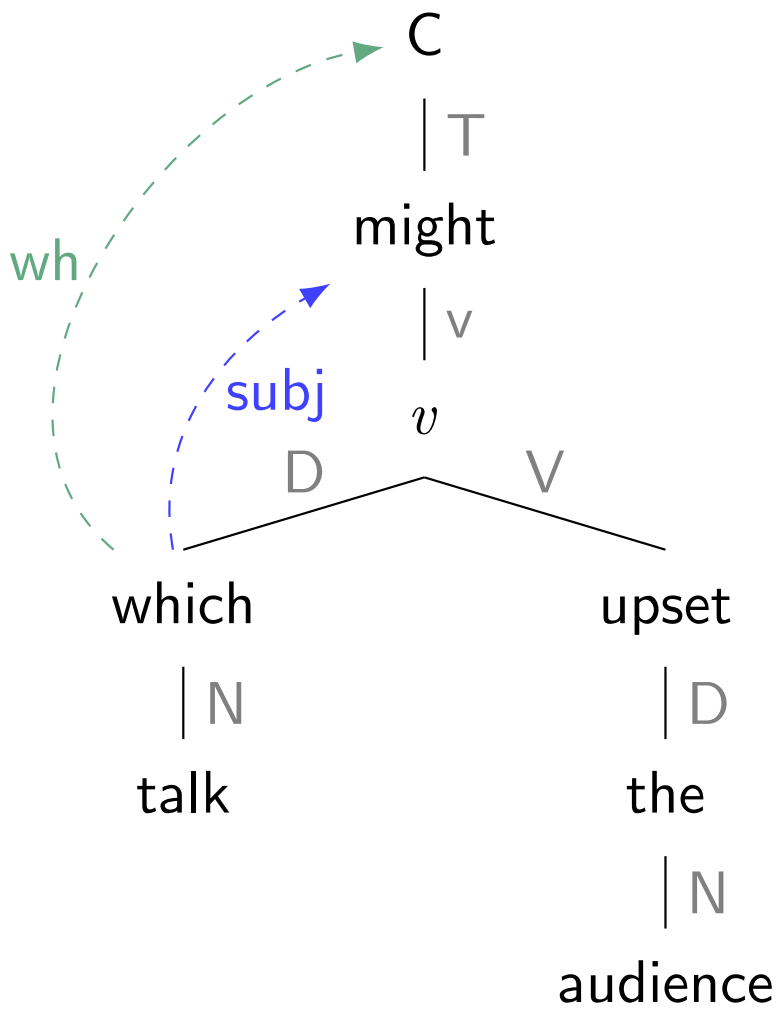

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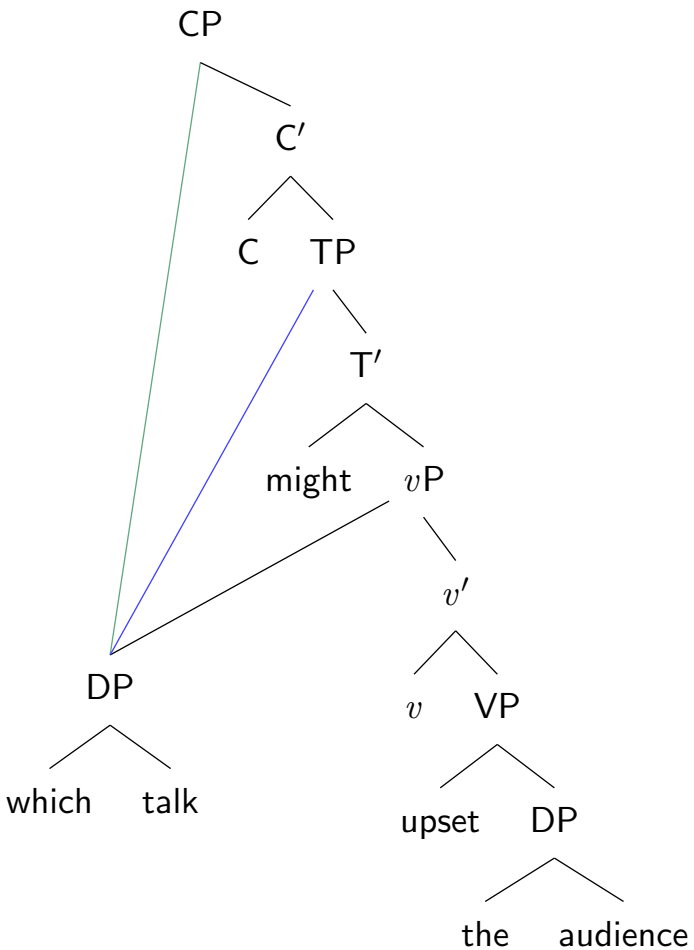

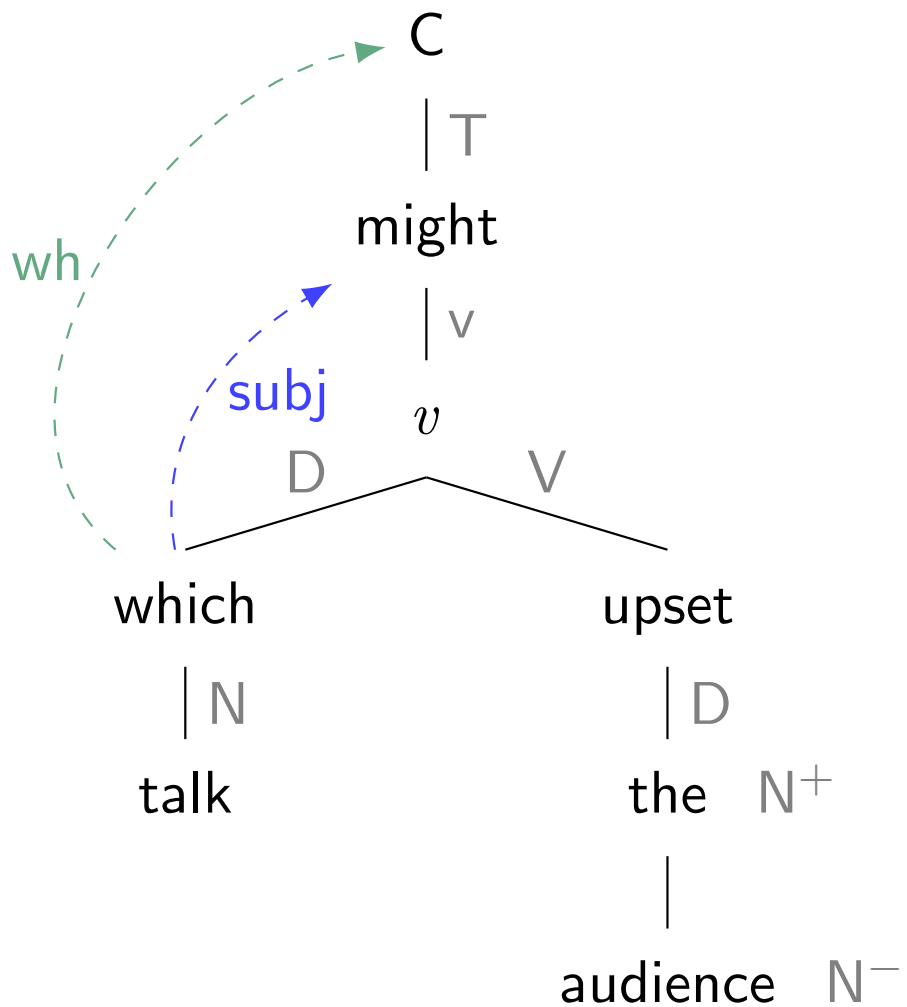

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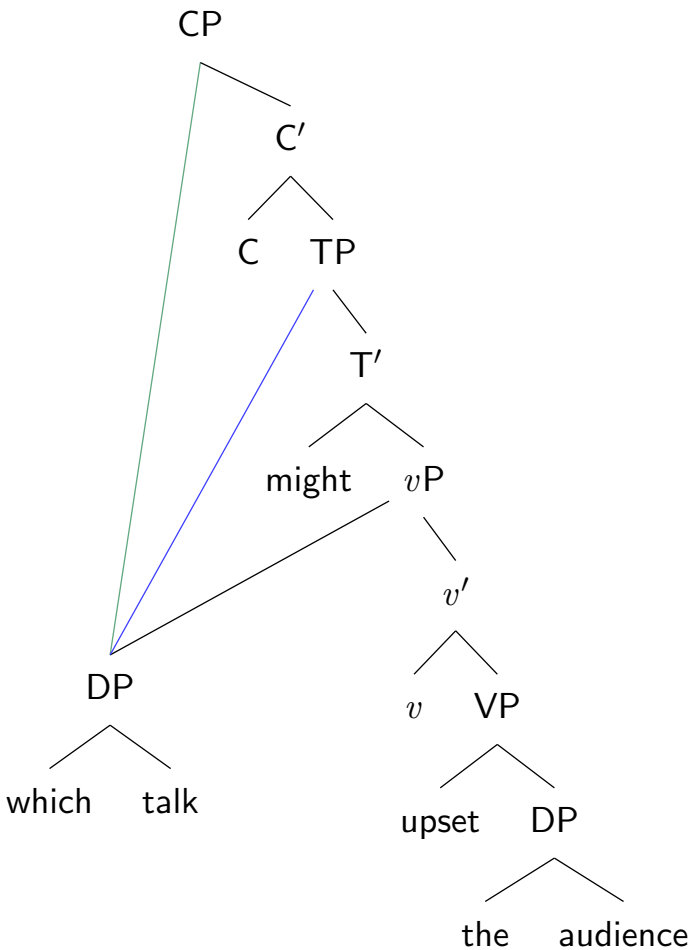

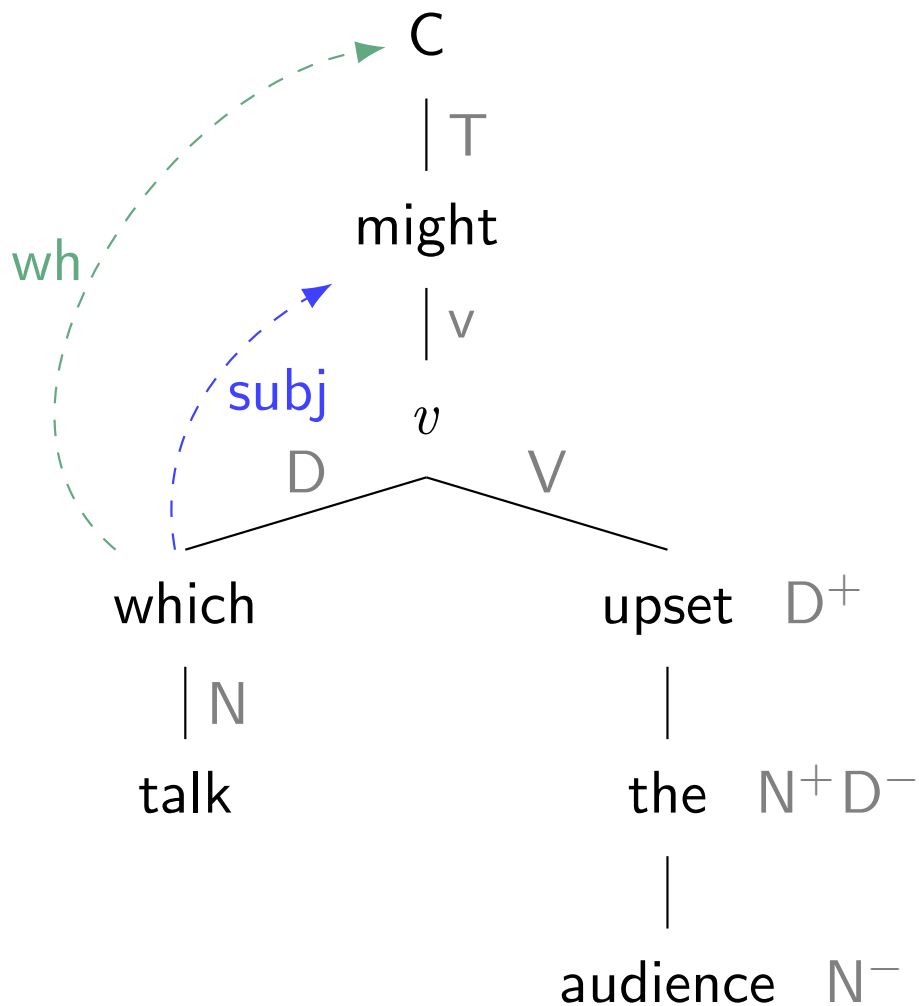

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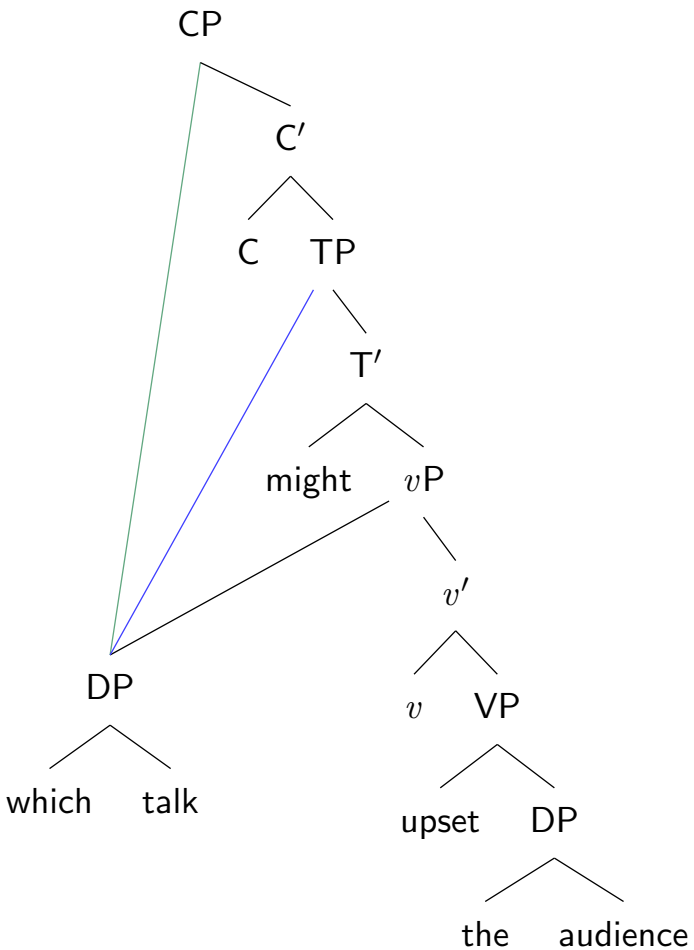

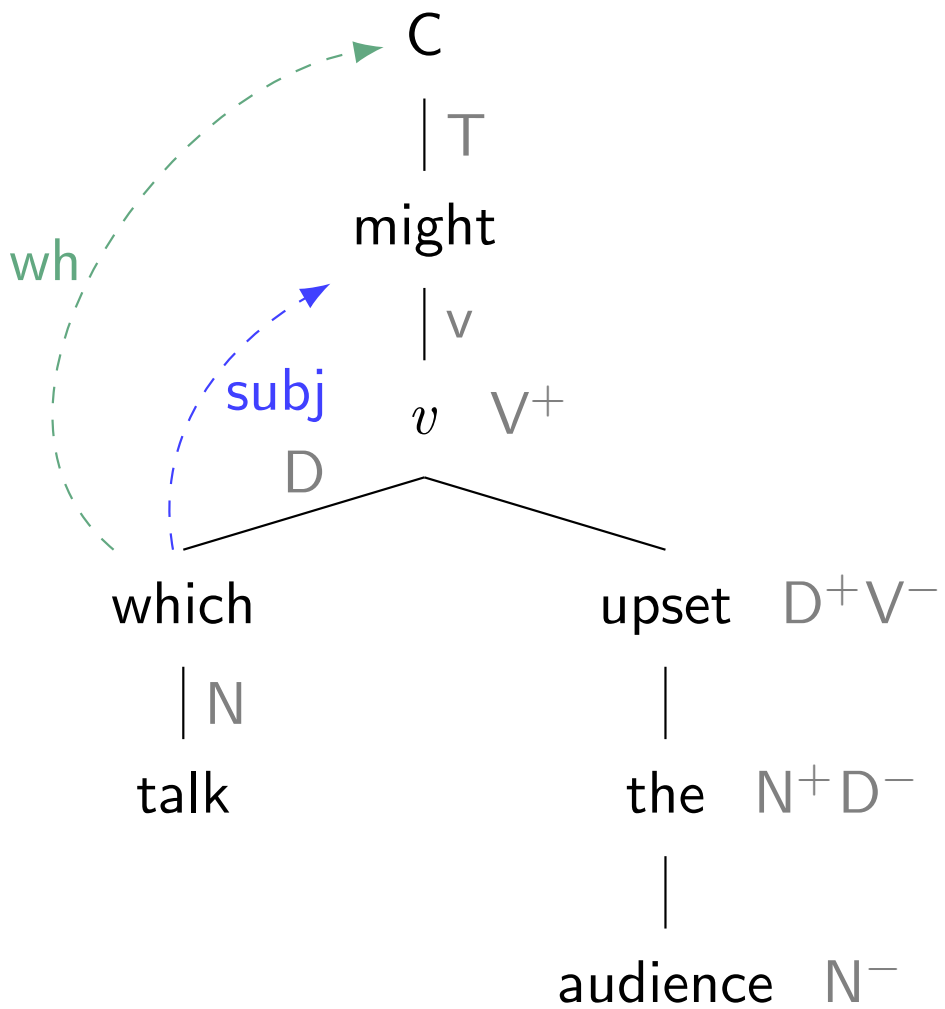

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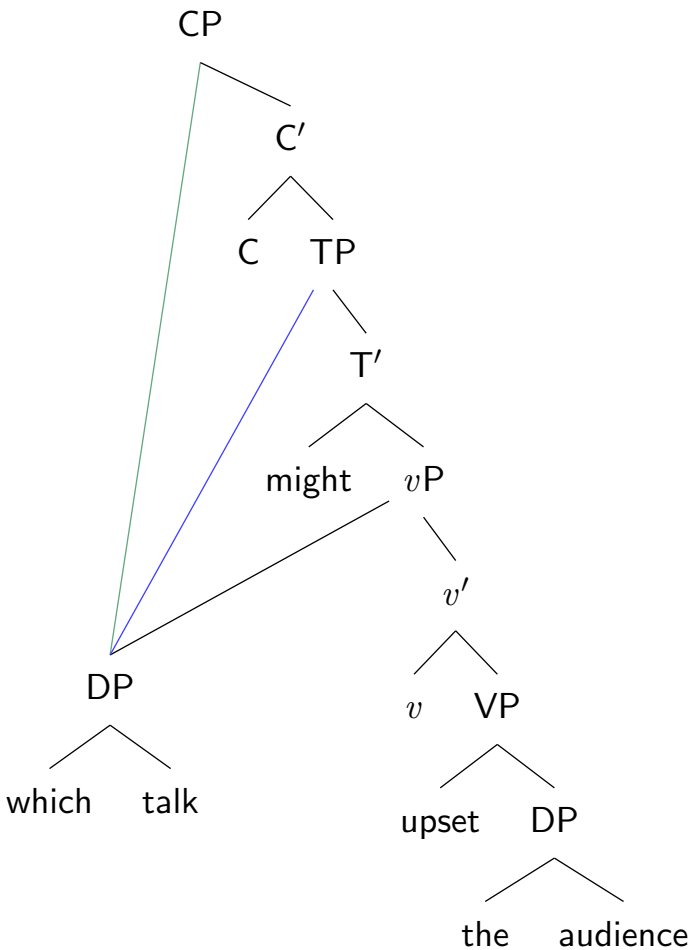

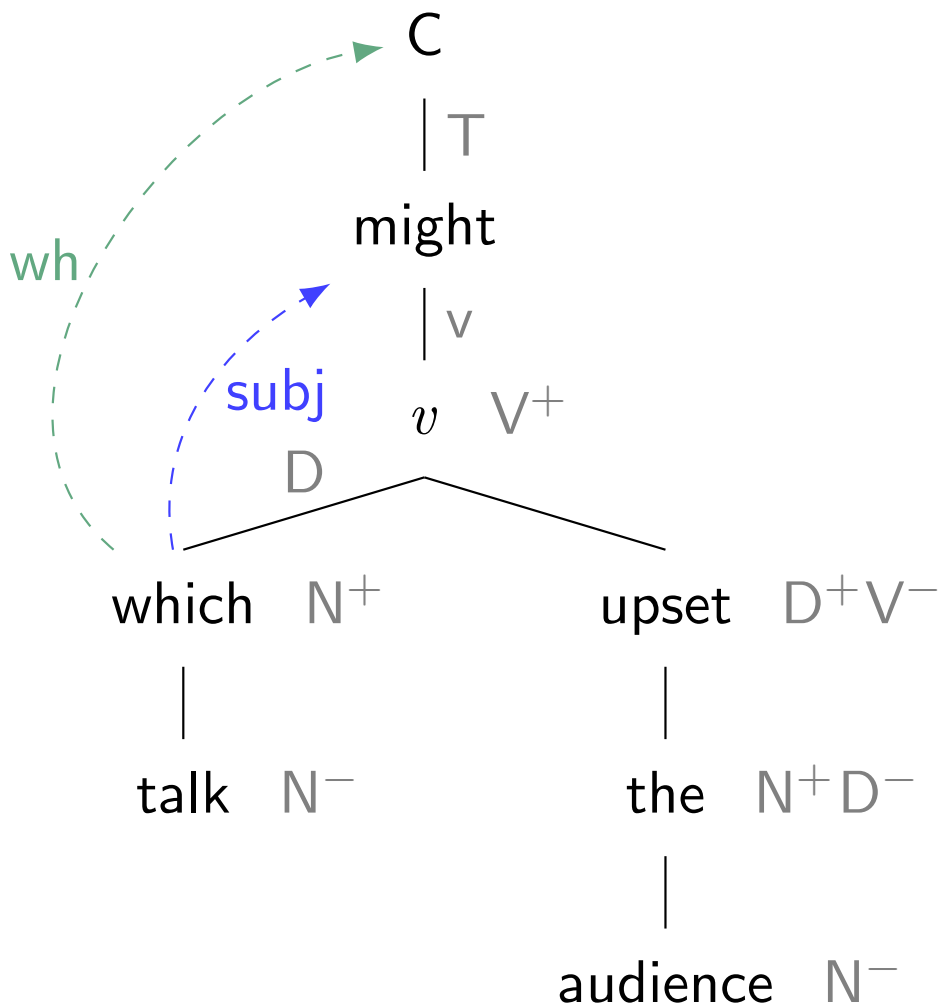

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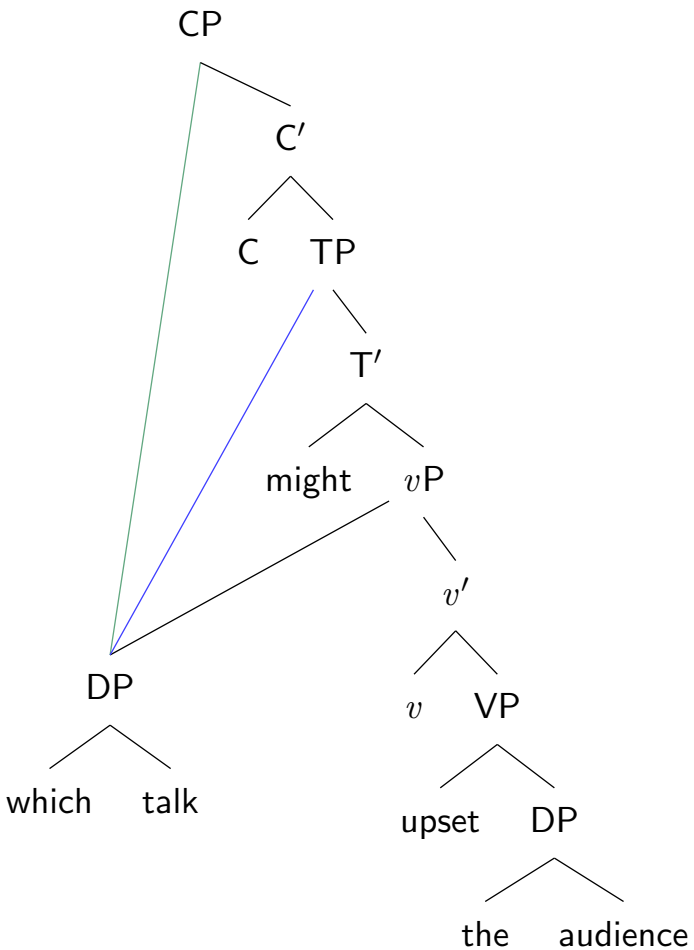

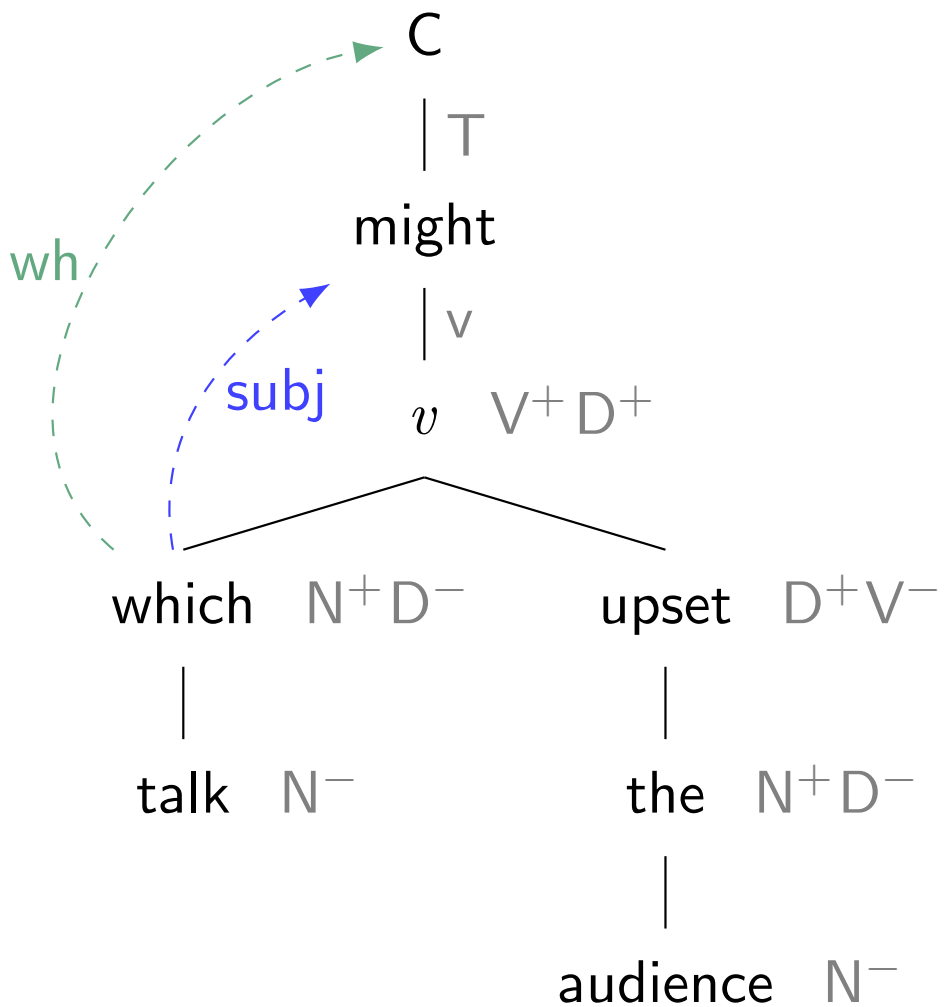

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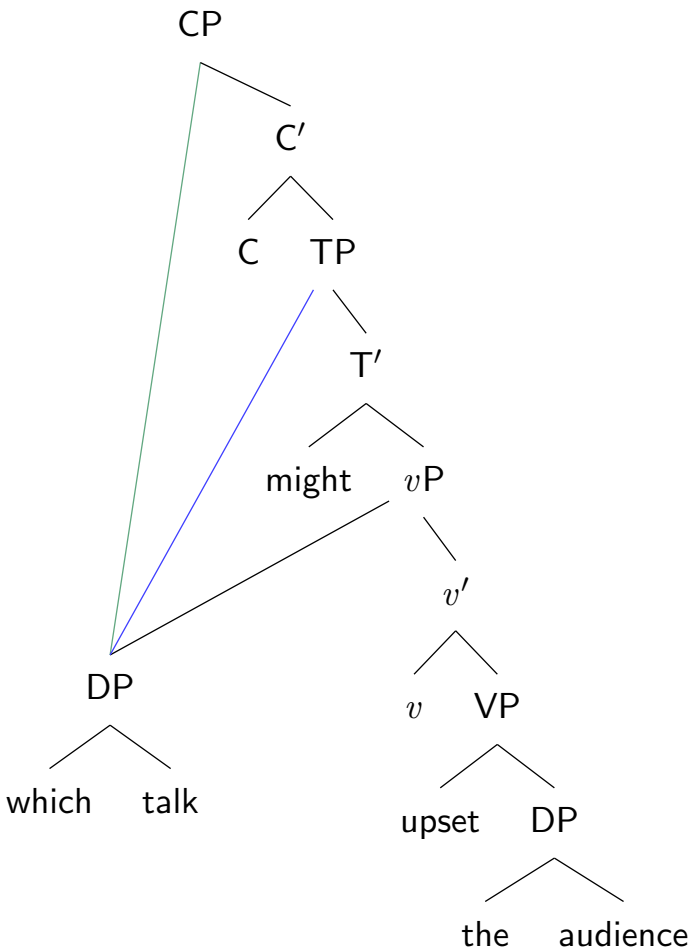

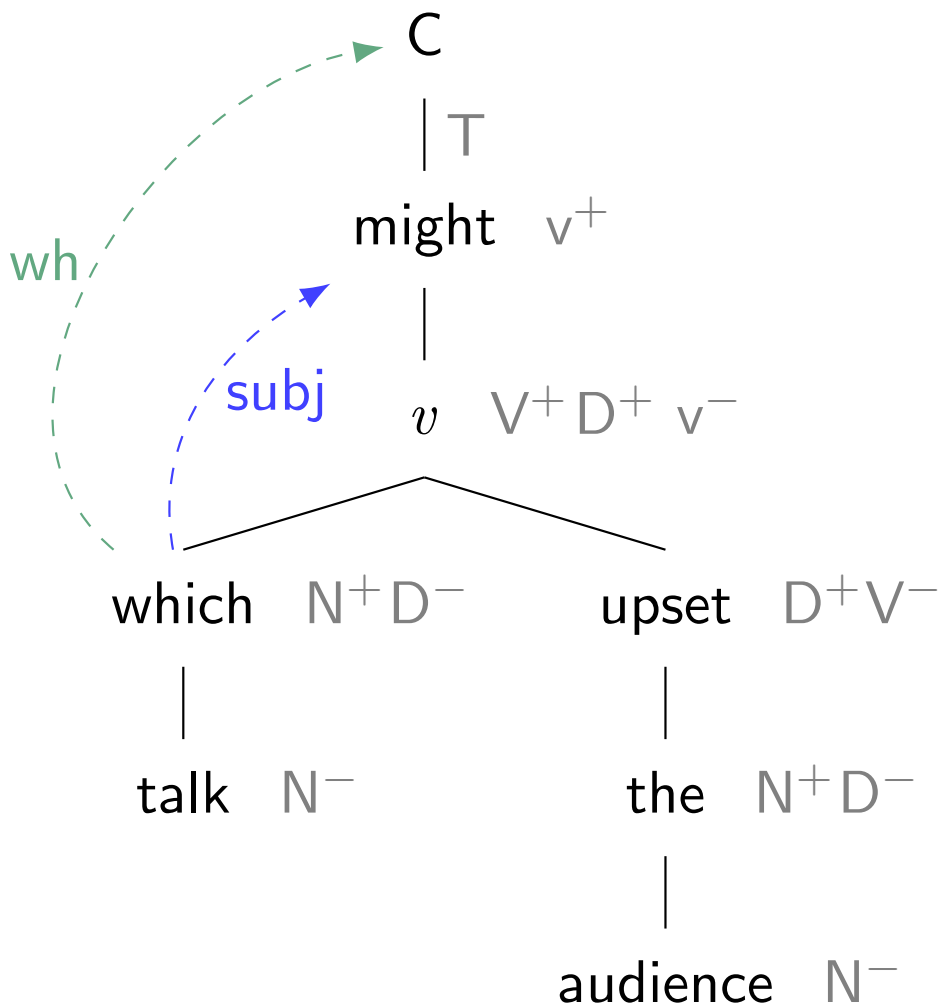

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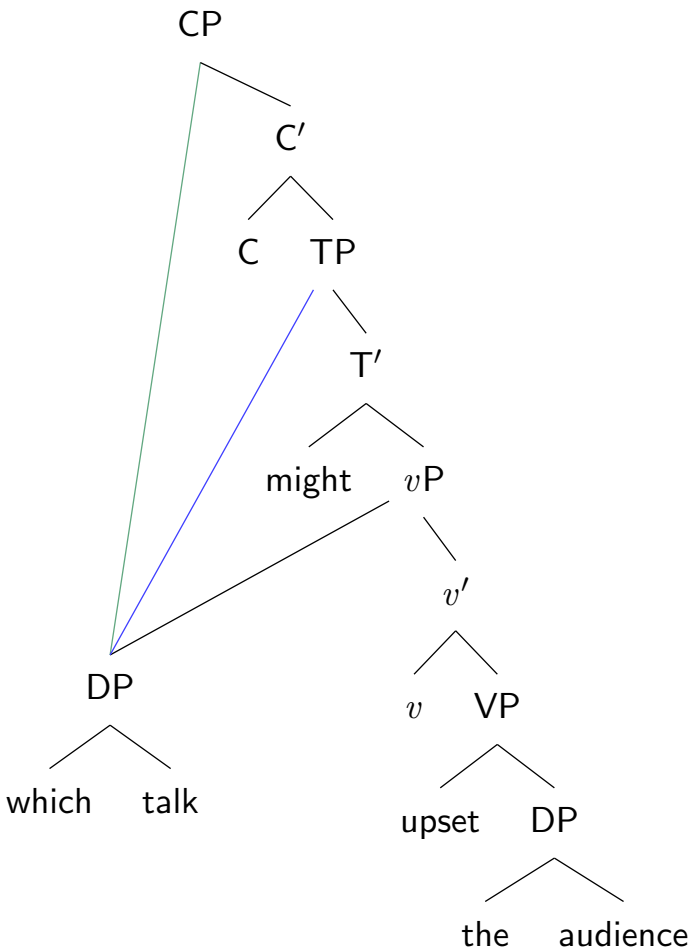

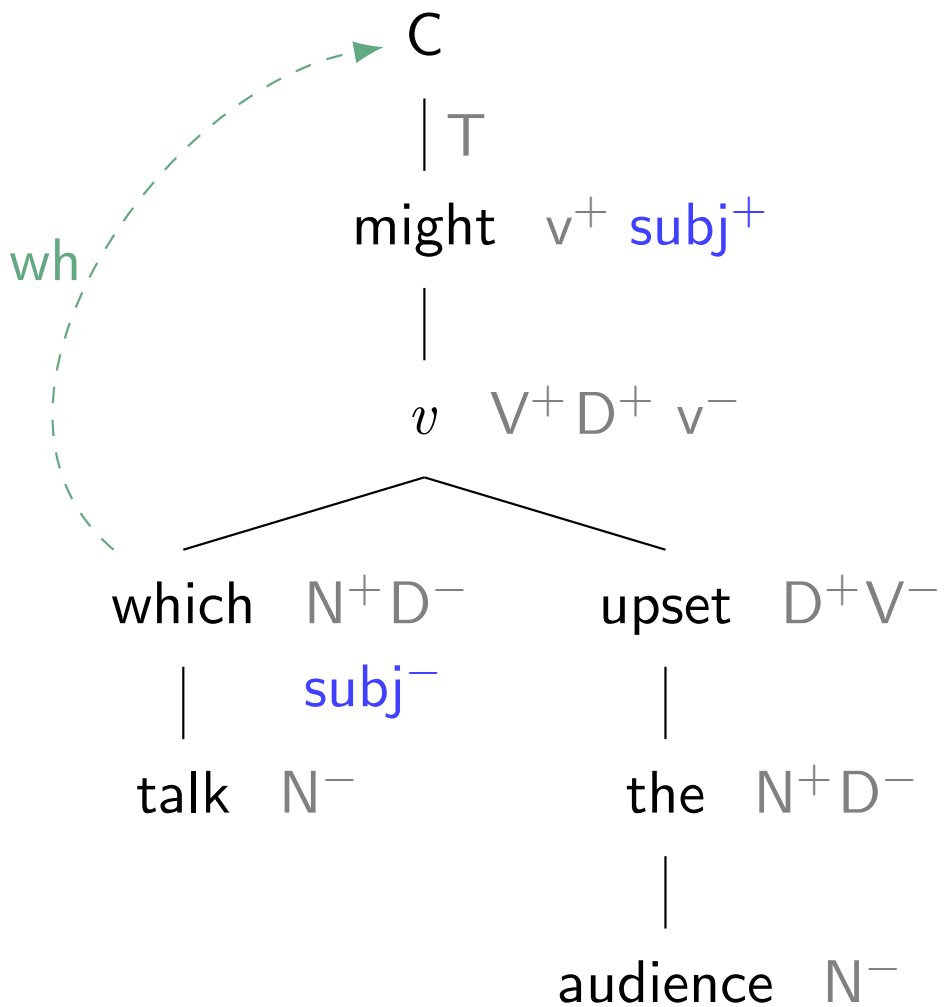

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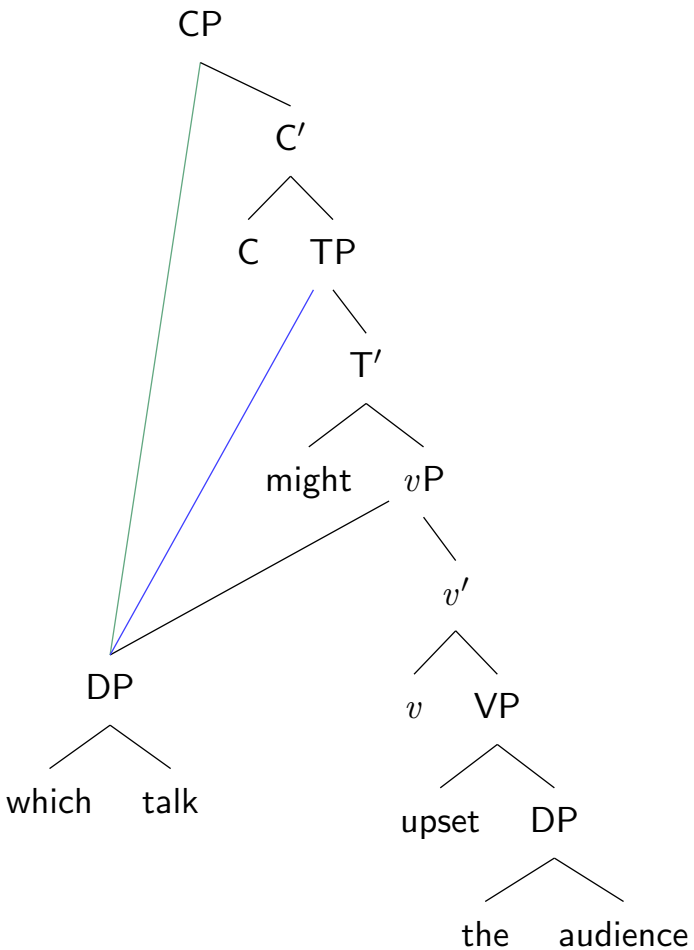

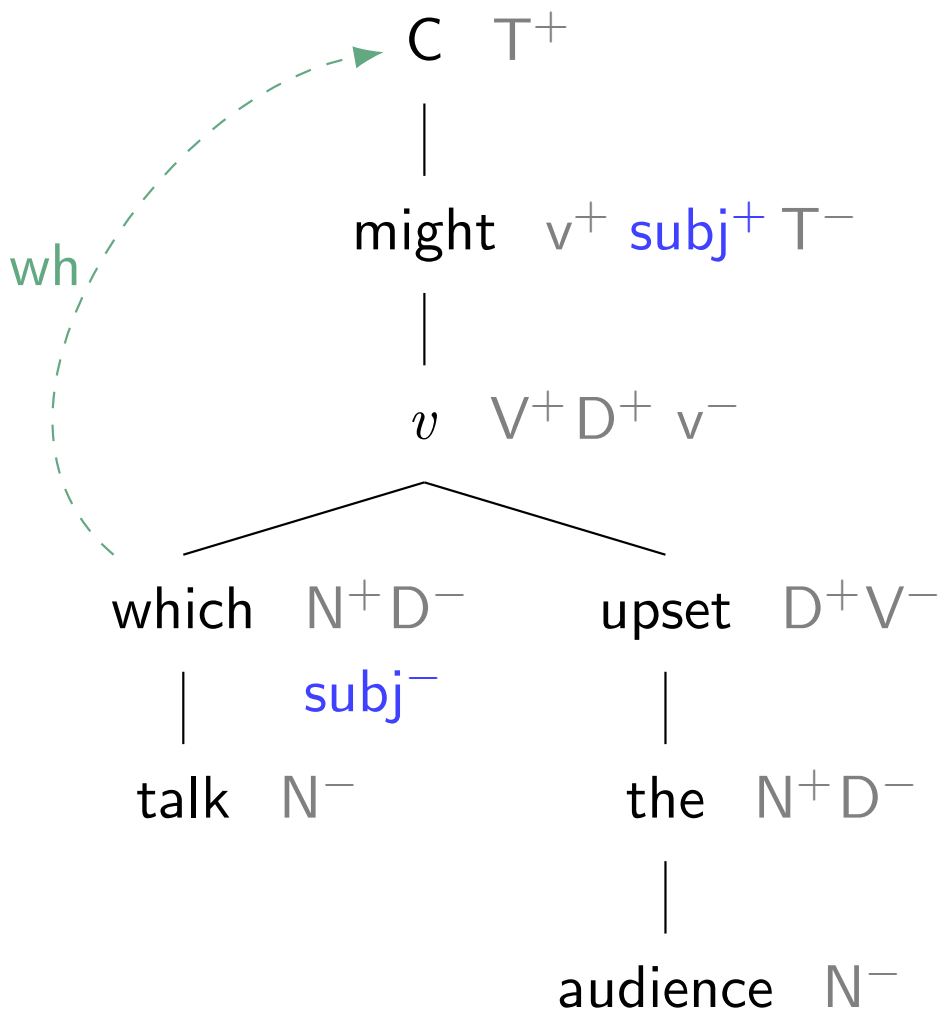

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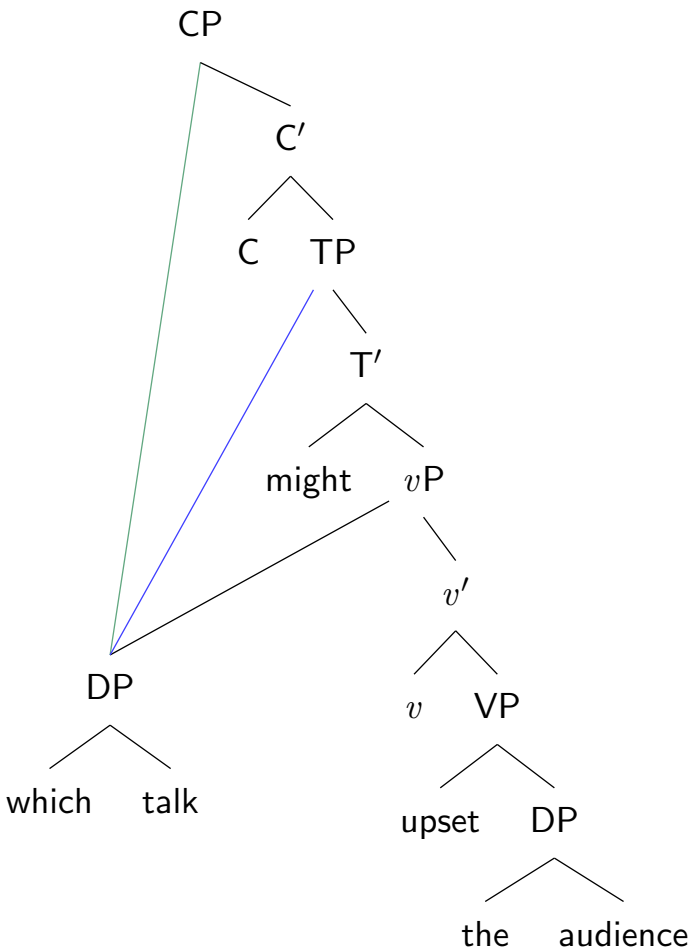
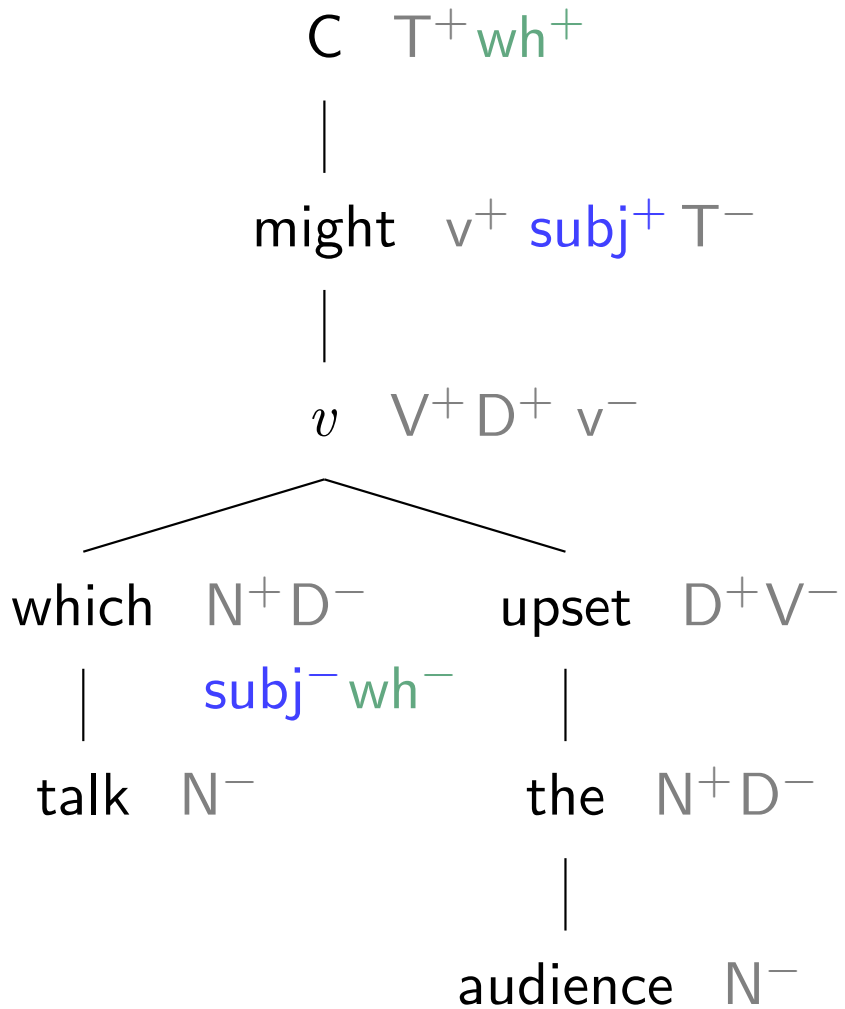


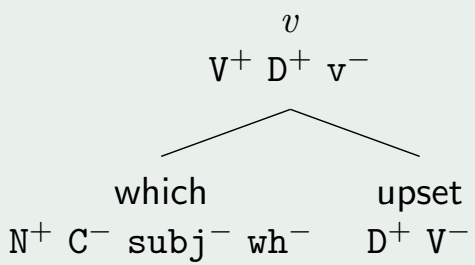


Embrace the abstractness

- "This looks like a dependency tree!"
- Sure does, but it's more abstract: a **computational trace**

Different interpretations of the same computational trace

- v has the dependents *which* and *upset*
- Merge(v, *upset*), then Merge(v, *which*)
- 3-Merge(v, *upset*, *which*)
- Split v into *which* and *upset*



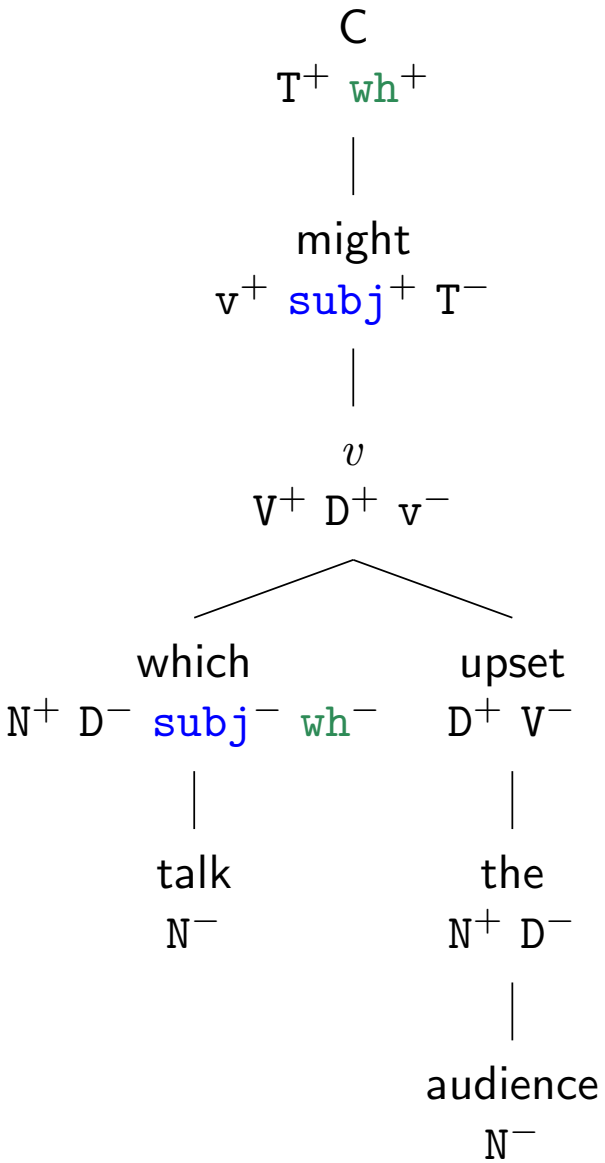
- The trace records the computational common core of all these different systems.
- What can we say about this common core?

Establishing a computational baseline

- **The Ceiling Constraint**
  Every $\texttt{f}^-$ needs an $\texttt{f}^+$
- **A different formulation**
  For every node **n** and every $\texttt{f}^-$:
  if **n** carries $\texttt{f}^-$, then its **a-string**
  contains a node with $\texttt{f}^+$.

Definition (a[ncestor]-string; simplified)

The **a-string** of **n** consists of all the nodes that are derivationally ordered after **n**.



Establishing a computational baseline

- **The Ceiling Constraint**
  Every $\mathtt{f}^-$ needs an $\mathtt{f}^+$
- **A different formulation**
  For every node **n** and every $\mathtt{f}^-$:
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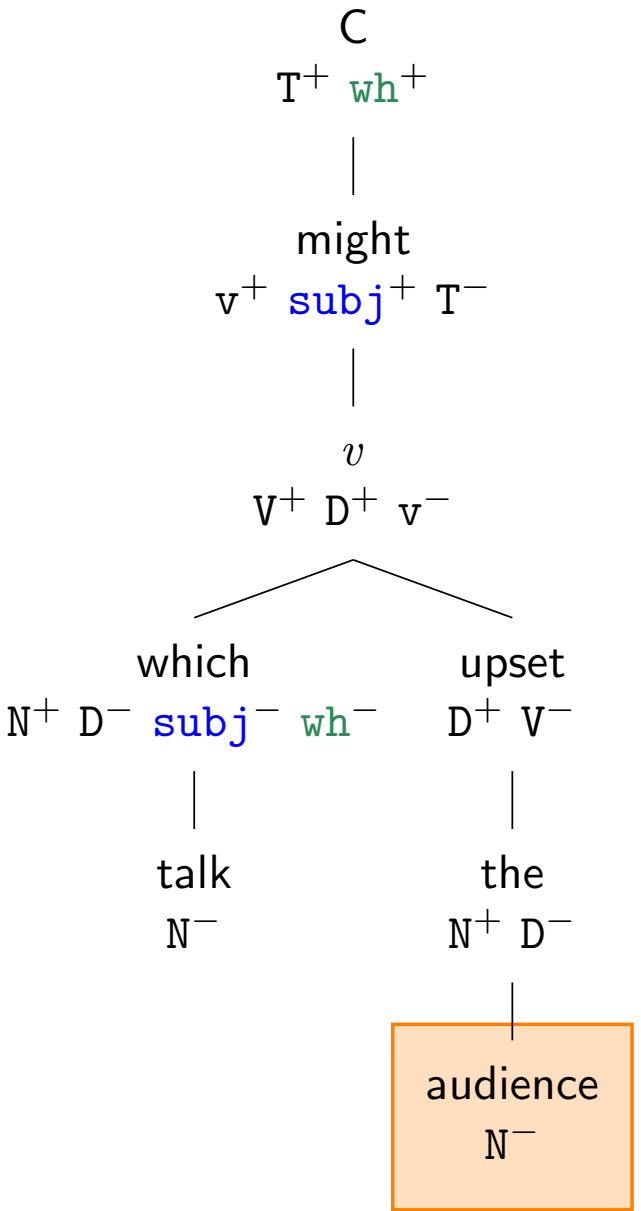

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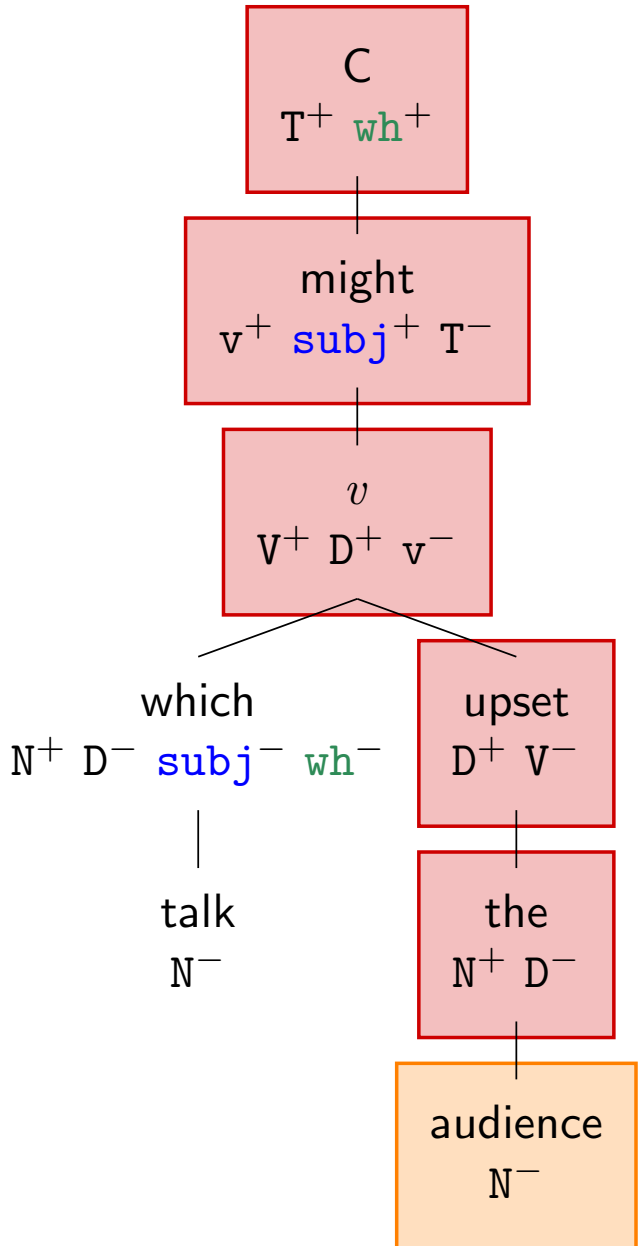

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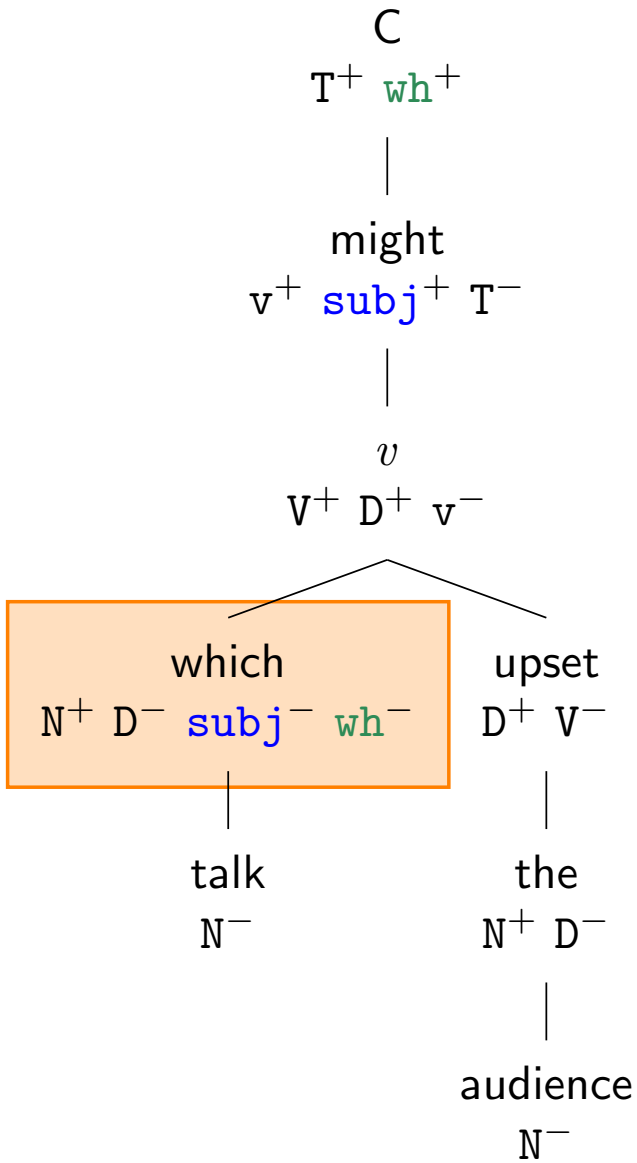

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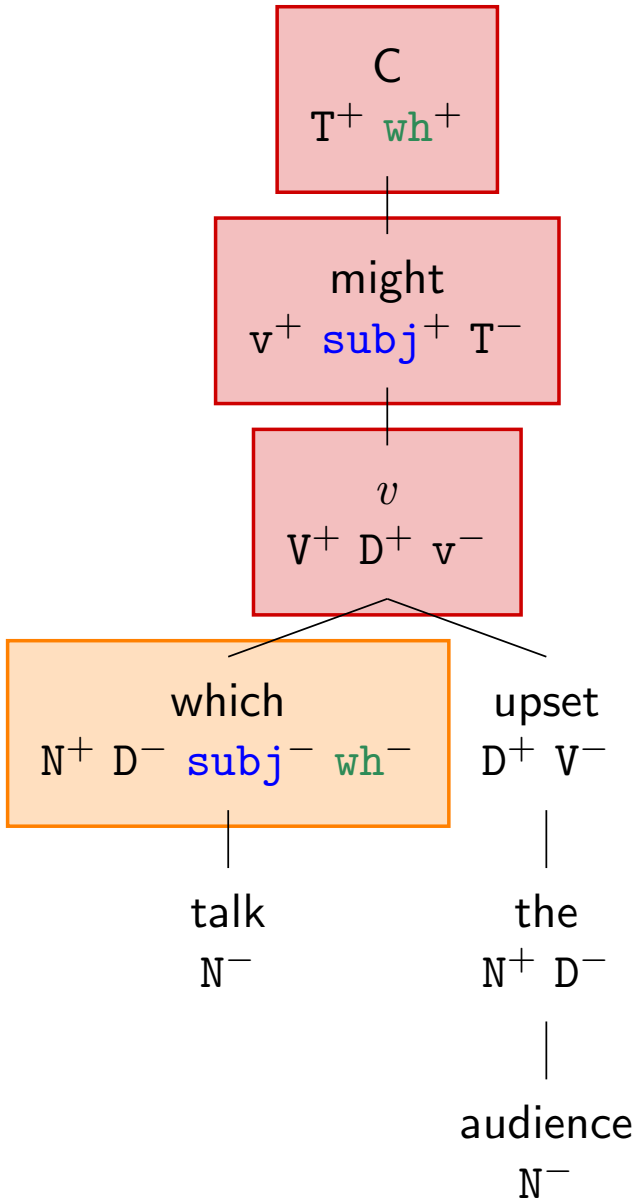


Telling whether a string contains $\mathtt{f}^+$

- The a-string of a node with $\mathtt{f}^-$ must belong to the string set $\Sigma^*\mathtt{f}^+\Sigma^*$.
  - Σ^*: any arbitrary string of 0 or more nodes
  - $\mathtt{f}^+$: any one node that carries $\mathtt{f}^+$
- This is one of the simplest possible string sets, it is **tier-based reverse 1-definite**:
  1. Project an $\mathtt{f}$-tier
  2. The first symbol must be $\mathtt{f}^+$

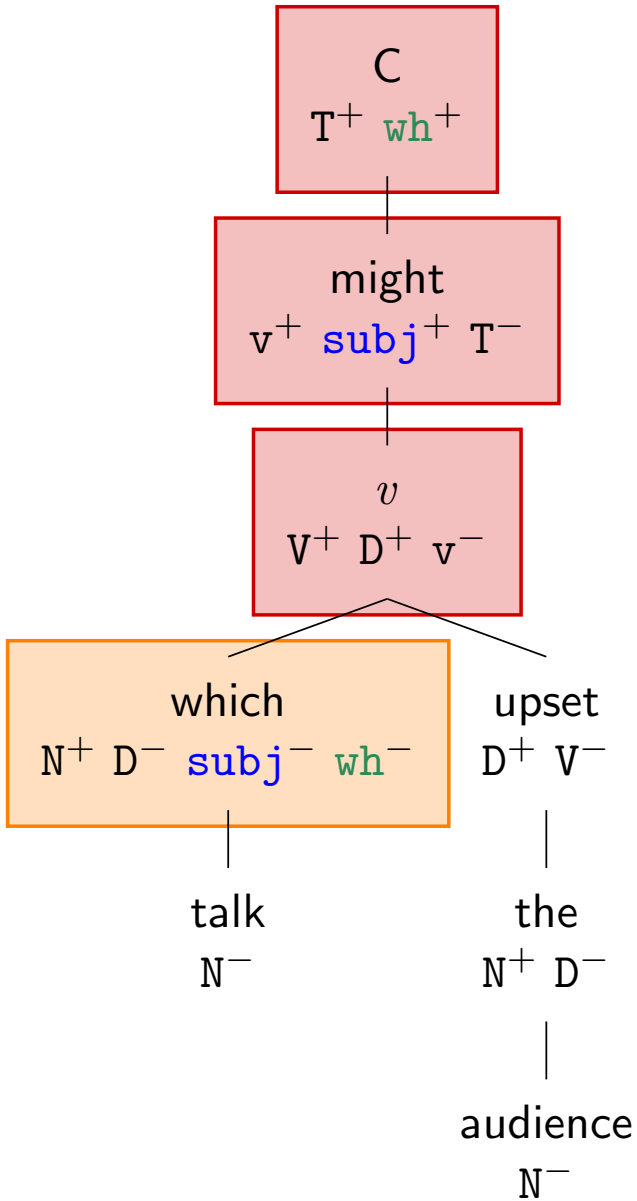
(Lambert 2022)

Dakotah Lambert

A small example

1. **Checking $\texttt{subj}^-$ on which**

2. **Checking $\texttt{wh}^-$ on which**



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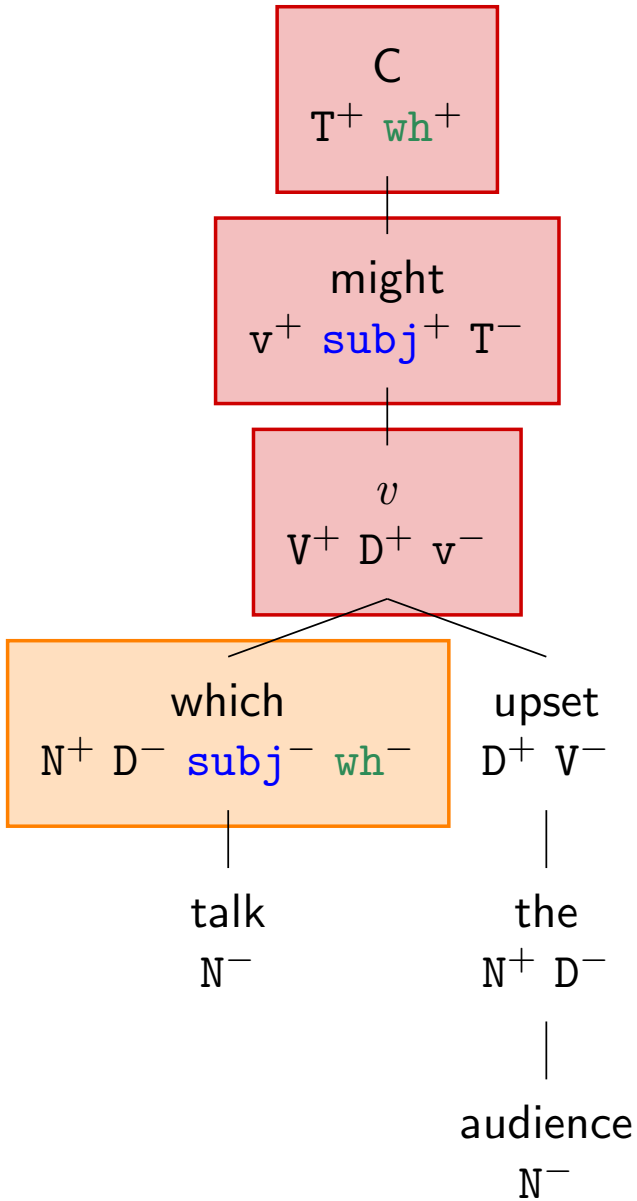
1. **Checking $\texttt{subj}^-$ on which**

v	might	C
$\texttt{V}^+\ \texttt{D}^+\ \texttt{v}^-$	$\texttt{v}^+\ \texttt{subj}^+\ \texttt{T}^-$	$\texttt{T}^+\ \texttt{wh}^+$

2. **Checking $\texttt{wh}^-$ on which**



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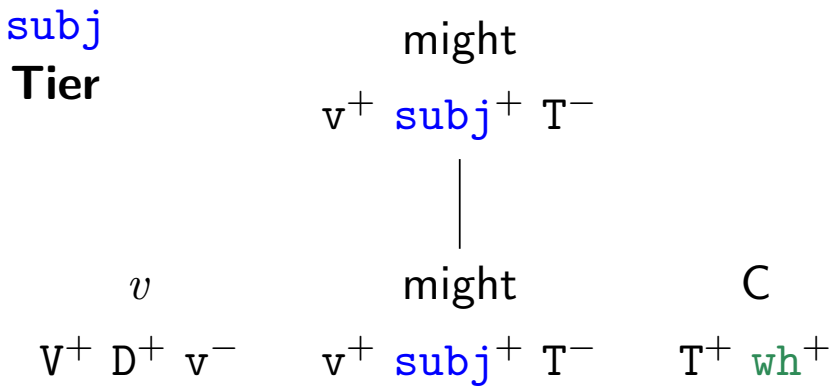

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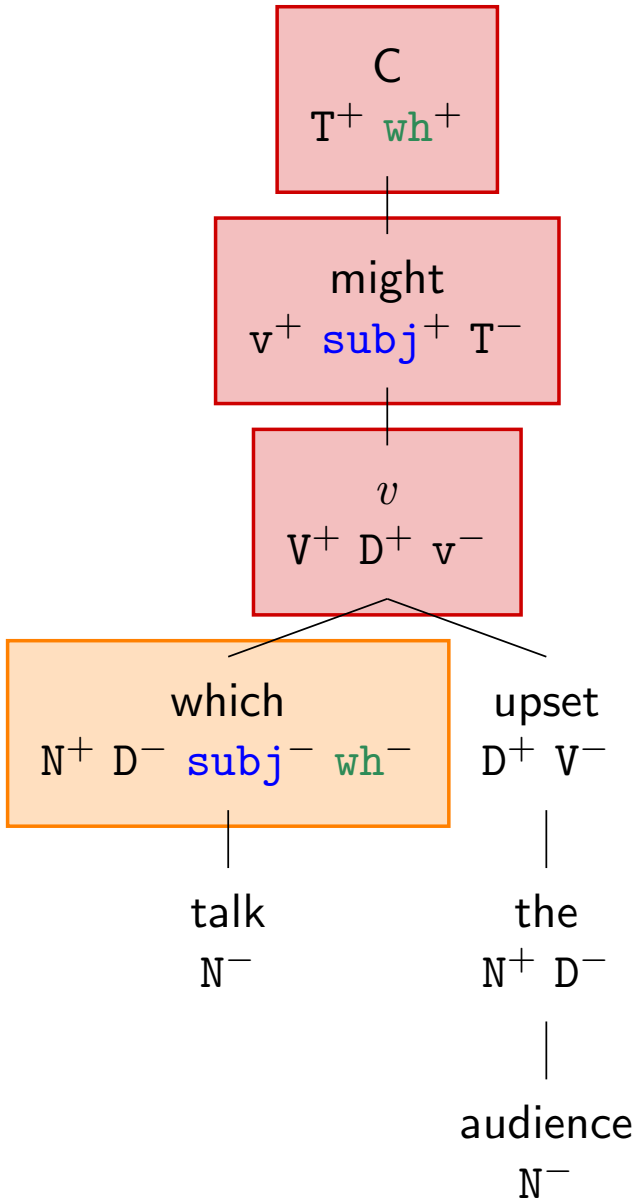

A small example

1 Checking $\texttt{subj}^-$ on which

subj Tier

might
$\texttt{v}^+\ \texttt{subj}^+\ \texttt{T}^-$

v
$\texttt{V}^+\ \texttt{D}^+\ \texttt{v}^-$

might
$\texttt{v}^+\ \texttt{subj}^+\ \texttt{T}^-$

C
$\texttt{T}^+\ \texttt{wh}^+$

2 Checking $\texttt{wh}^-$ on which

v
$\texttt{V}^+\ \texttt{D}^+\ \texttt{v}^-$

might
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C
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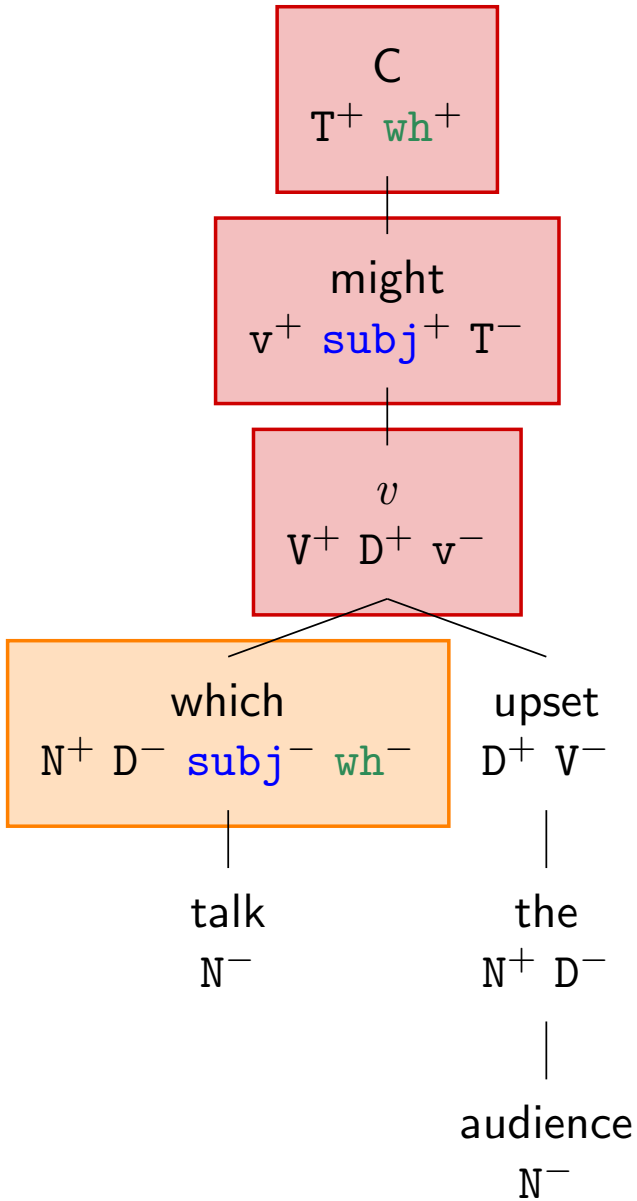

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subj
Tier

might
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v
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might
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C
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wh
Tier

C
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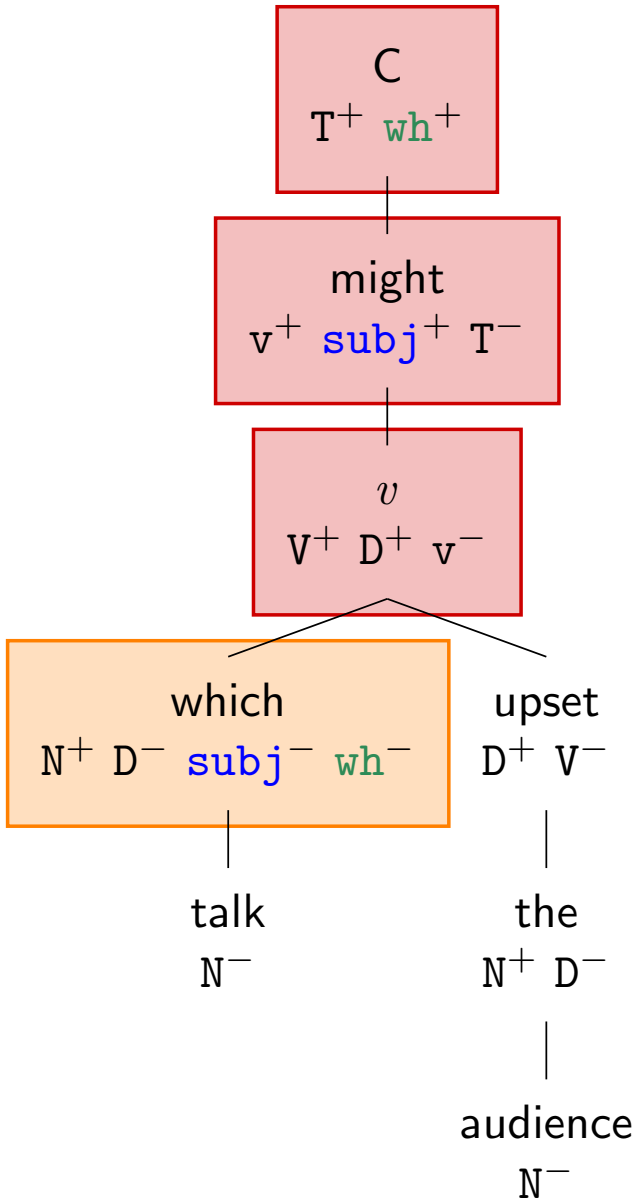

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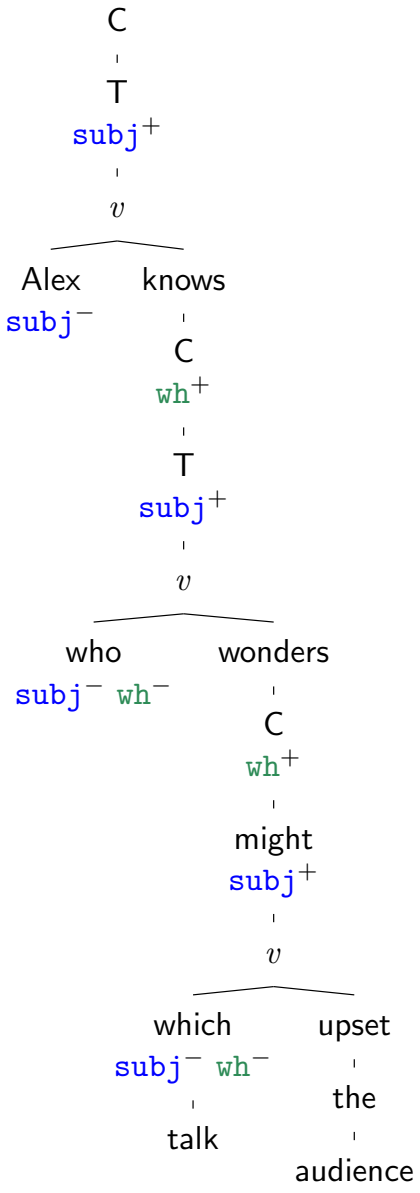

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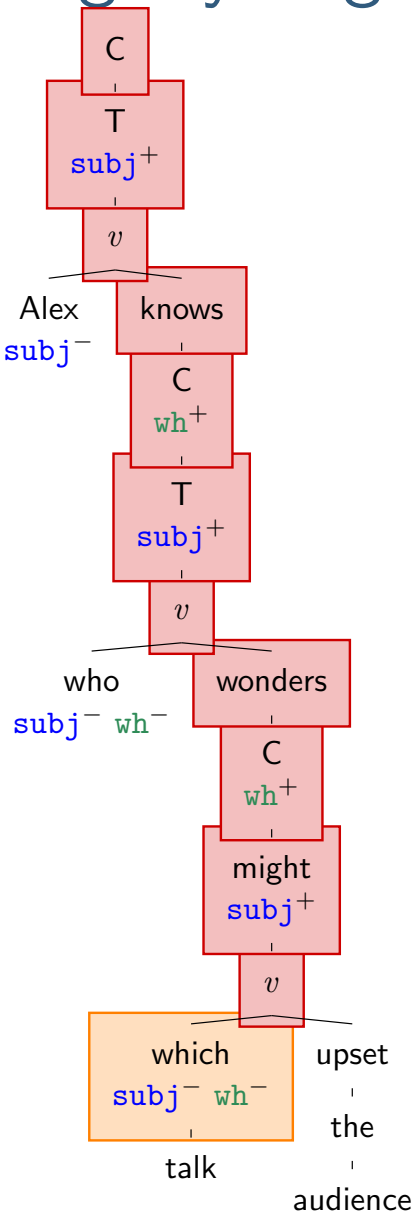

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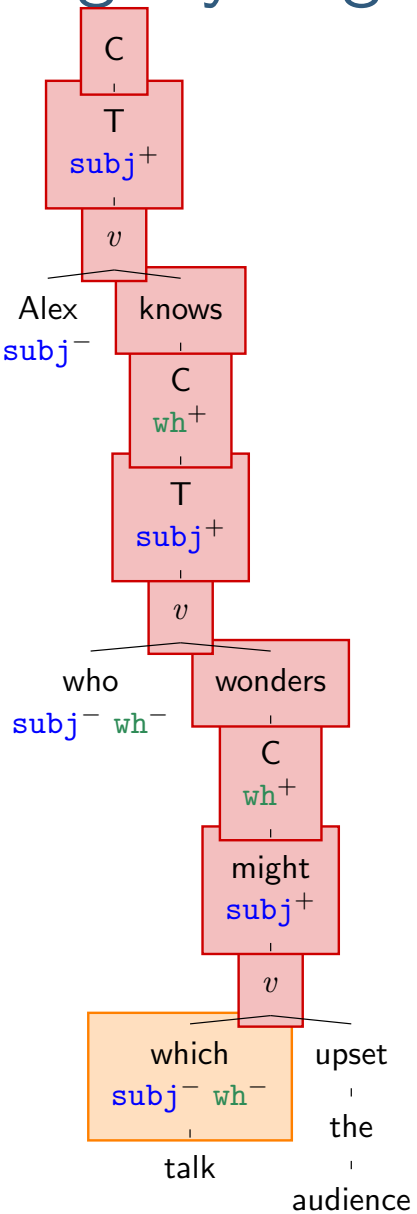

v might C wonders v T C knows v T C

subj+ wh+ subj+ wh+ subj+

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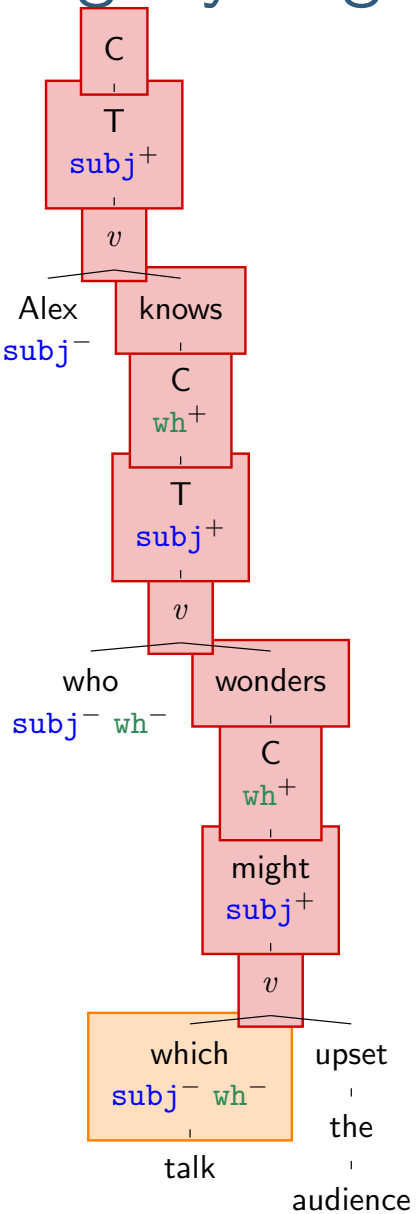

might
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T
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T
subj+
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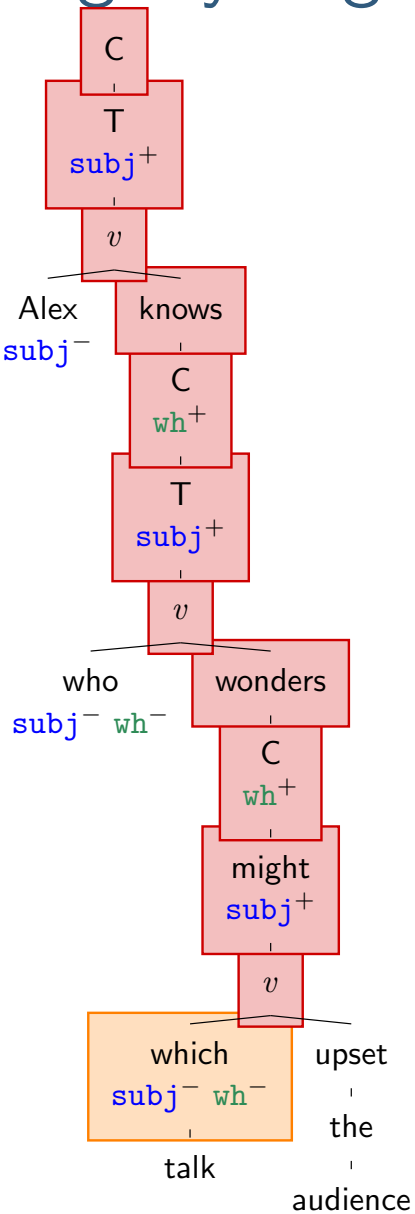

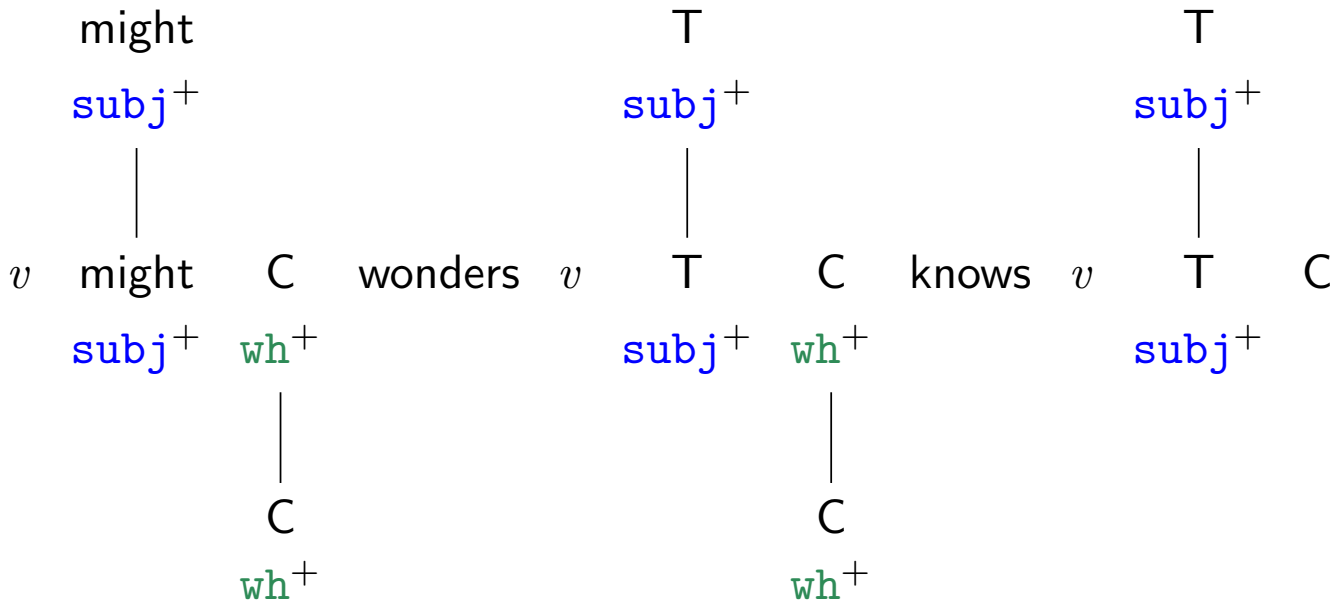

What is so simple about tier-based reverse 1-definite?

String sets that are tier-based reverse 1-definite
require barely any cognitive abilities to verify well-formedness:

1. **Streaming**
   Read in symbols one after the other.
2. **Discrimination/Tier projection**
   Ignore symbols you don't care about.
3. **No memory**
   You don't need to represent the full tier.
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   You are done.

Surprisingly simple, **surprisingly useful**

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Island constraints

- A cognitive/computational system that can handle the Ceiling Constraint, can also produce **island effects**!
- How? Just **project crud**...

Example: projecting *because* creates an adjunct island effect

- **Who did you complain [because Alex might kiss t?]*

kiss v might because complain v T did $\texttt{wh}^+$

- The first symbol on the wh-tier doesn't have $\texttt{wh}^+$ $\Rightarrow$ the Ceiling Constraint is violated

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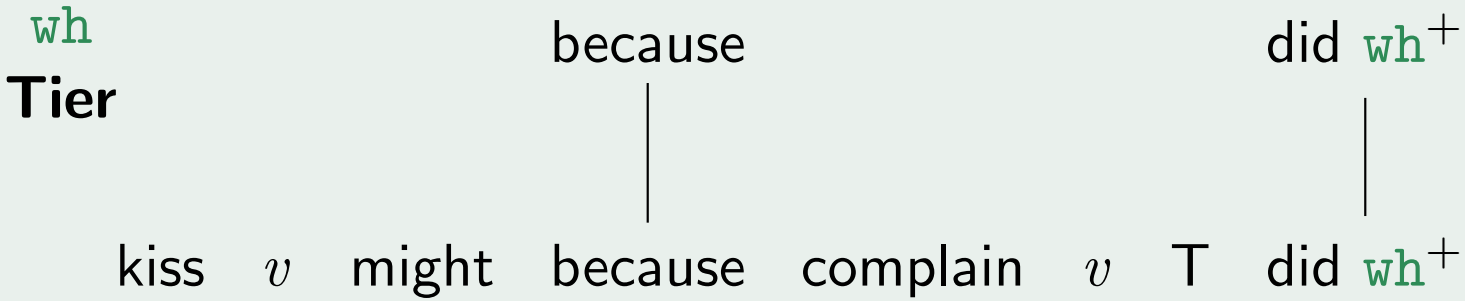

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What just happened?

Ontological entailment from cognitive lower bounds

- We know that **X** exists and requires cognitive resource **R**.
- Cognitive resource **R** also allows computing **Y**.
- Hence we shouldn't be surprised to find **Y**.

(The argument is the exact opposite of the Ferris wheel fallacy.)

- The existence of (some) island constraints is unsurprising.
- A computational device that can handle movement also has the means to limit movement via islands.

Which island constraints work like this?

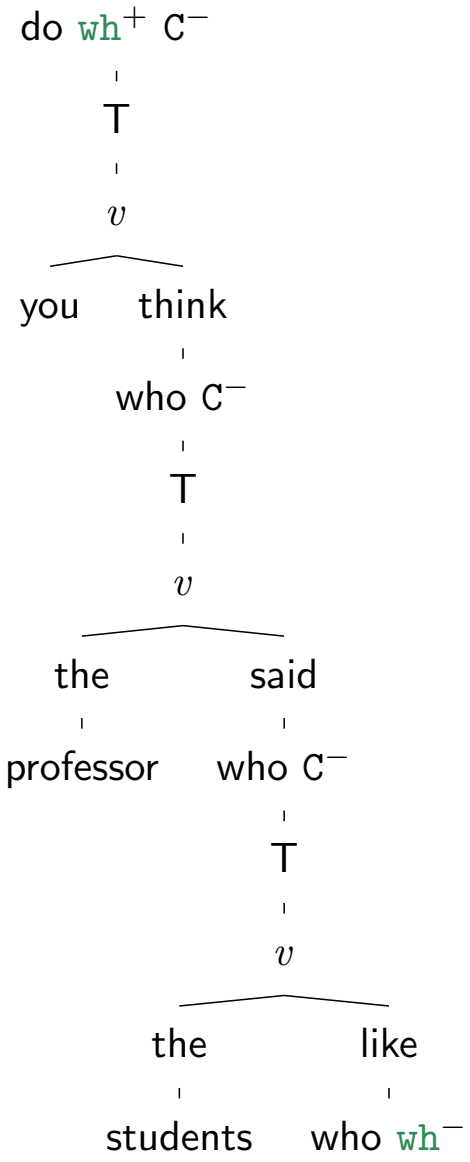
- **Adjunct island constraint**
  project a node if is the head of an adjunct
  presumably that is easy to determine
- **Complex NP constraint**
  project any N that selects C
  i.e. any node with both $\texttt{N}^{-}$ and $\texttt{C}^{+}$
- And many other phenomena actually are island-like.

German wh-copying

(1) Wen glaubst du [wen der Professor gesagt hat [wen
who think.2s you [who the professor said has [who
die Studenten mögen t]]?
the students like]]
'Who do you think that the professor said that the students like?'

- The copy movement analysis has tons of problems.
  illicit with full wh-phrases, copy conversion, interaction with *dass*, and much more; see Pankau (2013)
- Our computational approach allows for German wh-copying with no additional machinery.

German wh-copying example



- **Ceiling Constraint**
  checked as usual
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  wh-copies are some functional head;
  let's go with C for convenience
- **Tier-based reverse 1-definite constraints**

Node	Project...	Start with...
who wh−	all nodes with C−	wh+ or who C−
what wh−	all nodes with C−	wh+ or what C−
who C−	all nodes with C−	wh+ or who C−
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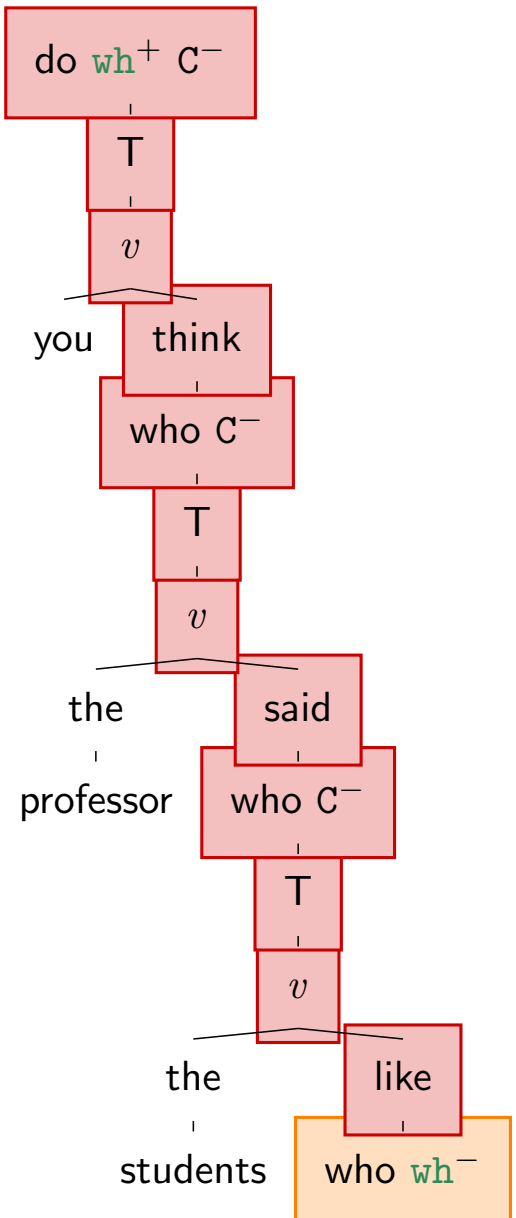

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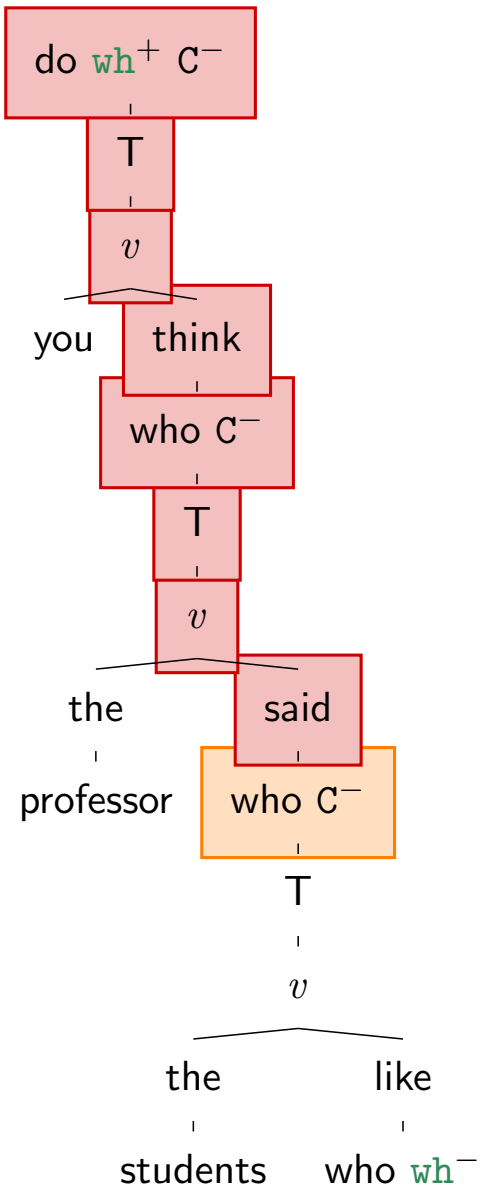

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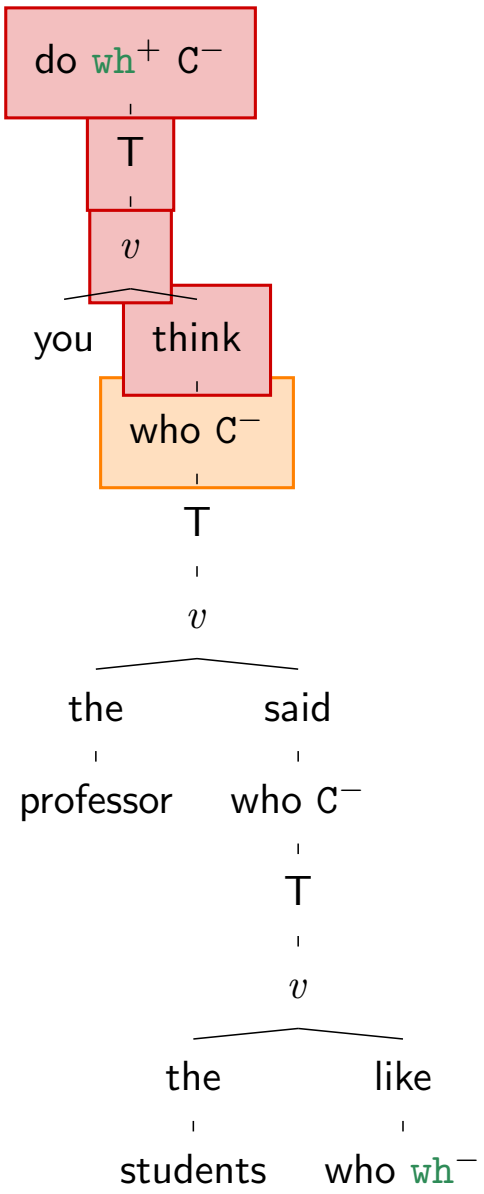

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do wh+ C−

Dealing with *dass* 'that'

- Wh-copying can skip some C-heads at first.

(2) a. **Who** do you think **who** the professor said **who** the students like t?
b. **Who** do you think **who** the professor said *that* the students like t?
c. **Who** do you think *that* the professor said *that* the students like t?

- But once you do wh-copying, you can't go back to *dass*.

(3) * **Who** do you think *that* the professor said **who** the students like t?

- Again unsurprising, requires **just a minor tweak**

Node	Project...	Start with...
who wh$^-$	all nodes with C$^-$	wh$^+$ or who C$^-$
what wh$^-$	all nodes with C$^-$	wh$^+$ or what C$^-$
who C$^-$	all nodes with C$^-$	wh$^+$ or who C$^-$
what C$^-$	all nodes with C$^-$	wh$^+$ or what C$^-$

(Exercise: in some dialects you can mix wh-copies and *dass*, and that is again unsurprising; what do we need to change above?)

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what wh$^-$	all nodes with C$^-$ except *that*	wh$^+$ or what C$^-$
who C$^-$	all nodes with C$^-$	wh$^+$ or who C$^-$
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(Exercise: in some dialects you can mix wh-copies and *dass*, and that is again unsurprising; what do we need to change above?)

Comparison to wh copy movement analysis

Our view of German wh-copying. . .

- . . . likens it to island effects
  mis-agreeing C-heads are islands
- . . . explains why full wh-phrases can't be copied
  the copies are functional heads, not phrases
- . . . allows for copy conversion, e.g. *wo* 'where' as the wh-copy of *in welchem Haus* 'in which house'
  we can allow *wo* as the first symbol for *in wh*
- . . . captures the dialectal variation with respect to *dass* 'that'
  minor differences in what projects for what types of nodes
- . . . requires **no extra machinery whatsoever**

German wh-copying ≈ extraction morphology

- **Extraction morphology** refers to cases where a node's morphological realization is affected by other material moving across it
  - aL/go alternation in Irish
  - Wolof u-chains
  - Chamorro wh-agreement
  - Duala *no*-marking
  - Ewe subject pronoun choice
  - ⋮
- **Spoilers**: these are **variants of German wh-copying**
  or rather, German wh-copying is extraction morphology

Georgi's typology of extraction morphology

- Georgi (2017) identifies a Minimalist 2-by-2 typology depending on whether extraction morphology appears on
  - the final landing site: Yes/No
  - the intermediate landing sites: Yes/No
- We correctly predict these to be independent parameters.
  - agreement on final landing site:
    can be done as part of the Ceiling Constraint
  - agreement on intermediate landing sites:
    separate constraints like German wh-copying

An interesting quirk: Duala no-marking

- In Duala (Niger-Congo), the extraction morphology appears on a head that the mover does not move through.
- *no* appears on T of the clause with the final landing site

(4) Kalati$_i$ nde Kuo a bodi *(**no**) nu moto t_i kiele.
book Foc Kuo 3sg give no that man yesterday
'It's a book Kuo gave to that man yesterday.' (Epée 1976)

- Problem for movement-based accounts, but not for us.

Node	**Project...**	**Start with...**
wh$^-$	all T-*no* and wh$^+$	T-*no*
T-*no*	all T, T-*no*, wh$^-$, and wh$^+$	wh$^+$

Ewe subject alternation

- In Ewe (Niger Congo),
  the 3rd person subject *é* becomes *wò*
  if a wh-phrase moves across.

(5) Kofi biɛ [$_{\text{CP}}$ be lamata$_i$ **wò**/*é fo Kɔsi t_i].
Kofi asked C why he hit Kɔsi
'Kofi asked why he hit Kɔsi.'

- We're stuck. Do you know why?

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Kɔsi					

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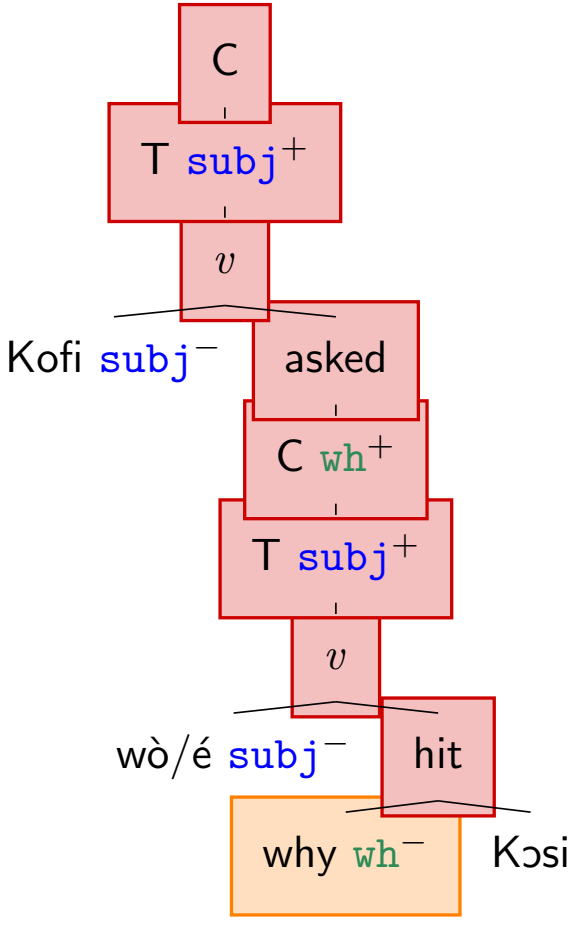
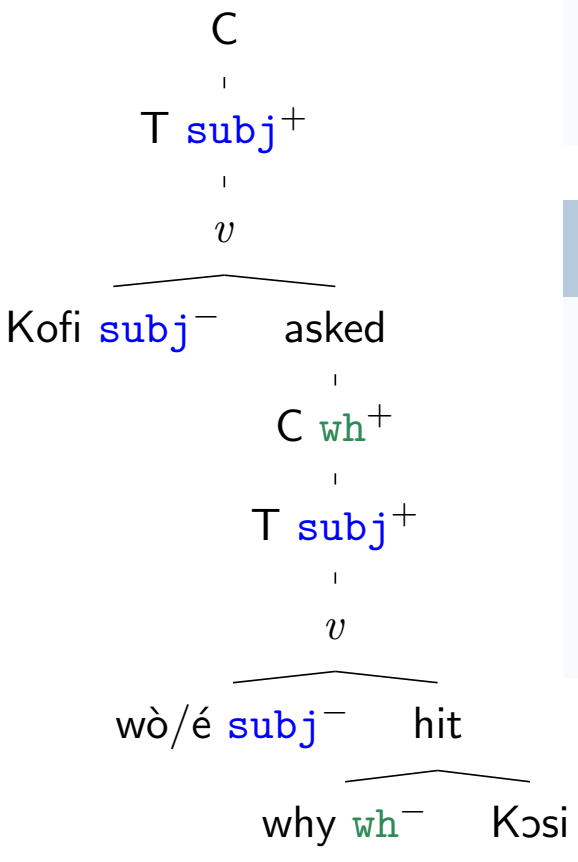
- We're stuck. Do you know why?

You can't constrain what you can't see!



A new string type: c[ommand]-strings



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The **c-string** of **n** consists of all the nodes that are either

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- left siblings of a node in the a-string of **n**.

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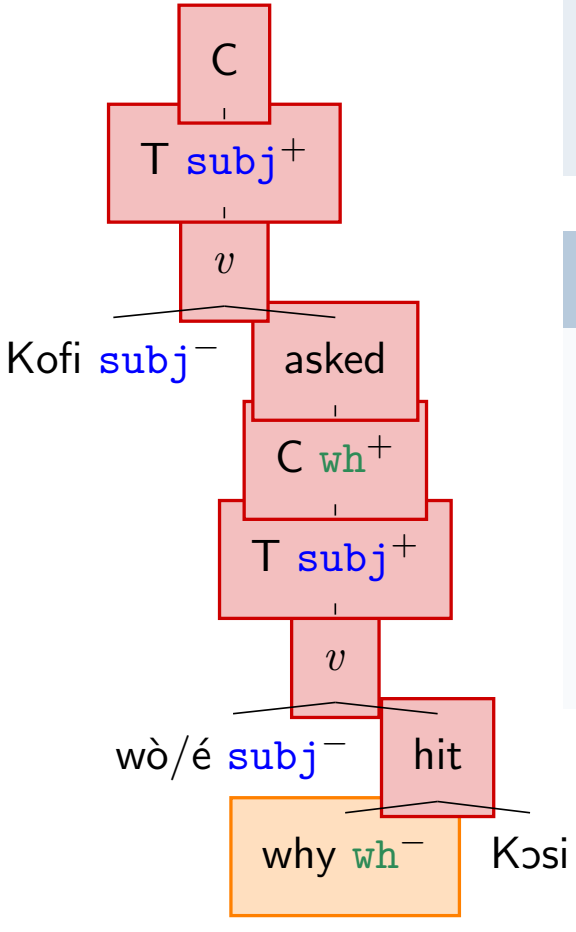

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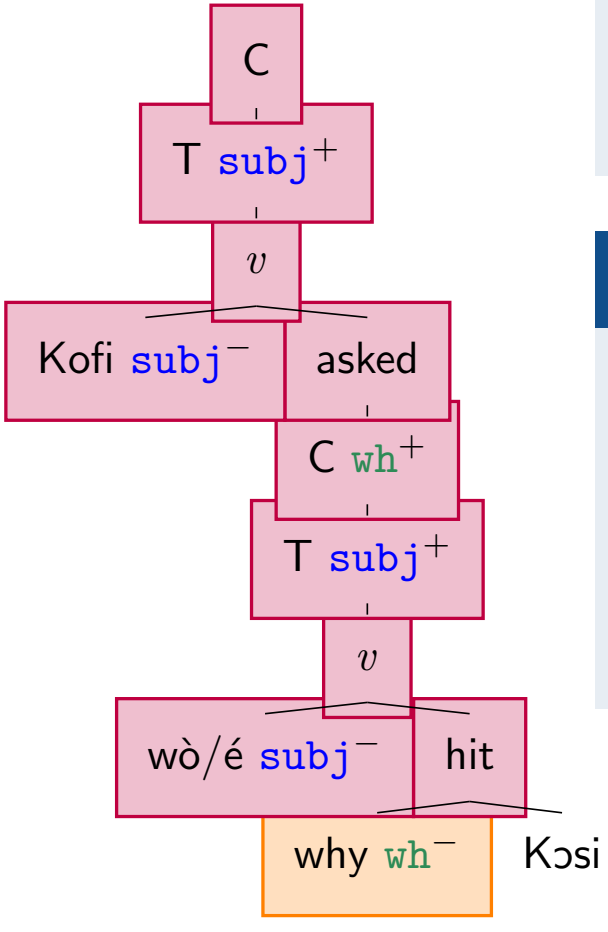

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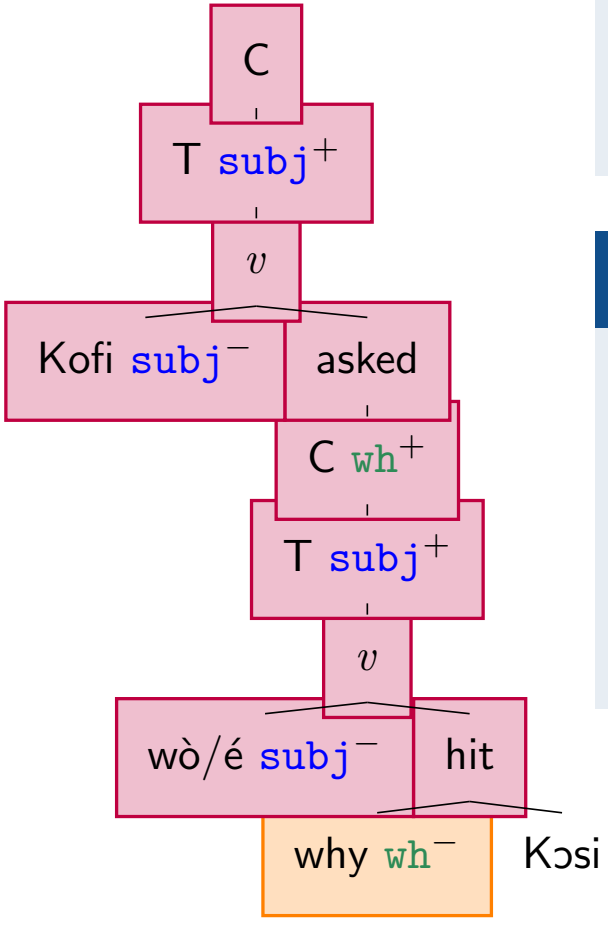
The **c-string** of **n** consists of all the nodes that are either

- in the a-string of **n**, or
- left siblings of a node in the a-string of **n**.

A new string type: c[ommand]-strings



Definition (a[ncestor]-string; simplified)

The **a-string** of **n** consists of all the nodes that are derivationally ordered after **n**.

Definition (c[ommand]-string; simplified)

The **c-string** of **n** consists of all the nodes that are either

- in the a-string of **n**, or
- left siblings of a node in the a-string of **n**.

Node	Project...	Start with...
wh−	wh+ and *é*	wh+

é acts like an island for wh-movers

Relativized minimality

- A new string type just for Ewe? No, for a lot of stuff!
  Binding! Agree! But we don't have time...

(6) a. Who bought what?
b. * What did who buy?

- Relativized minimality = **island effect over c-strings**

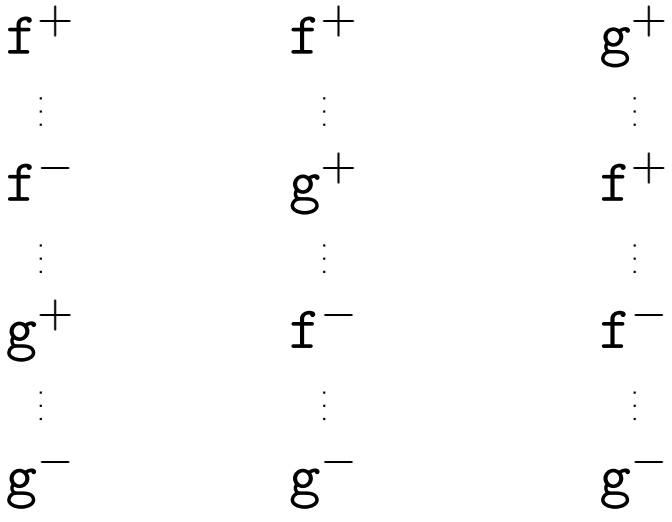
Node	**Project...**	**Start with...**
$\texttt{wh}^-$	$\texttt{wh}^+$ and all potential carriers of $\texttt{wh}^-$	$\texttt{wh}^+$

c-string of *who* in (6a): v T C$\texttt{wh}^+$ Tier: C$\texttt{wh}^+$
c-string of *what* in (6b): buy who v T C$\texttt{wh}^+$ Tier: who C$\texttt{wh}^+$

A minor extension for freezing effects

- **Freezing**: Once an XP has started moving,
  no YP contained in XP may move out of XP.
  a relativized version like UCOOL is empirically more adequate,
  but works the same for our purposes
- Freezing can be done over a-strings,
  but it requires a larger window: **tier-based reverse 2-definite**

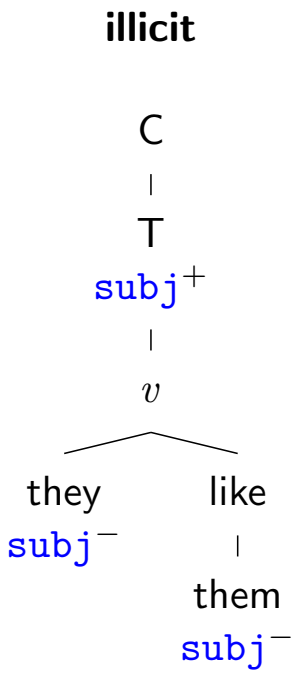
allowed **allowed** **forbidden**



Node	Project...	Start with...
g^-	f^-, f^+, g^+	not f^-f^+

Size-2 windows for movement

- Freezing's larger window isn't that special, we need it for movement, too.
- **The Ceiling Constraint**
  Every $\texttt{f}^-$ needs an $\texttt{f}^+$
- **The Foundation Constraint**
  Every $\texttt{f}^+$ is matched with exactly one $\texttt{f}^-$



A brief sketch for T$\texttt{subj}^+$

- Do a recursive descent traversal from T$\texttt{subj}^+$, but don't go below any $\texttt{subj}^-$.
- Resulting string: v they$\texttt{subj}^-$ like them$\texttt{subj}^-$
- The $\texttt{subj}^-$ tier must have length 1.
  Checking this requires a window of size 2.

Overview of string-types and window size

Constraint	**string**	**size**
Ceiling Constraint	a	1
Foundation Constraint	rec.desc.	2
Strong islands	a	1
German wh-copying	a	1
	rec.desc.	1
Extraction morphology	a	1
	rec.desc.	1
Ewe subject alternation	c	1
Principle A	$\sim$c	1
Long-distance reflexives	$\sim$c	1
Freezing	a	2
Ban on Improper movement	a	1
Omnivorous agreement	rec.desc.	2

A mathematical theorem: from local to global

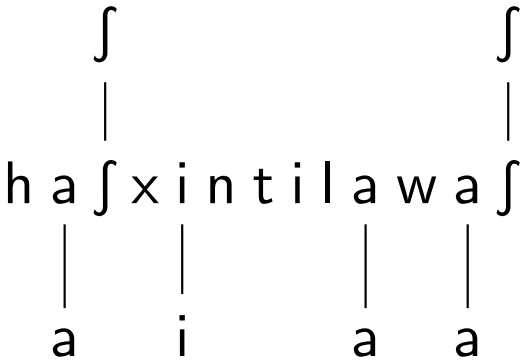
- Isn't it taxing (and redundant) for syntax to compute these strings for each node?
- No! For each string type τ we can convert this to a **single constraint** that directly defines the set of all well-formed τ-strings.

Toy example without tiers

- Suppose our nodes can only be x or y.
- The a-string of x must start with y.
- The a-string of y must start with x or contain nothing at all.
- Then the set of well-formed a-strings is exactly the set of strings that may only contain the following bigrams:
  - xy (x followed by y)
  - yx (y followed by x)
  - $y\rtimes$ (y followed by the right string edge)

Syntax as multi-phonology

- For each string type τ, the converted constraint is **multi tier-based strictly local (MTSL)**.
- This type of constraint is also **very common in phonology**.



- **Syntax as multi-phonology**
  - Phonology: building a single MTSL string
  - Syntax: building many intertwined MTSL strings

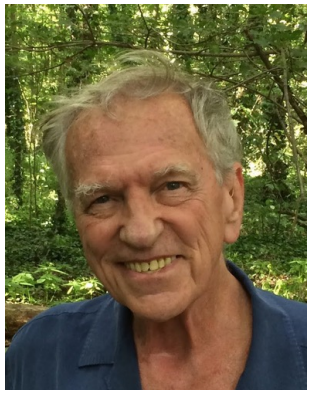
Open ends

- Connections to other work?
  Kayne's unambiguous paths, path equations in LFG, trees as path languages
- Some phenomena don't fit this view.
  parasitic gaps, coordinate structure constraint
- Many phenomena I haven't had time to look at yet.
  Anybody looking for a research project?

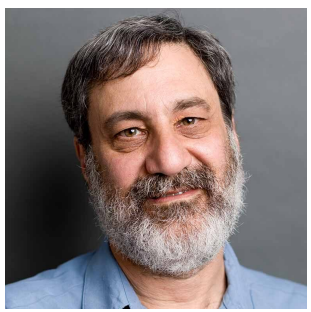
Conclusion: don't lock yourself into a single viewpoint

- Don't just think in terms of trees, strings are very insightful!
- A variety of syntactic phenomena belong to a very simple class of constraints over particular types of strings.
  a-strings, c-strings, rec.desc.-strings
- Computation provides an explanation for why these phenomena can occur in the first place.
- The view is much more abstract than regular syntax, making it easier to hook into cognitive science, NLP, ...
- When go from the node-based perspective back to a more global one, we get **syntax as multi-phonology**.

If you can't say something two ways,
you can't say it at all.
(Keenan and Moss 2017)



Edward Keenan



Larry Moss

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