Test Suite Generation

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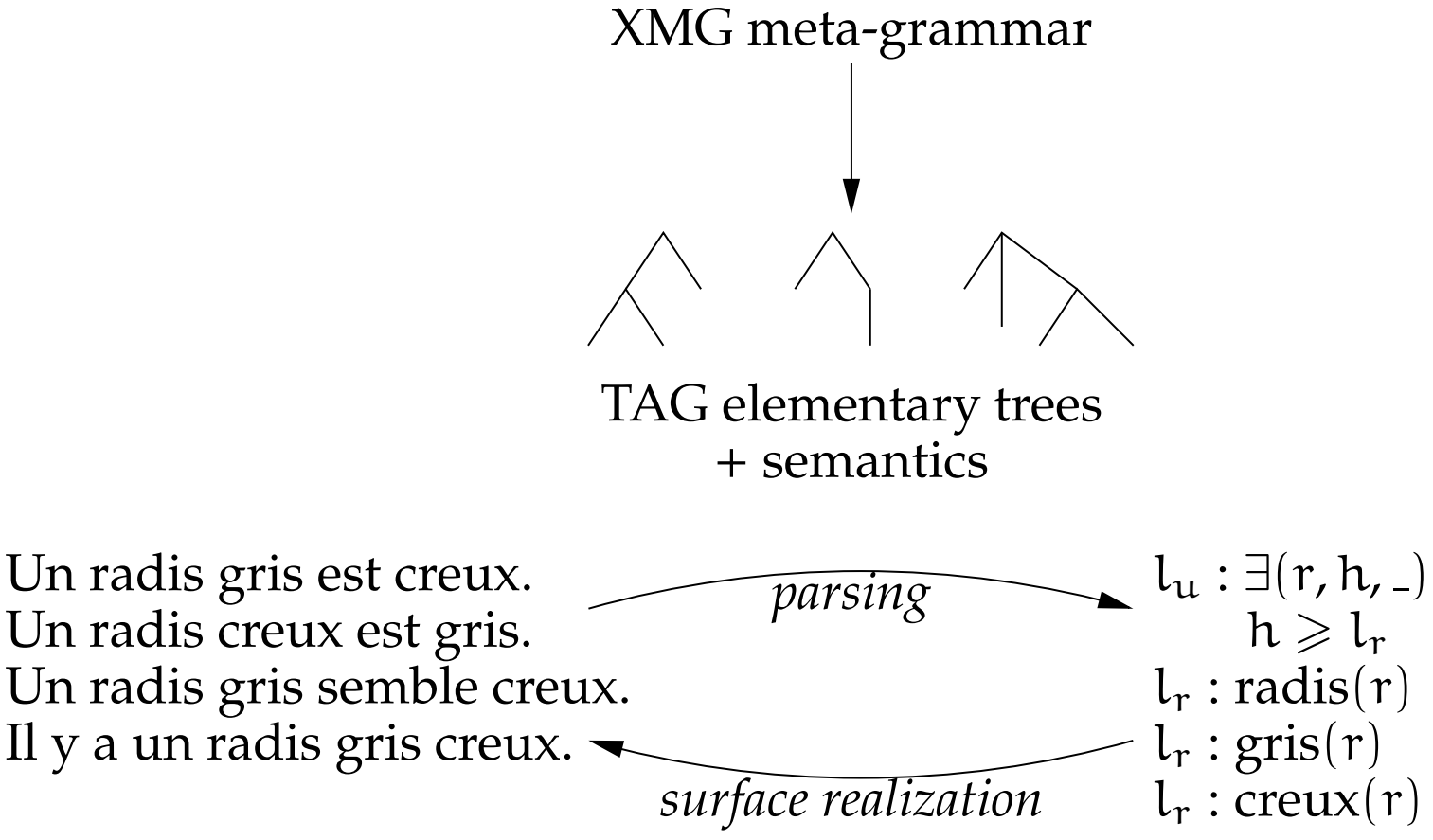
LSV Seminairs, Cachan, September 23, 2008

SemFraG

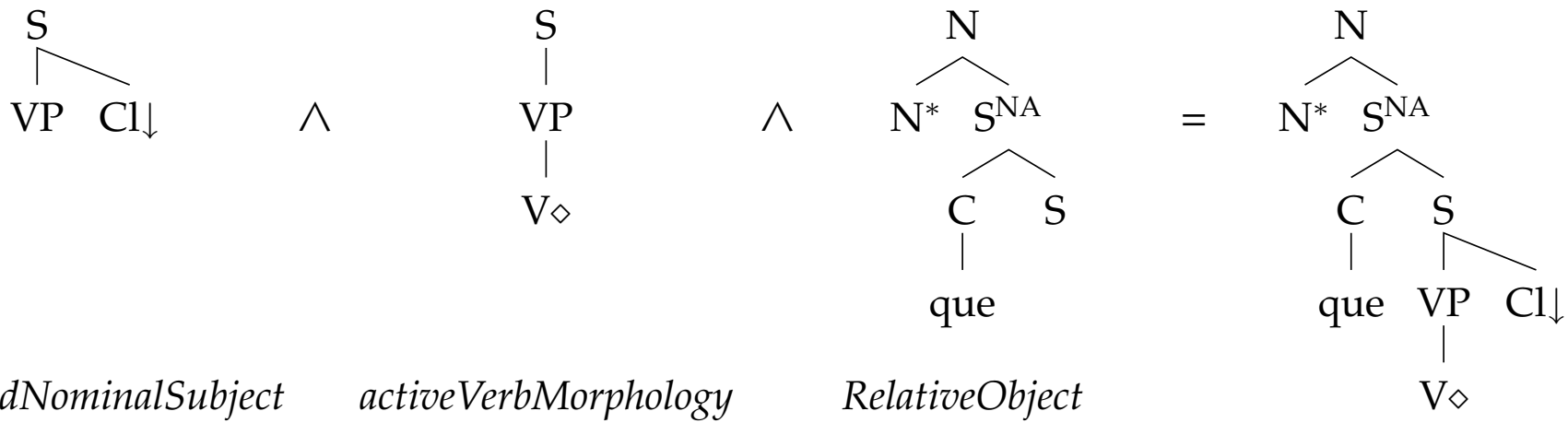
Crabbé [2005], Gardent [2008]



Meta Grammar

XMG, Crabbé [2005] and many others

CanonicalSubject *activeVerbMorphology* *CanonicalObject*



InvertedNominalSubject *activeVerbMorphology* *RelativeObject*

Grammar Evaluation

Against TSNLP [Lehmann and Oepen, 1996]

- undergeneration
  - 76% of grammatical sentences parsed
- overgeneration
  - 83% of agrammatical sentences rejected
  - 1.65 parses per correct sentence on average
- how can we improve the grammar?

Error Mining for Undergeneration

van Noord [2004], Sagot and Éric de la Clergerie [2006]

1. parse a large corpus of correct sentences
2. failures indicate coverage issues
3. statistical analysis identifies a probable culprit for each failure
4. might attempt to provide corrections

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For Overgeneration?

Which test suite for pass/failure?

- a TreeBank
- a corpus of incorrect sentences
- sentences generated from the grammar
  - which input?
  - generation from logic formulae is NP-complete

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“Exhaustive” Generation

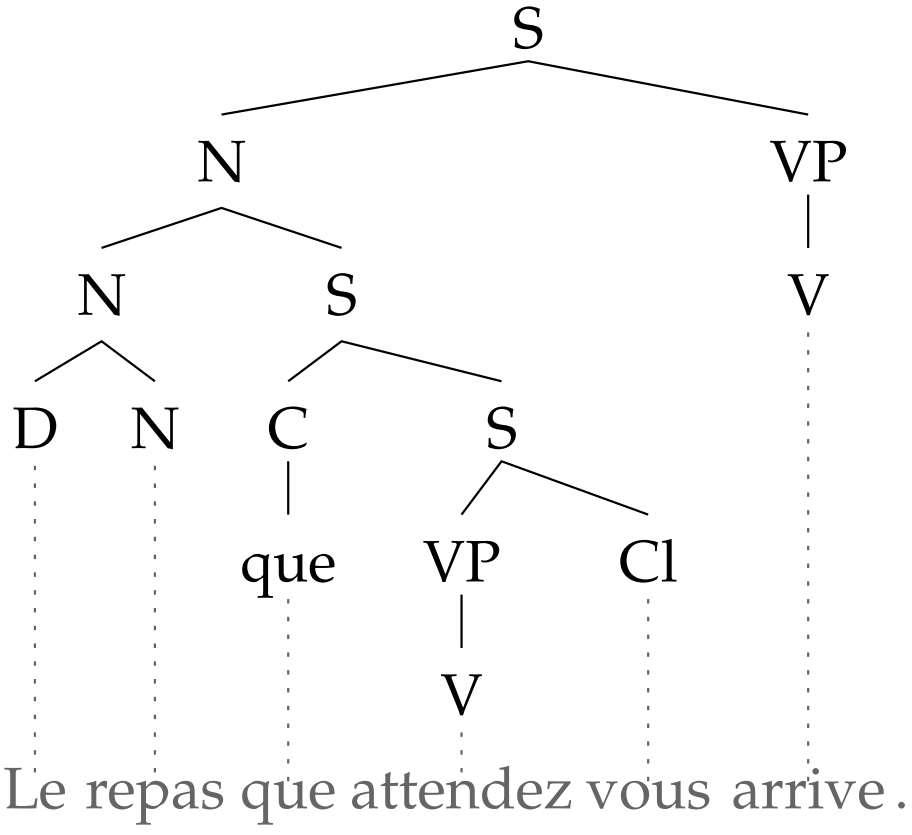
- not in terms of elementary trees (about 6,000)
- in terms of *linguistic phenomena*
  - grammar compiled from a meta grammar
  - compilation traces
  - 110 classes match linguistic phenomena

Guided Generation

Input:
bag of classes

{ *InvertedNominalSubject*, *RelativeObject* }

Output:
set of trees

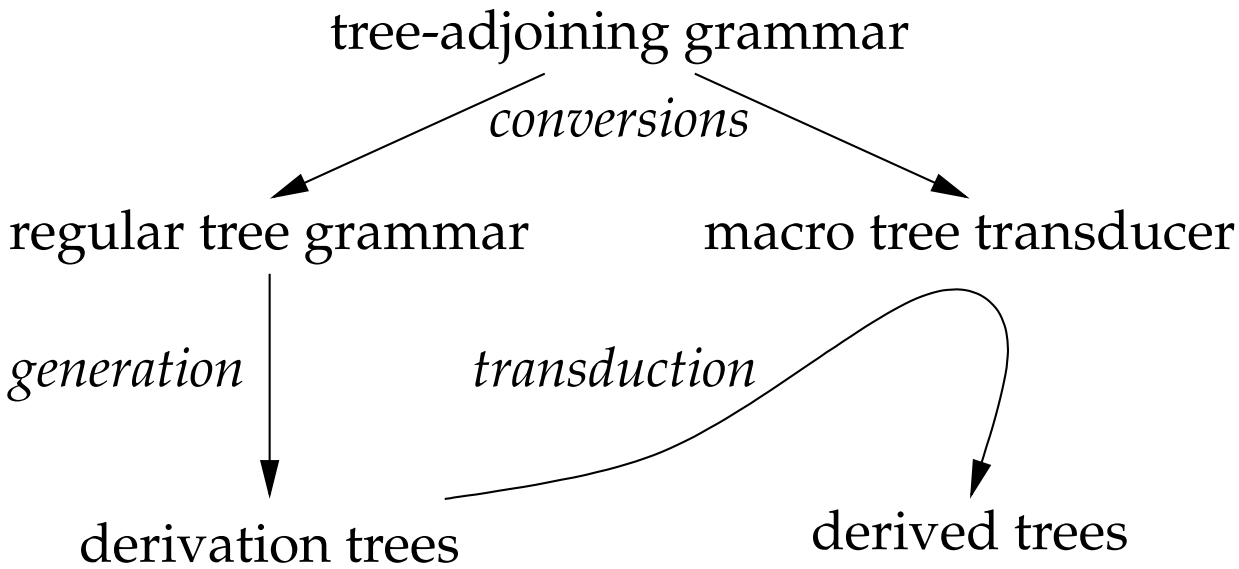


Example of a Test Suite

*Jean qu'attends-tu est grand.
Jean qui attend se lave.
Le chat noir est grand.
Il le faut.
Beaucoup de chats noirs se lavent.
Jean qu'il attend agit.
*Le chat est avec beaucoup de poils grand.
Jean qui agit est grand.
*Le repas qu'attendez-vous arrive.
*Jean est avec chat grand.

Digression: 2-level TAG Syntax

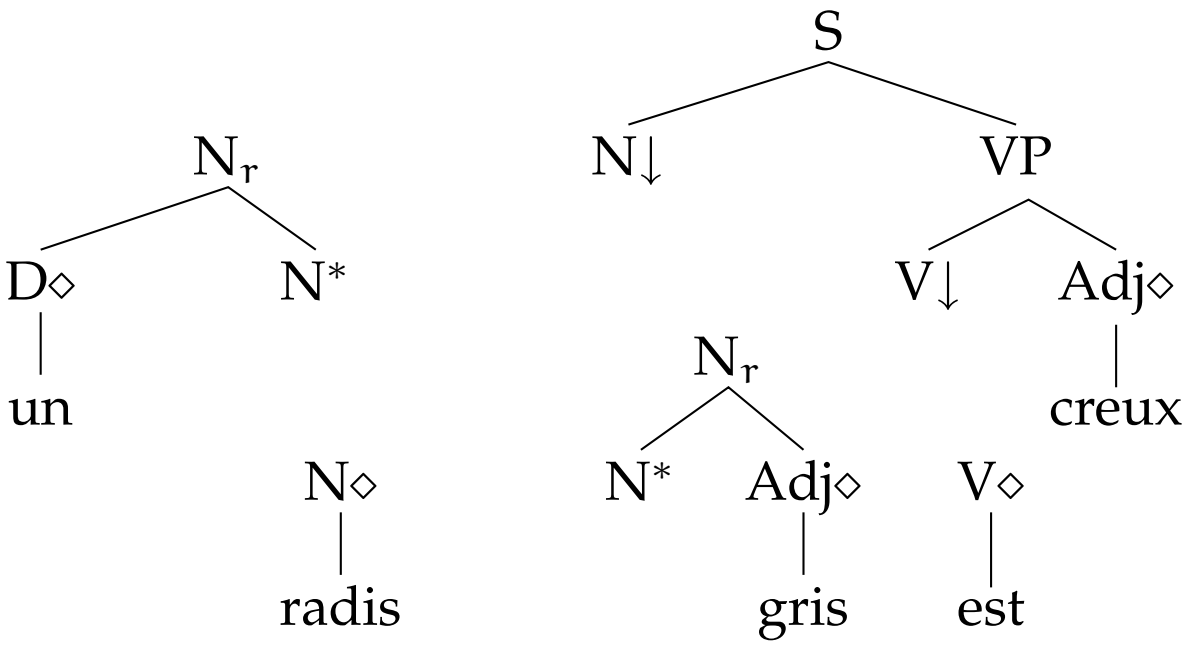
Shieber [2006] and many others



Tree Adjoining Grammars

Joshi et al. [1975], Joshi and Schabes [1997]

Elementary trees:



Tree Adjoining Grammars

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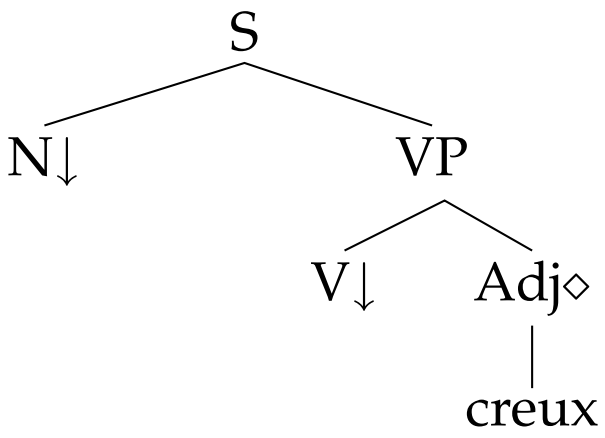
Two operations:

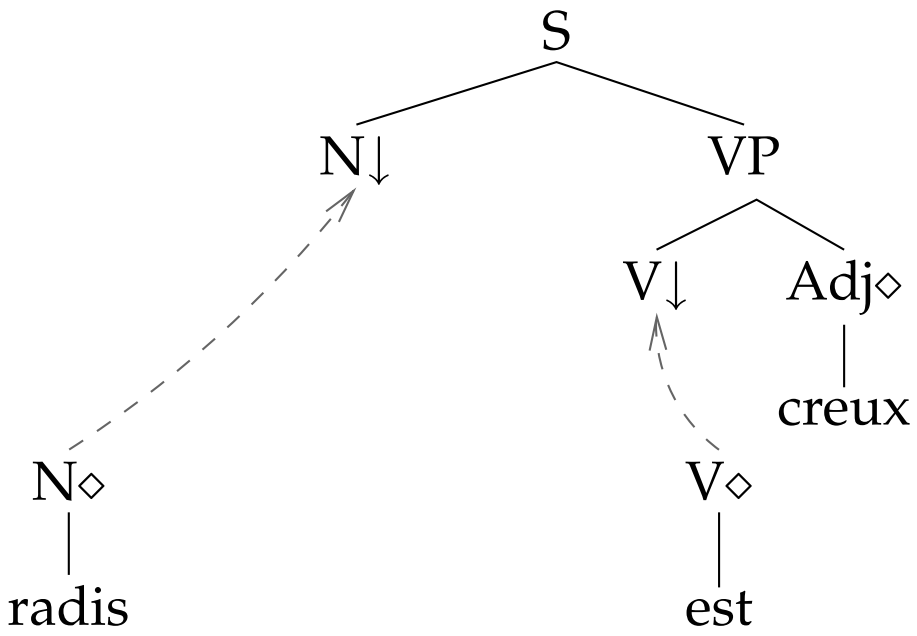


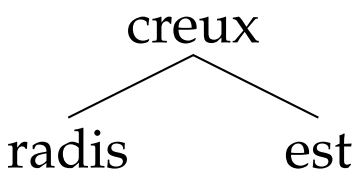
creux

Tree Adjoining Grammars

Joshi et al. [1975], Joshi and Schabes [1997]

Two operations: substitution:





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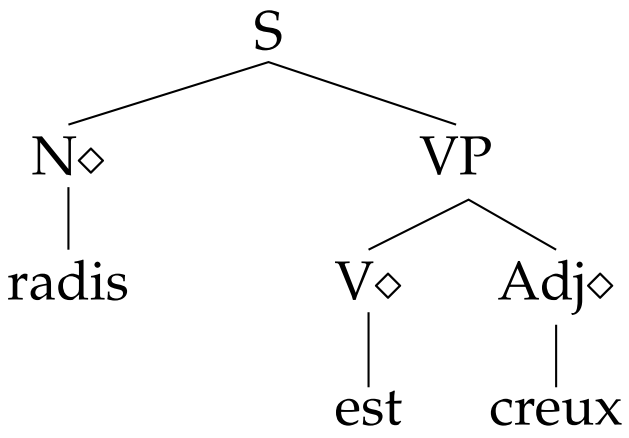

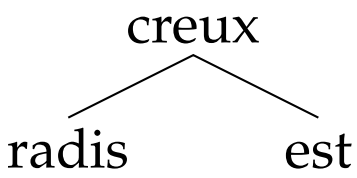

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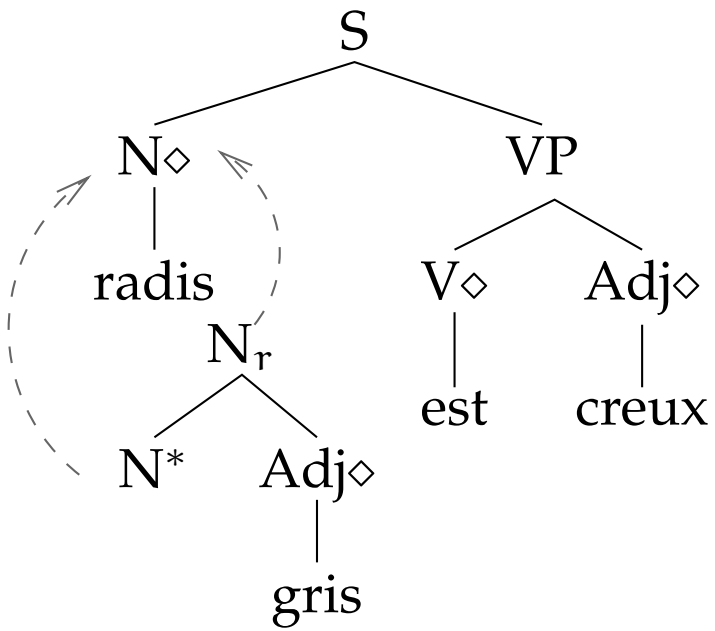
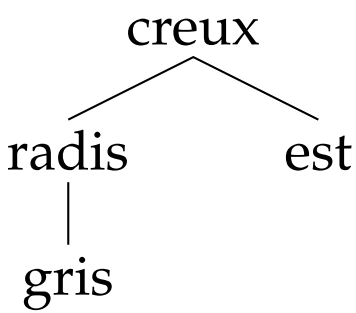
Two operations: adjunction:





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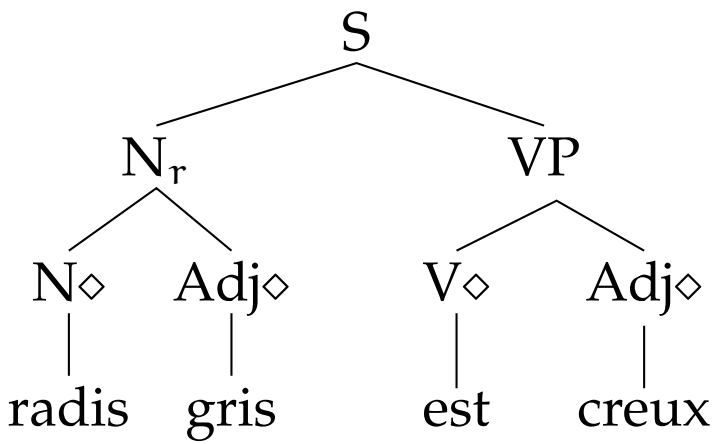

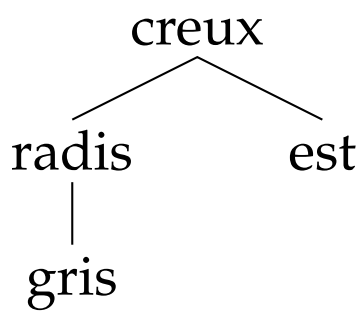

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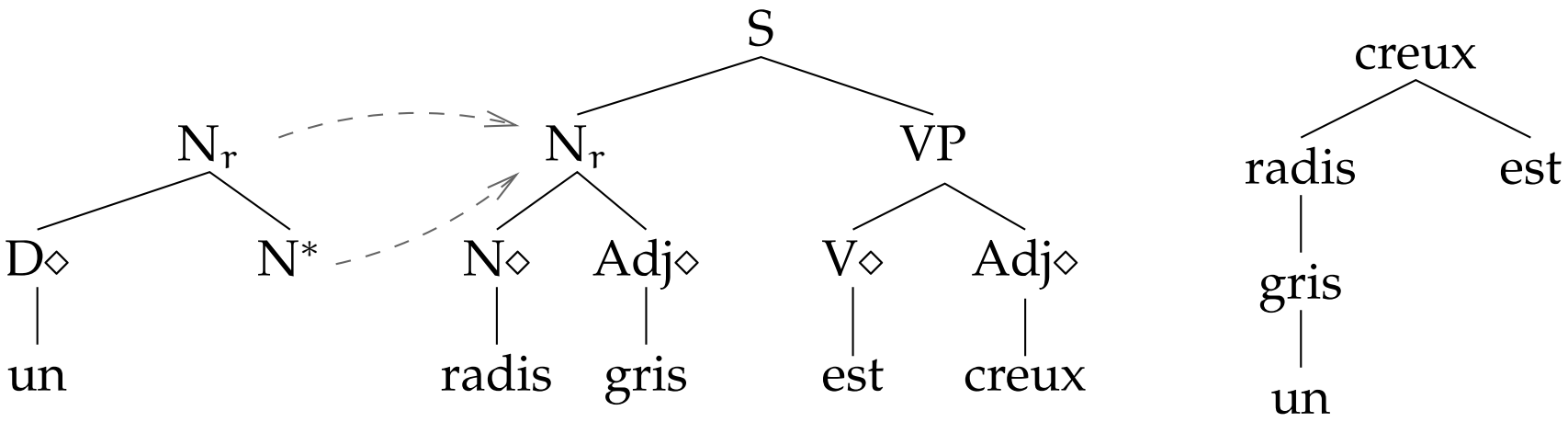

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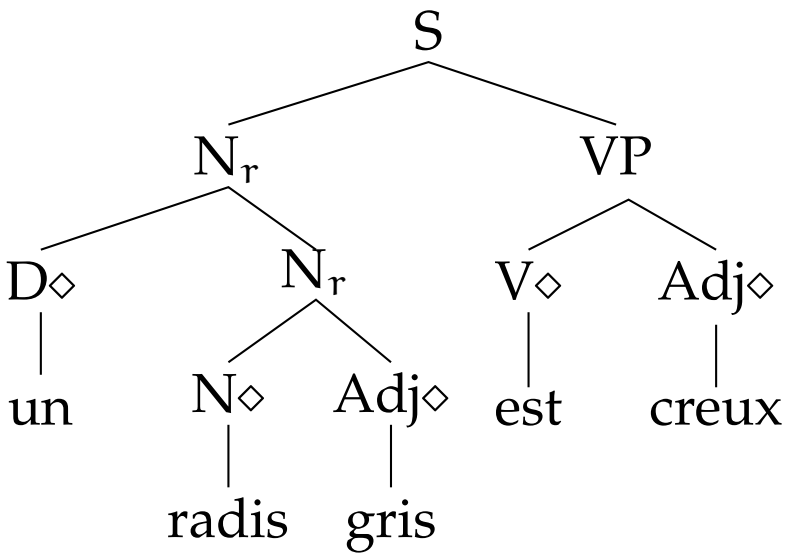
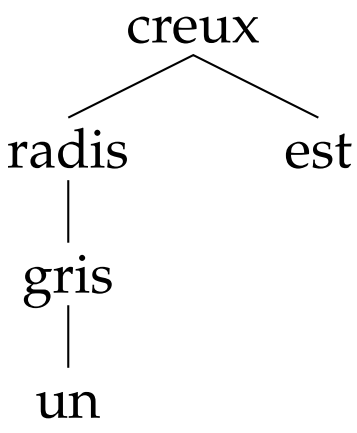
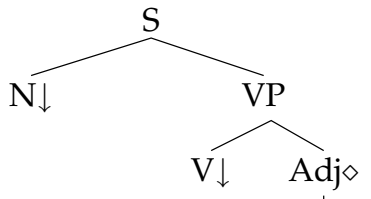
Derived and derivation trees:





Derivation Tree Language (1)

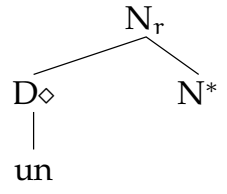
(reduced) Regular tree grammar



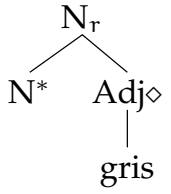
$$S_I \rightarrow \text{creux}(S_A, N_I, VP_A, V_I, Adj_A)$$

$$N_I \rightarrow \text{radis}(N_A)$$

$$V_I \rightarrow \text{est}(V_A)$$



$$N_A \rightarrow \text{un}(N_A, D_A)$$



$$N_A \rightarrow \text{gris}(N_A, Adj_A)$$

$$Adj_A \rightarrow \varepsilon(),\ D_A \rightarrow \varepsilon(),\ N_A \rightarrow \varepsilon(),\ S_A \rightarrow \varepsilon(),\ V_A \rightarrow \varepsilon(),\ VP_A \rightarrow \varepsilon()$$

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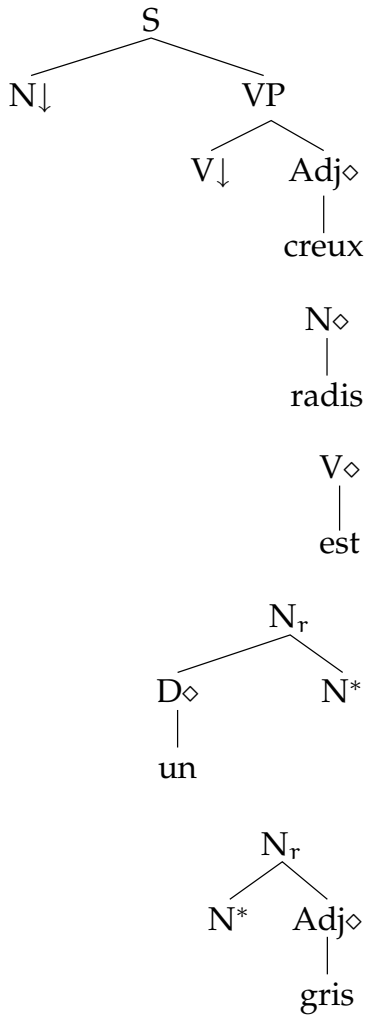


From Derivations to Derived Trees

Macro tree transducer

$$q_I(\text{creux}(t_1, t_2)) \rightarrow S(q_I(t_1),\ VP(q_I(t_2),\ \text{Adj}(\text{creux})))$$

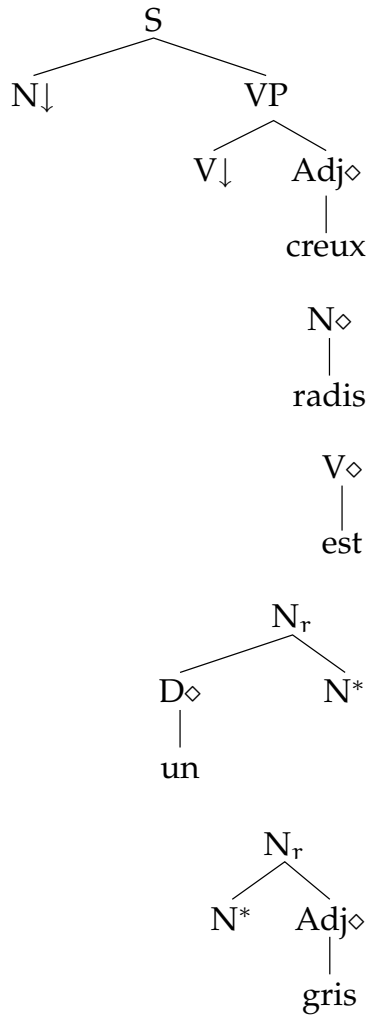
$$q_I(\text{radis}(t_1)) \rightarrow q_A(t_1,\ N(\text{radis}))$$

$$q_I(\text{est}()) \rightarrow V(\text{est})$$

$$q_A(\text{un}(t_1),\ y) \rightarrow q_A(t_1,\ N(D(\text{un}),\ y))$$

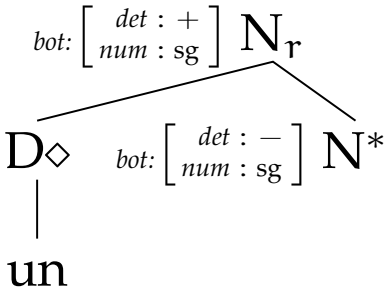
$$q_A(\text{gris}(t_1),\ y) \rightarrow q_A(t_1,\ N(y,\ \text{Adj}(\text{gris})))$$

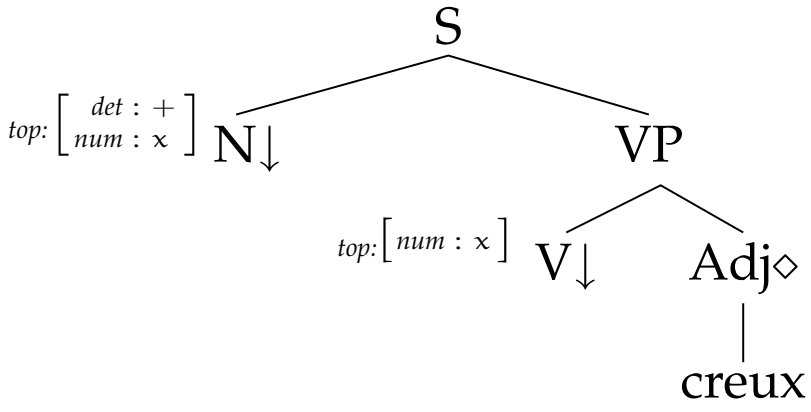
$$q_A(\varepsilon(),\ y) \rightarrow y$$

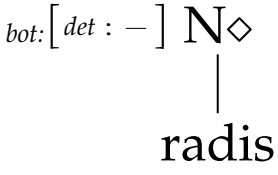


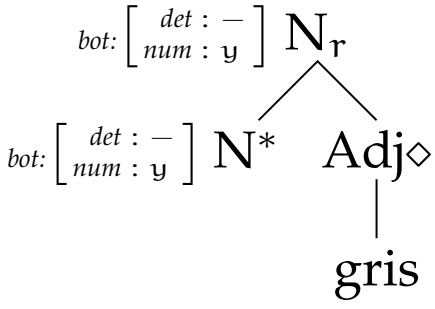
Feature-Based TAG

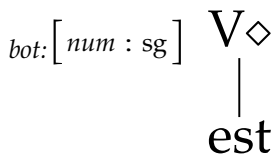
Vijay-Shanker and Joshi [1988]











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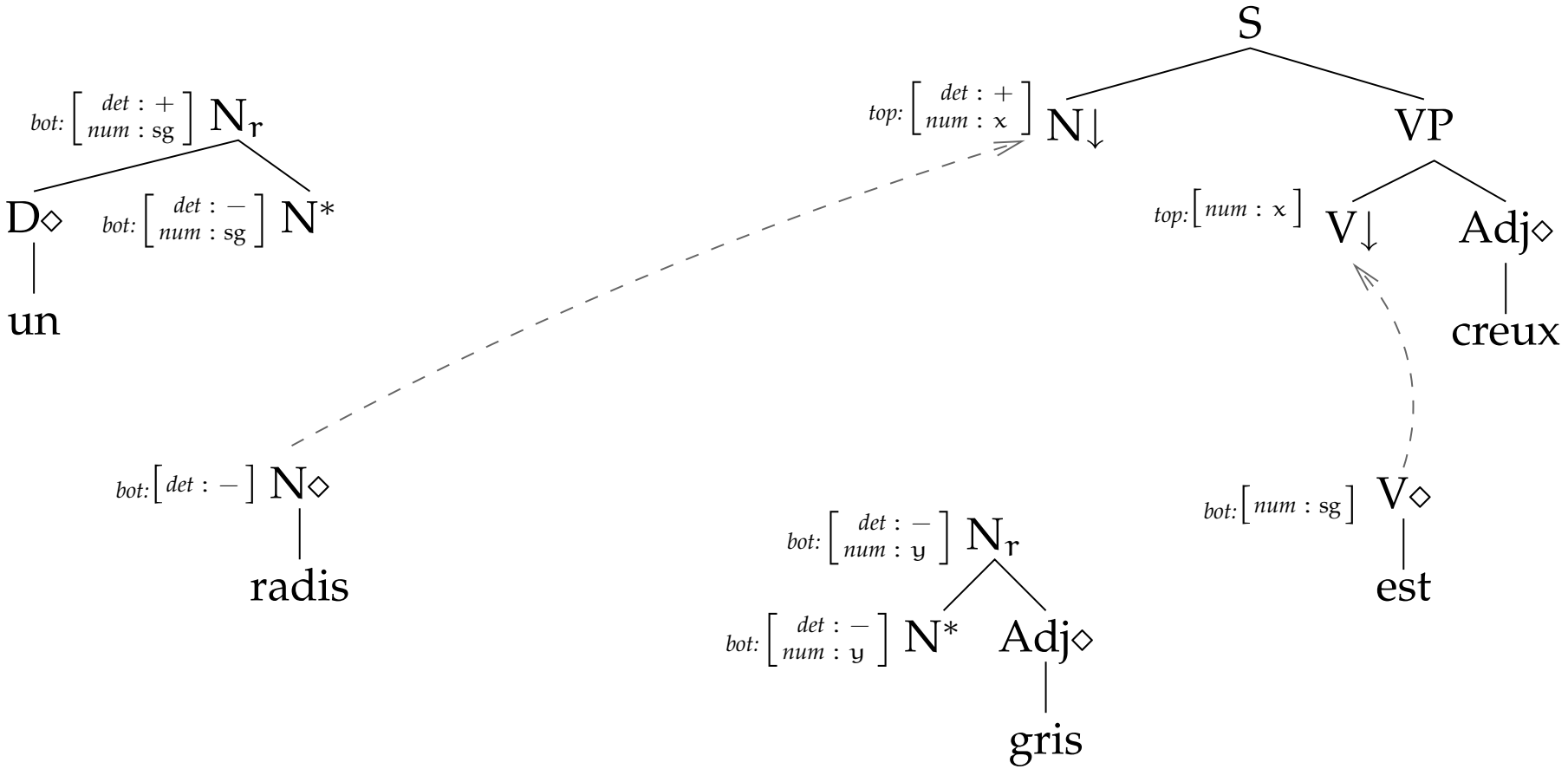

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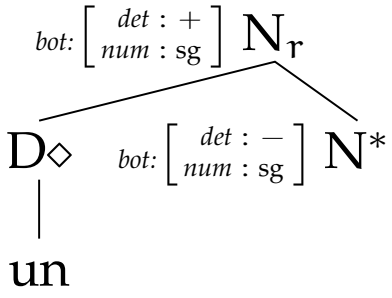

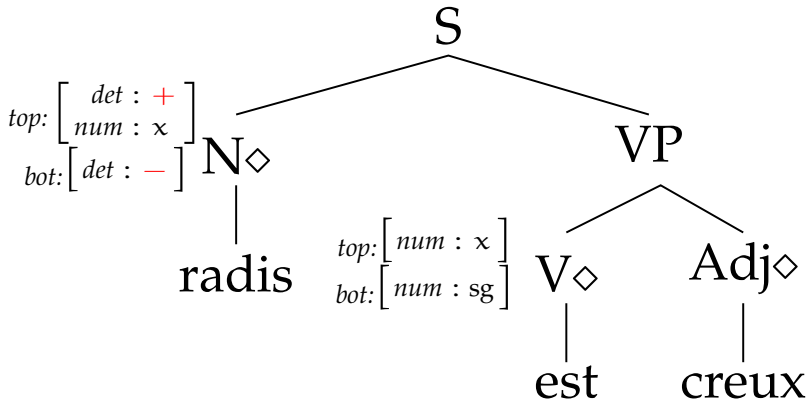

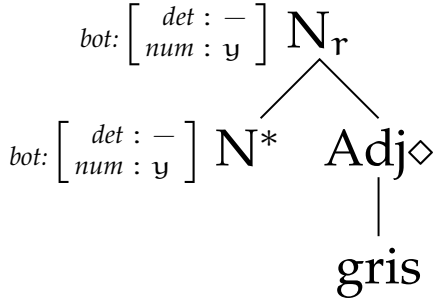

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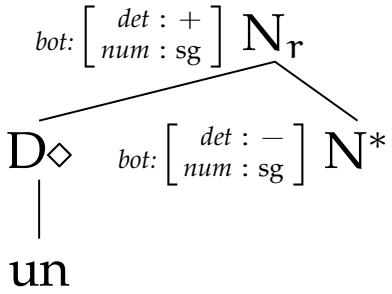

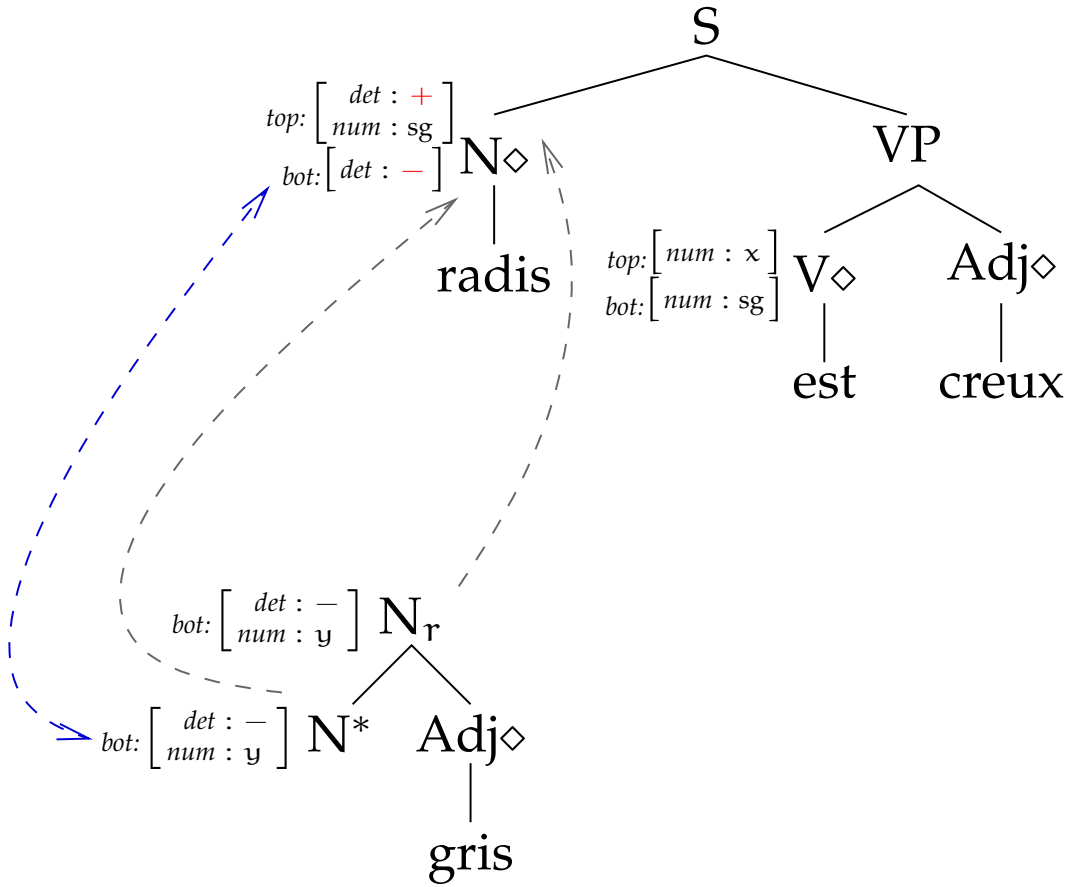

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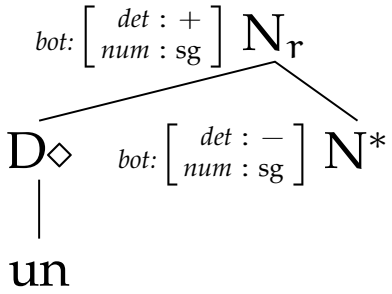

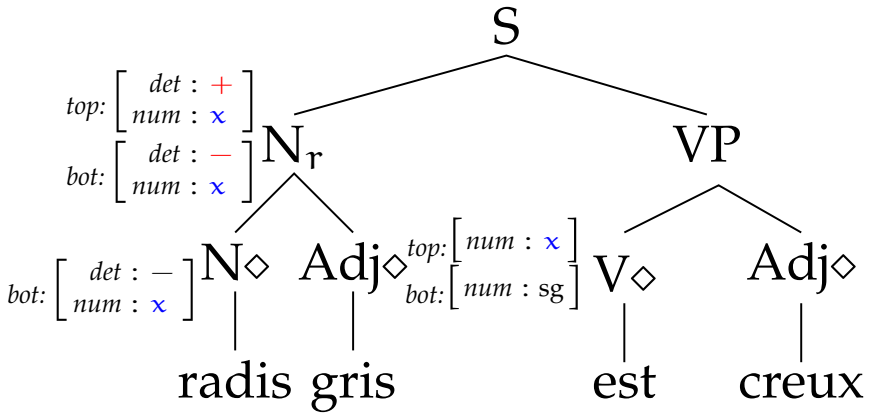

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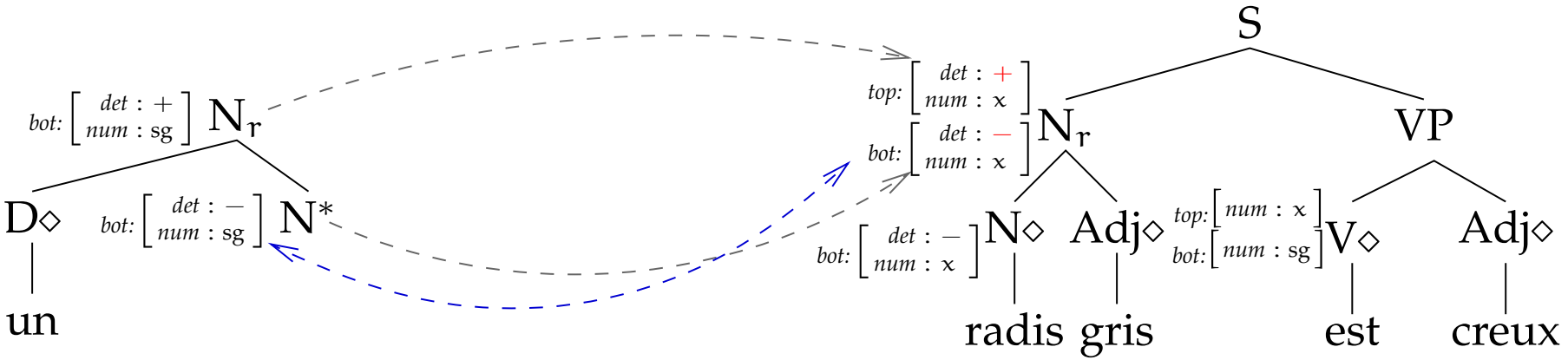

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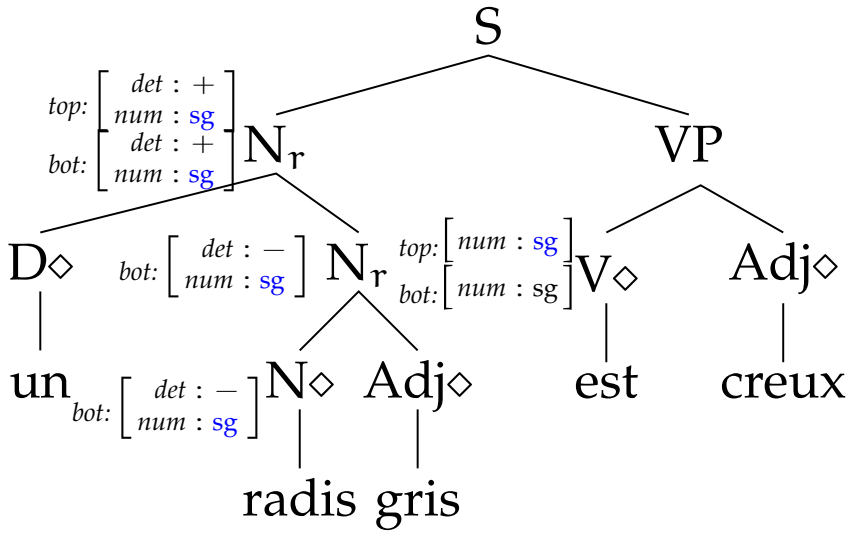


Features in RTG

- $\mathcal{D}$: set of feature structures
- work on terms over $N \times \mathcal{D}$
- rules of form $(A, d) \to a((B_1, d'_1), \ldots, (B_n, d'_n))$
- rewrites $(s, e) \Rightarrow (t, e')$ maintain a global environment for substitutions in feature structures

$$s = C[(A, d')],\ t = C[a((B_1, \sigma(d'_1)), \ldots, (B_n, \sigma(d'_n)))]$$
$$\sigma = \mathsf{mgu}(d, e(d')),\ e' = \sigma \circ e$$

- language

$$L(G) = \{t \in T(\mathcal{F}) \mid \exists e, ((S, \top), id) \Rightarrow^* (t, e)\}$$

Derivation Tree Language (2)

$$(S_I, \top) \rightarrow \text{creux}\left(N_I\left[top : \begin{bmatrix} det : + \\ num : x \end{bmatrix}\right], V_I\left[top : [num : x]\right]\right)$$

$$N_I\left[top : t\right] \rightarrow \text{radis}\left(N_A\begin{bmatrix} top : t \\ bot : [det : -] \end{bmatrix}\right)$$

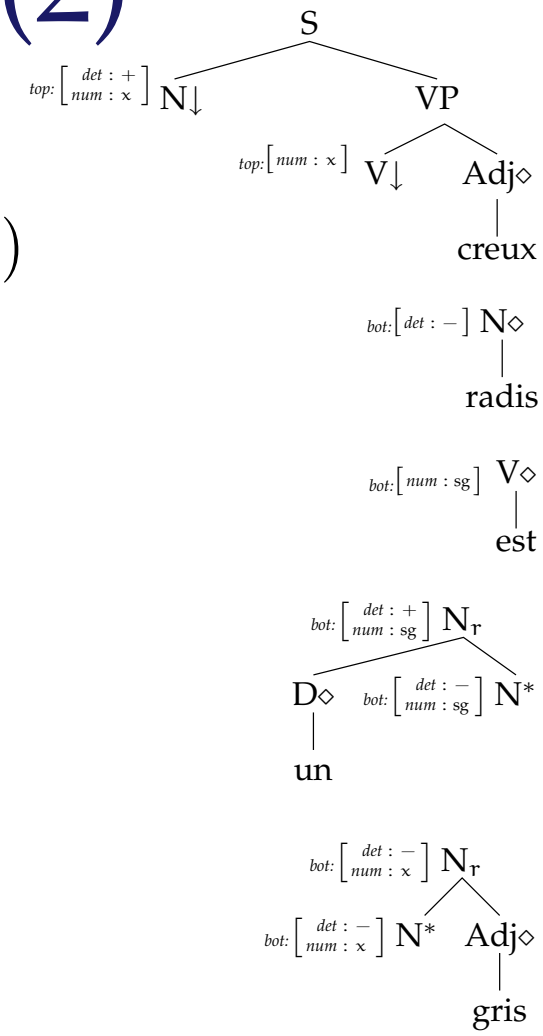
$$V_I\left[top : t\right] \rightarrow \text{est}\left(V_A\begin{bmatrix} top : t \\ bot : [num : sg] \end{bmatrix}\right)$$

$$N_A\begin{bmatrix} top : t \\ bot : \begin{bmatrix} det : - \\ num : sg \end{bmatrix} \end{bmatrix} \rightarrow \text{un}\left(N_A\begin{bmatrix} top : t \\ bot : \begin{bmatrix} det : + \\ num : sg \end{bmatrix} \end{bmatrix}\right)$$

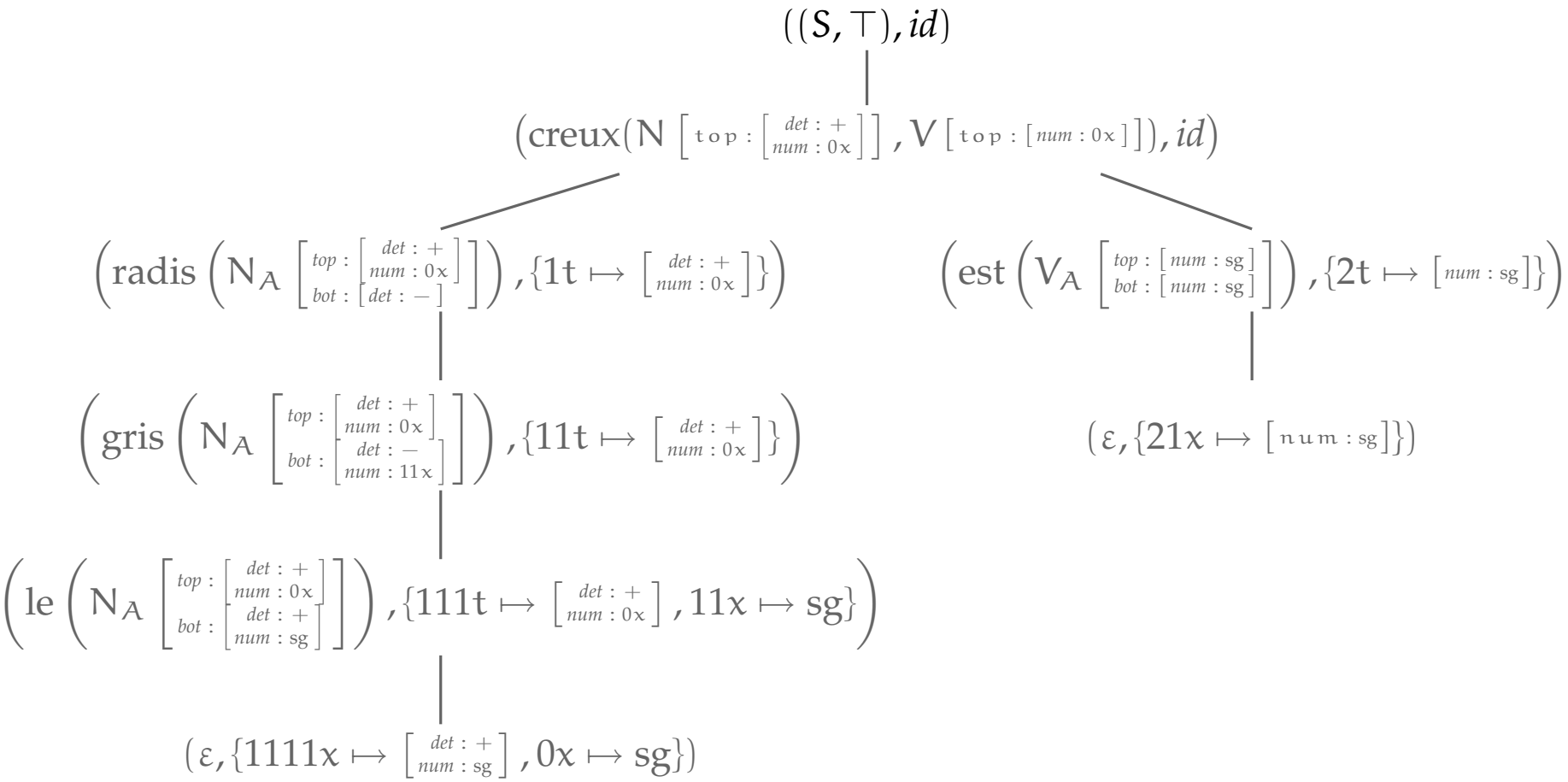
$$N_A\begin{bmatrix} top : t \\ bot : \begin{bmatrix} det : - \\ num : x \end{bmatrix} \end{bmatrix} \rightarrow \text{gris}\left(N_A\begin{bmatrix} top : t \\ bot : \begin{bmatrix} det : - \\ num : x \end{bmatrix} \end{bmatrix}\right)$$

$$N_A\begin{bmatrix} top : x \\ bot : x \end{bmatrix} \rightarrow \varepsilon()$$

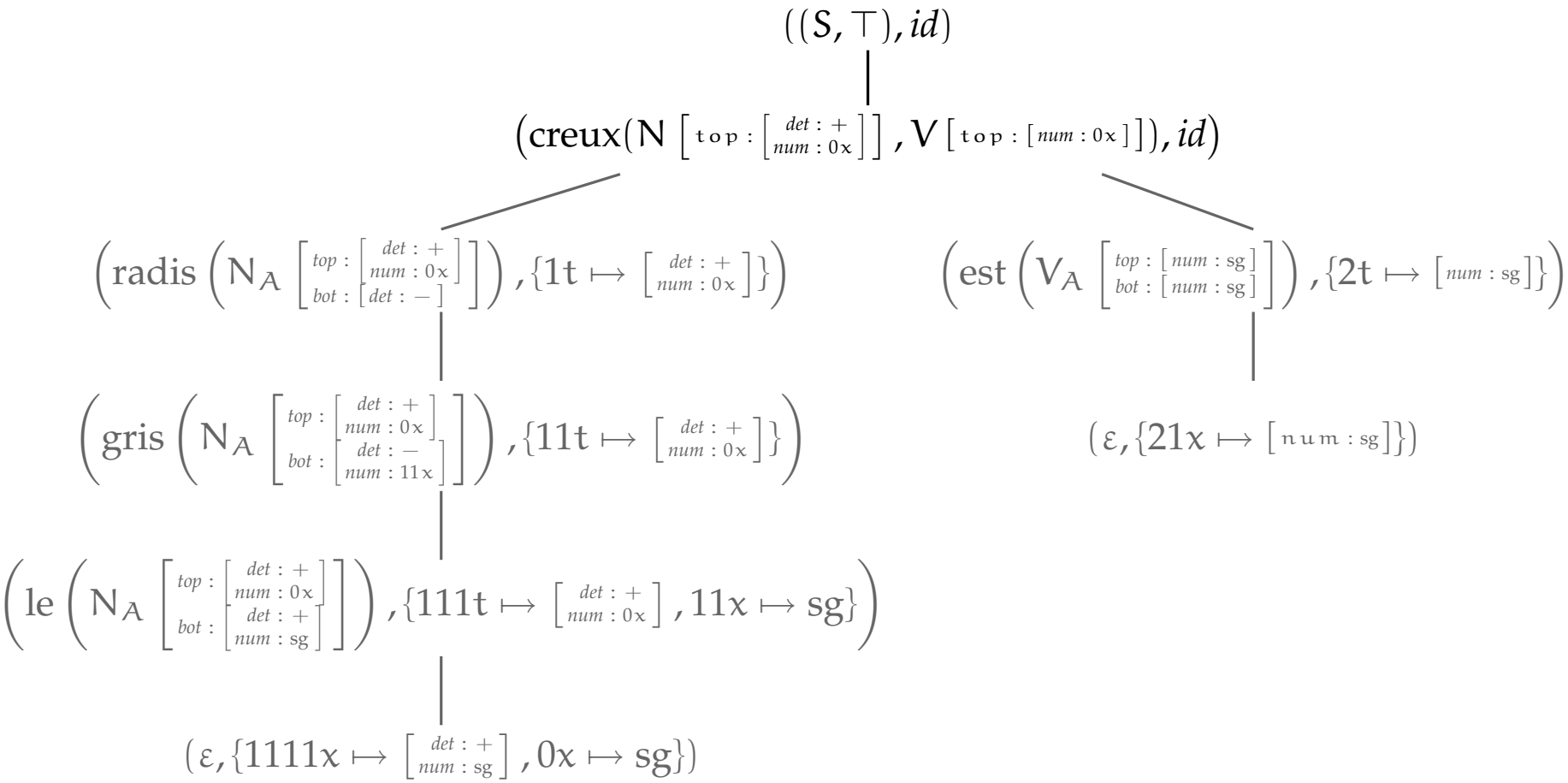
$$V_A\begin{bmatrix} top : x \\ bot : x \end{bmatrix} \rightarrow \varepsilon()$$



Example


((S, ⊤), id)
(creux(N [top : [det : +, num : 0x]], V [top : [num : 0x]]), id)
(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
(est (V_A [top : [num : sg], bot : [num : sg]]), {2t ↦ [num : sg]})
(gris (N_A [top : [det : +, num : 0x], bot : [det : −, num : 11x]]), {11t ↦ [det : +, num : 0x]})
(ε, {21x ↦ [num : sg]})
(le (N_A [top : [det : +, num : 0x], bot : [det : +, num : sg]]), {111t ↦ [det : +, num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example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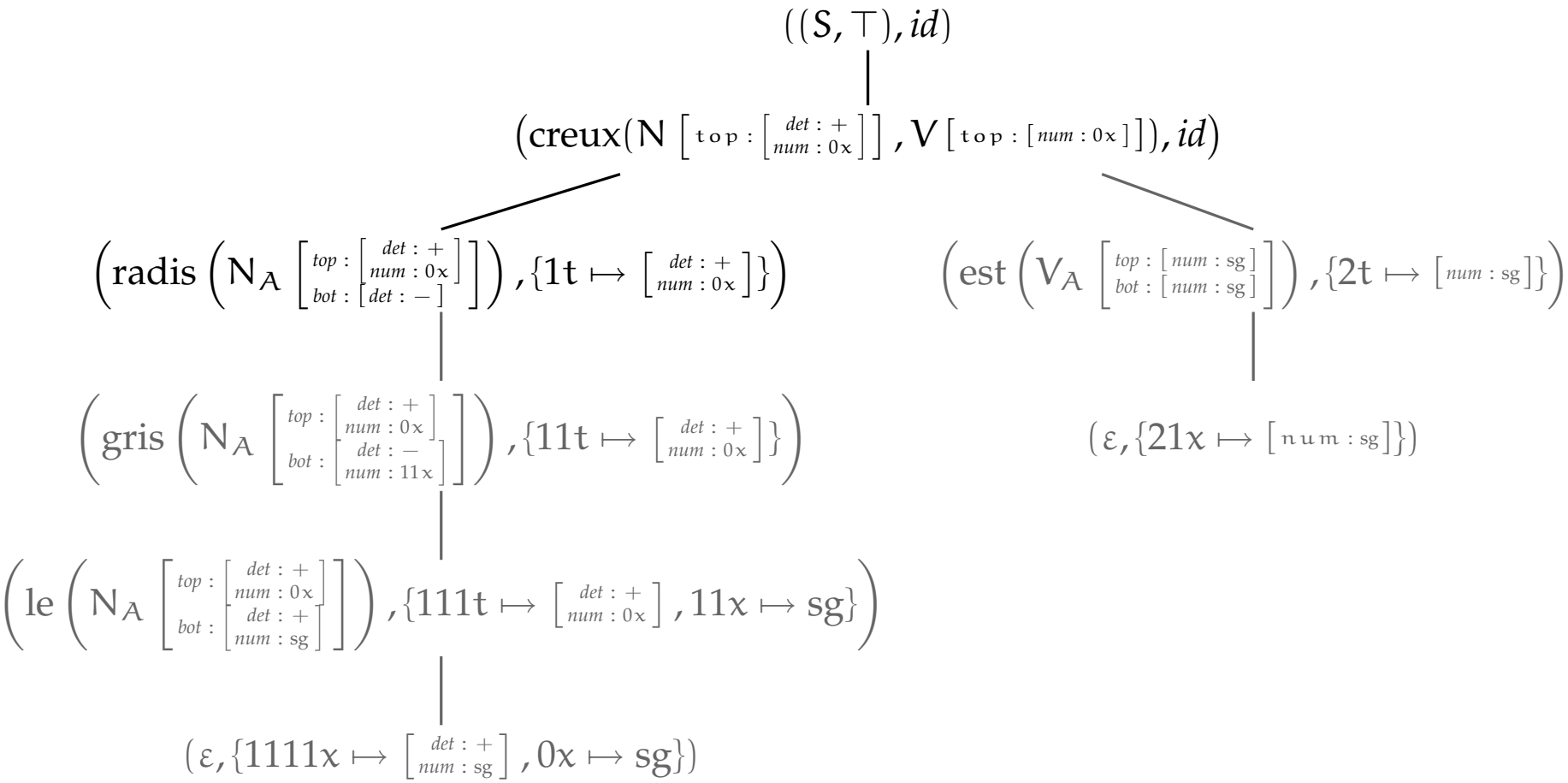
(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
(est (V_A [top : [num : sg], bot : [num : sg]]), {2t ↦ [num : sg]})
(gris (N_A [top : [det : +, num : 0x], bot : [det : −, num : 11x]]), {11t ↦ [det : +, num : 0x]})
(ε, {21x ↦ [num : sg]})
(le (N_A [top : [det : +, num : 0x], bot : [det : +, num : sg]]), {111t ↦ [det : +, num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example


((S, ⊤), id)
(creux(N [top : [det : +, num : 0x]], V [top : [num : 0x]]), id)
(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
(est (V_A [top : [num : sg], bot : [num : sg]]), {2t ↦ [num : sg]})
(gris (N_A [top : [det : +, num : 0x], bot : [det : −, num : 11x]]), {11t ↦ [det : +, num : 0x]})
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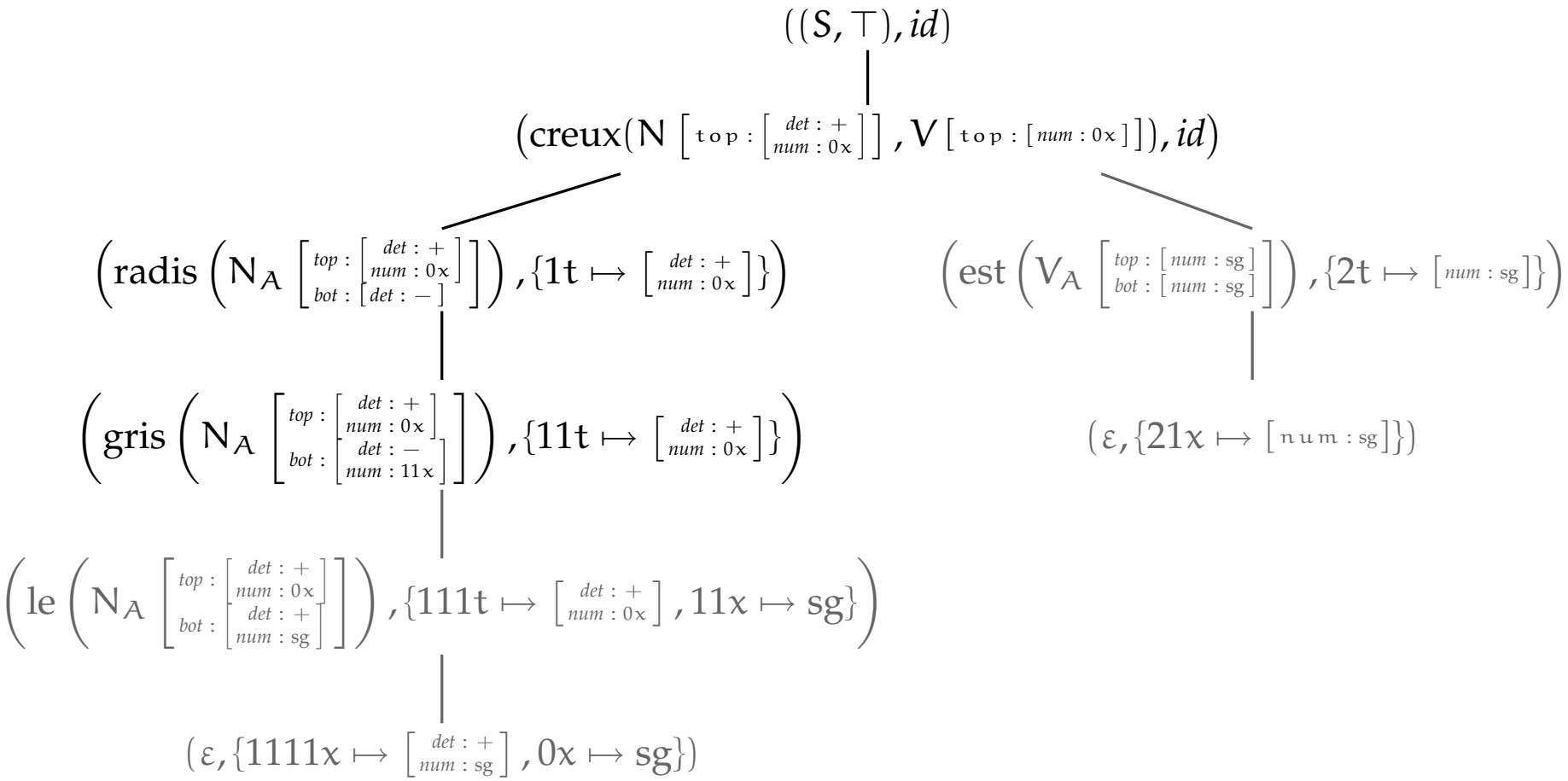
Example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(creux(N [top : [det : +, num : 0x]], V [top : [num : 0x]]), id)
(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
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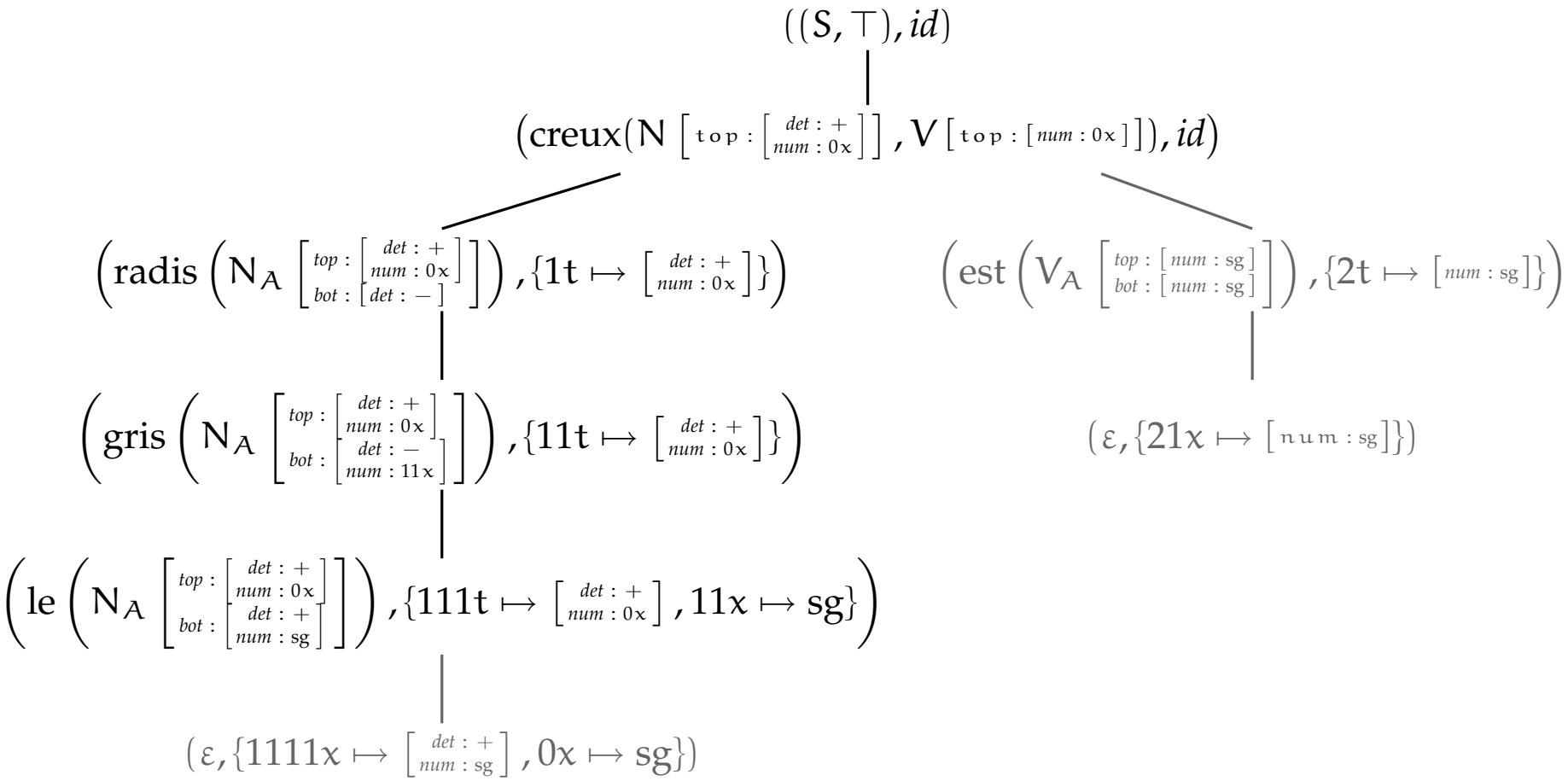
(gris (N_A [top : [det : +, num : 0x], bot : [det : −, num : 11x]]), {11t ↦ [det : +, num : 0x]})
(ε, {21x ↦ [num : sg]})
(le (N_A [top : [det : +, num : 0x], bot : [det : +, num : sg]]), {111t ↦ [det : +, num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example


((S, ⊤), id)
(creux(N [top : [det : +, num : 0x]], V [top : [num : 0x]]), id)
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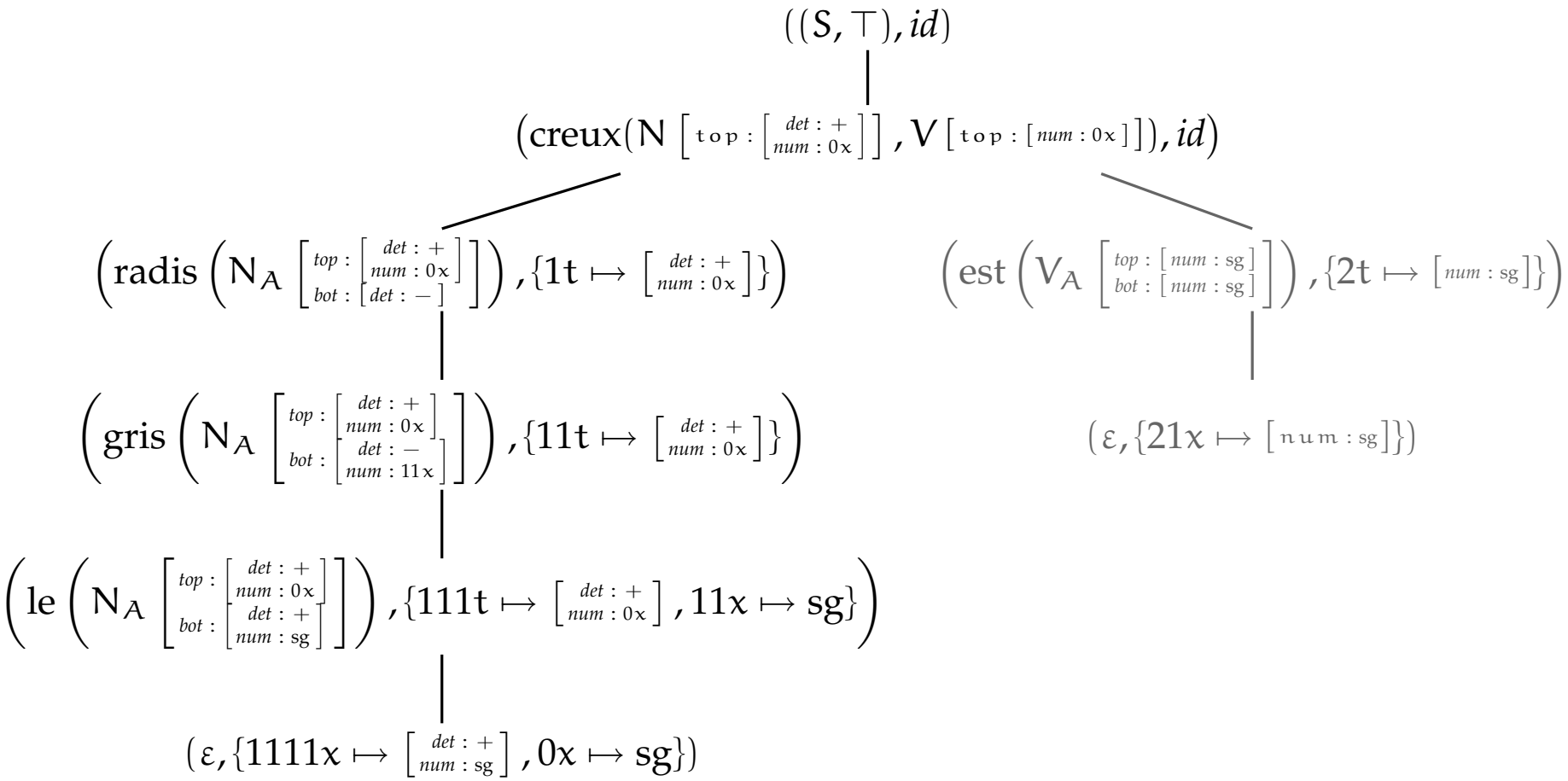
(le (N_A [top : [det : +, num : 0x], bot : [det : +, num : sg]]), {111t ↦ [det : +, num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example


((S, ⊤), id)
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(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
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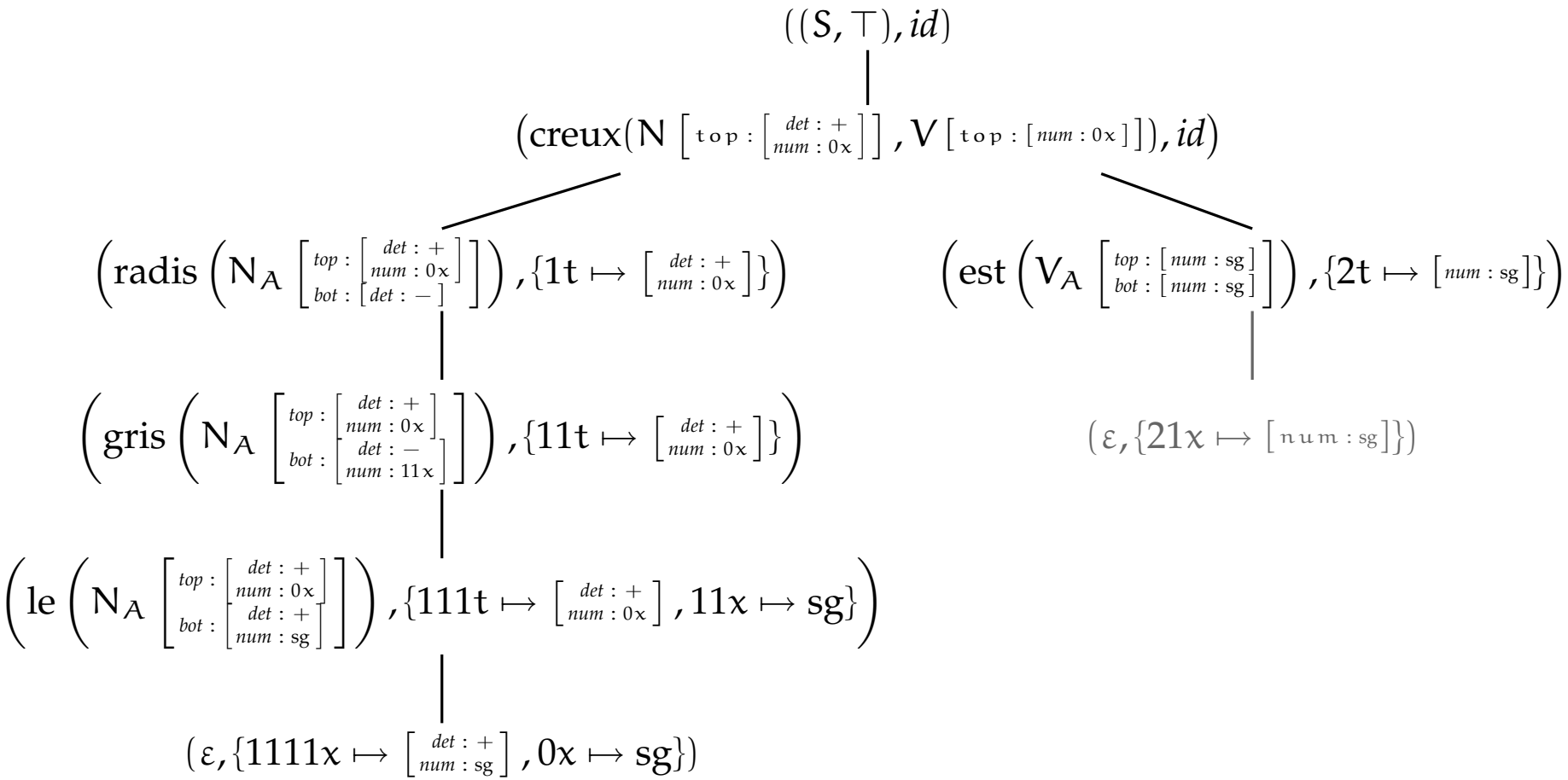
(le (N_A [top : [det : +, num : 0x], bot : [det : +, num : sg]]), {111t ↦ [det : +, num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example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(creux(N [top : [det : +, num : 0x]], V [top : [num : 0x]]), id)
(radis (N_A [top : [det : +, num : 0x], bot : [det : −]]), {1t ↦ [det : +, num : 0x]})
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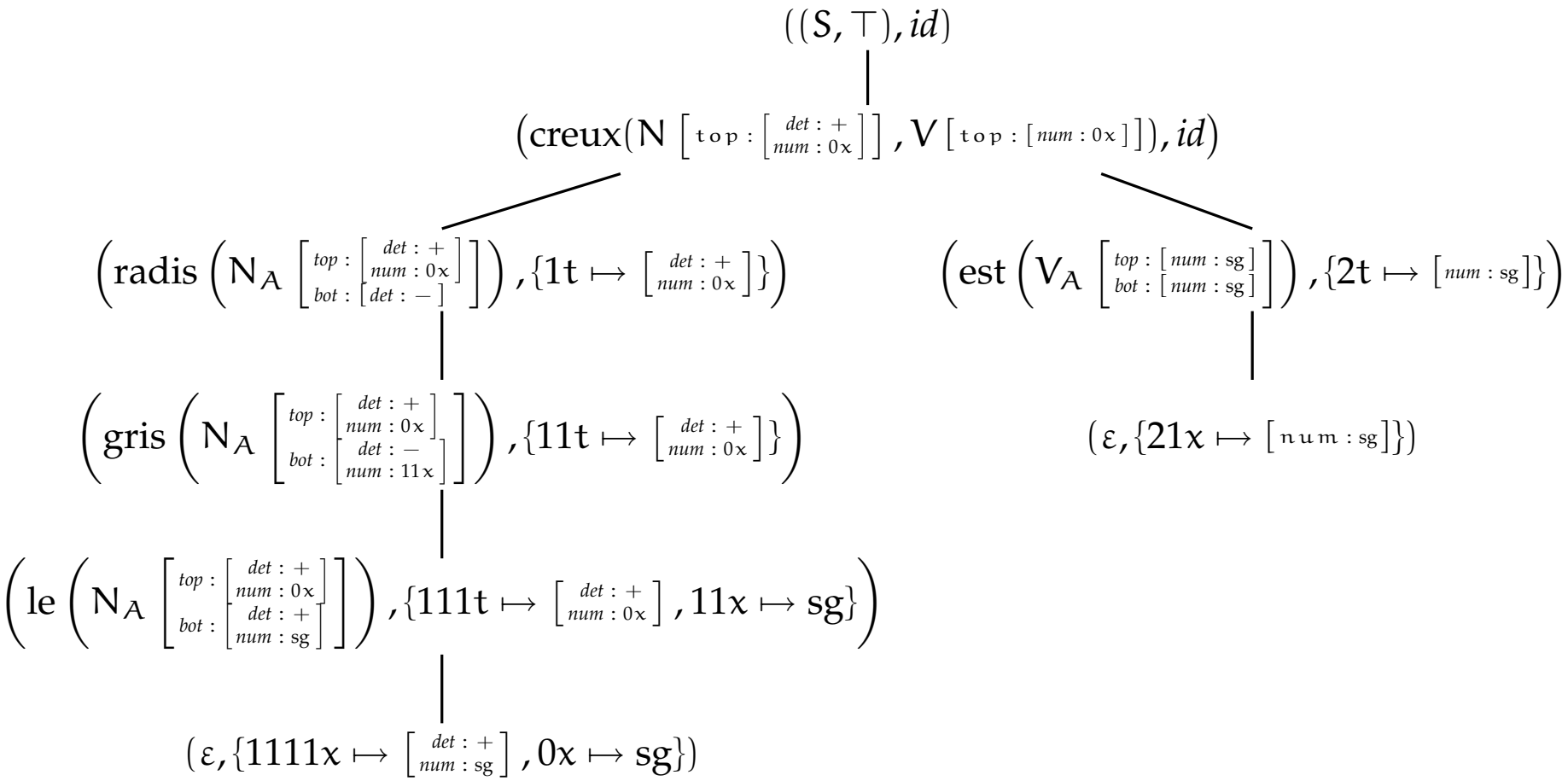
(ε, {1111x ↦ [det : +, num : sg], 0x ↦ sg})

Example


((S, ⊤), id)
(creux(N [top : [det : + num : 0x]], V [top : [num : 0x]]), id)
(radis (N_A [top : [det : + num : 0x] bot : [det : −]]), {1t ↦ [det : + num : 0x]})
(est (V_A [top : [num : sg] bot : [num : sg]]), {2t ↦ [num : sg]})
(gris (N_A [top : [det : + num : 0x] bot : [det : − num : 11x]]), {11t ↦ [det : + num : 0x]})
(ε, {21x ↦ [num : sg]})
(le (N_A [top : [det : + num : 0x] bot : [det : + num : sg]]), {111t ↦ [det : + num : 0x], 11x ↦ sg})
(ε, {1111x ↦ [det : + num : sg], 0x ↦ sg})

Left Corner Transform

Rosenkrantz and Lewis II [1970]

- top feature structures of root nodes usually empty
- reverse order of root adjunctions on initial trees

Derivation Tree Language (3)

$$(S, \top) \longrightarrow \text{creux}\left(\mathrm{N}_{\mathrm{I}}\left[top : \begin{bmatrix} det : + \\ num : \mathtt{x} \end{bmatrix}\right], \mathrm{V}_{\mathrm{I}}\left[top : [\, num : \mathtt{x}\,]\right]\right)$$

$$\mathrm{N}\left[bot : [\, det : -\,]\right] \longrightarrow \text{radis}$$

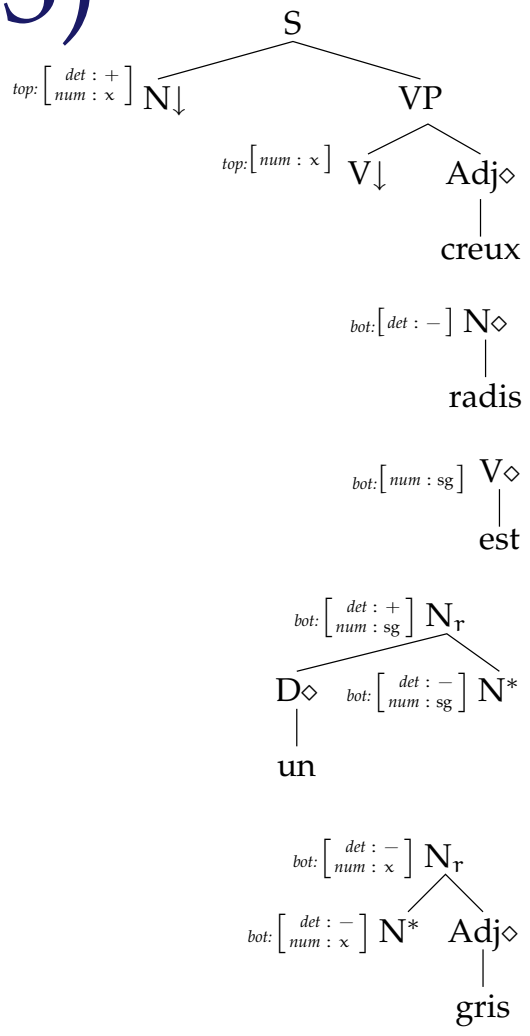
$$\mathrm{V}\left[bot : [\, num : \mathrm{sg}\,]\right] \longrightarrow \text{est}$$

$$\mathrm{N}\begin{bmatrix} top : \mathtt{t} \\ bot : \begin{bmatrix} det : + \\ num : \mathrm{sg} \end{bmatrix} \end{bmatrix} \longrightarrow \text{un}\left(\mathrm{N}\begin{bmatrix} top : \mathtt{t} \\ bot : \begin{bmatrix} det : - \\ num : \mathrm{sg} \end{bmatrix} \end{bmatrix}\right)$$

$$\mathrm{N}\begin{bmatrix} top : \mathtt{t} \\ bot : \begin{bmatrix} det : - \\ num : \mathtt{x} \end{bmatrix} \end{bmatrix} \longrightarrow \text{gris}\left(\mathrm{N}\begin{bmatrix} top : \mathtt{t} \\ bot : \begin{bmatrix} det : - \\ num : \mathtt{x} \end{bmatrix} \end{bmatrix}\right)$$

$$\mathrm{N}_{\mathrm{I}}\left[top : \mathtt{t}\right] \longrightarrow \varepsilon\left(\mathrm{N}\begin{bmatrix} top : \mathtt{t} \\ bot : \mathtt{t} \end{bmatrix}\right)$$

$$\mathrm{V}_{\mathrm{I}}\left[top : \mathtt{t}\right] \longrightarrow \varepsilon\left(\mathrm{V}\begin{bmatrix} top : \mathtt{t} \\ bot : \mathtt{t} \end{bmatrix}\right)$$



Test Suite Generation Algorithm

- greedy
- derivation-tree centric
- distances computed using the accessibility relation in the regular tree grammar
- elementary tree selection uses distances
  - to the remaining target classes
  - to the globally accumulated classes
  - to the classes accumulated in the current derivation

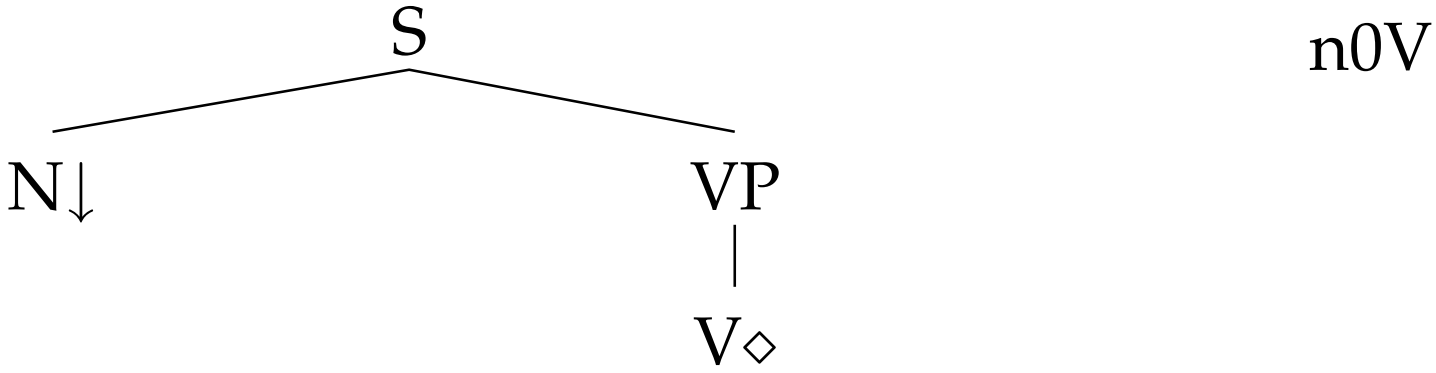
Algorithm

target: { *InvertedNominalSubject*, *RelativeObject* }

S

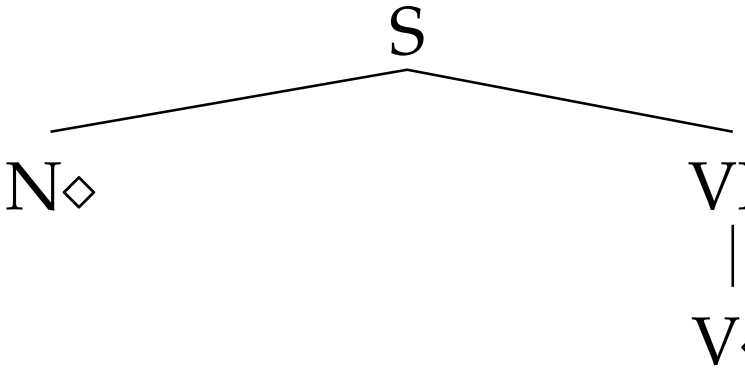
Algorithm

target: { *InvertedNominalSubject*, *RelativeObject* }



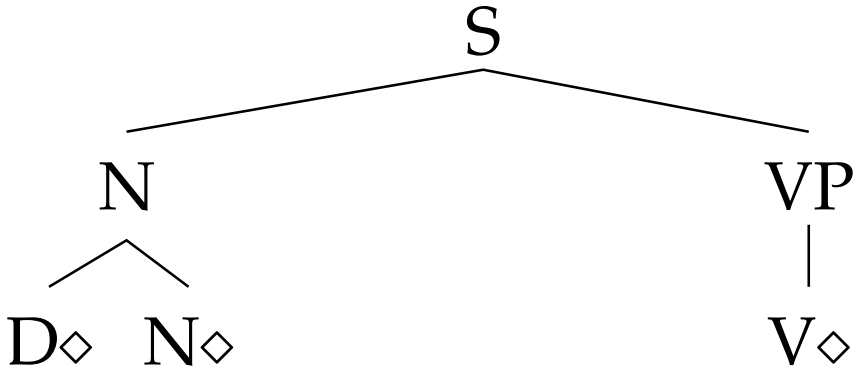
Algorithm

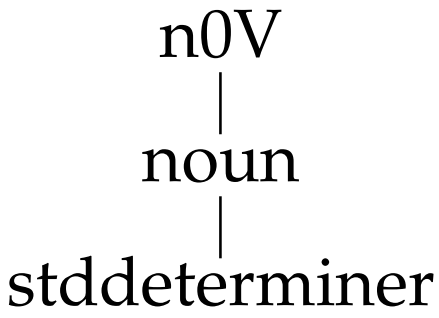
target: { *InvertedNominalSubject*, *RelativeObject* }



Algorithm

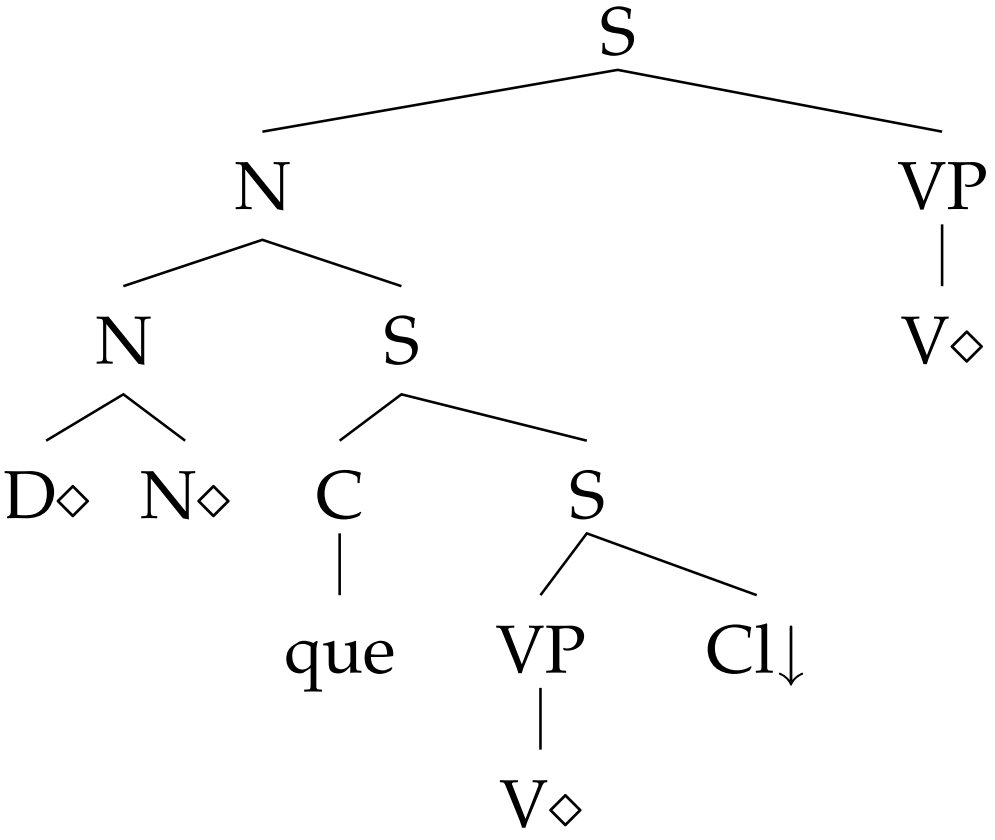
target: { *InvertedNominalSubject*, *RelativeObject* }

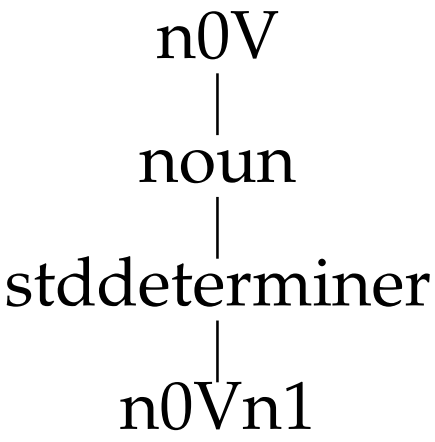




Algorithm

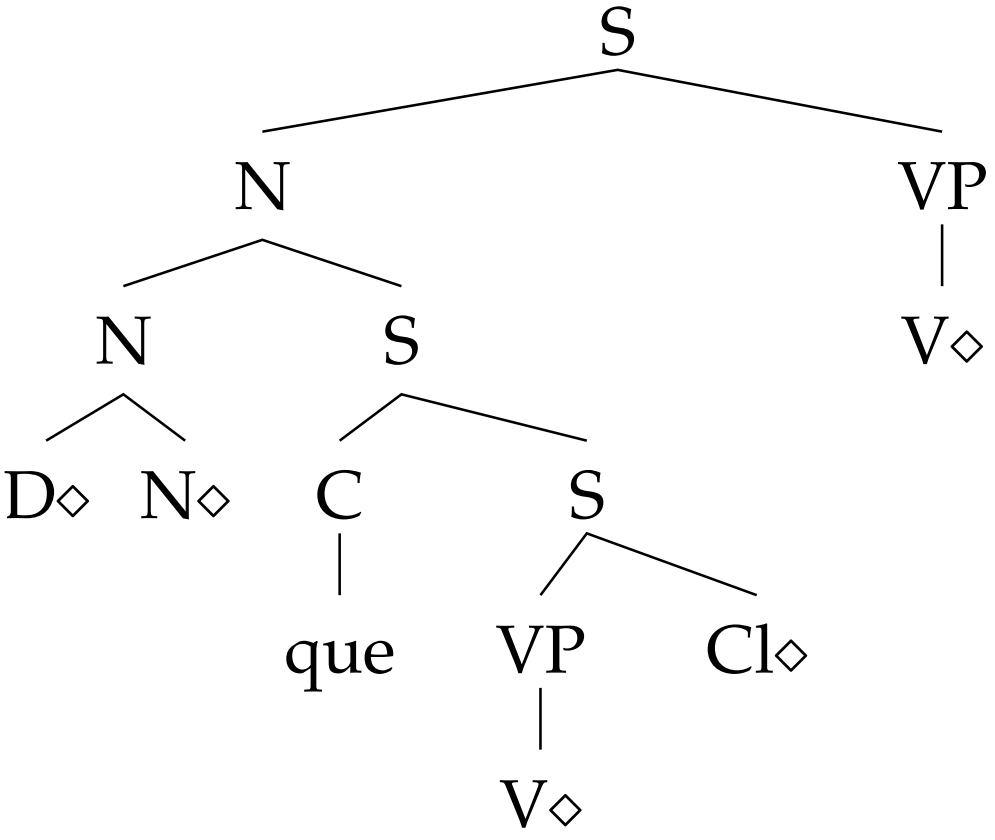
target: { }

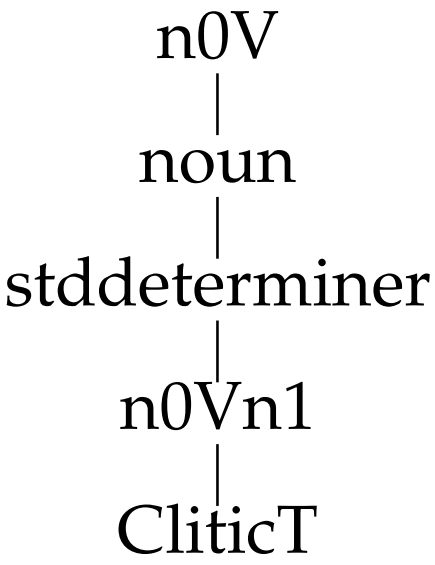




Algorithm

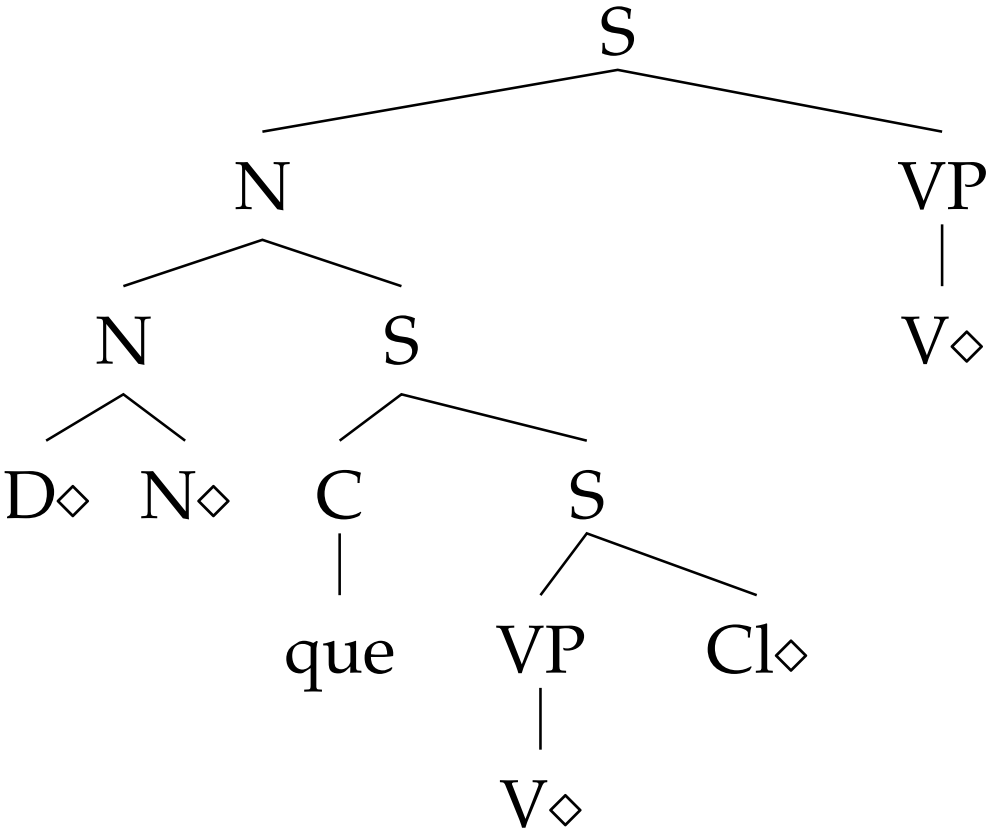
target: { }

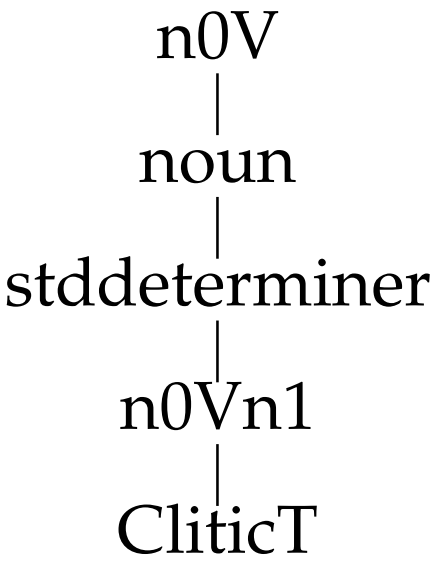




Algorithm

target: { }





Le repas que attendez vous arrive .

In Practice

- implementation (Prolog+XSLT+C)

  `svn co svn://scm.gforge.inria.fr/svn/paule/trunk/gtsg`
- grammar size
  - 5,800 trees
  - 44,000 nodes
  - allows up to 214.10^9 different feature structures
- many pre-computations
- approximation to 141 rhs variables

$$\begin{bmatrix} a : x \\ b : val \\ c : x \end{bmatrix} \equiv \begin{bmatrix} a : \_ \\ b : val \\ c : \_ \end{bmatrix}$$

More about the Algorithm

- full unification and backtracking
- no guarantee that a generated tree matches some target class:
  - drop the tree
  - change the computation environment
  - try again
- stop if no evolution

Influence of the Left-Corner Transform

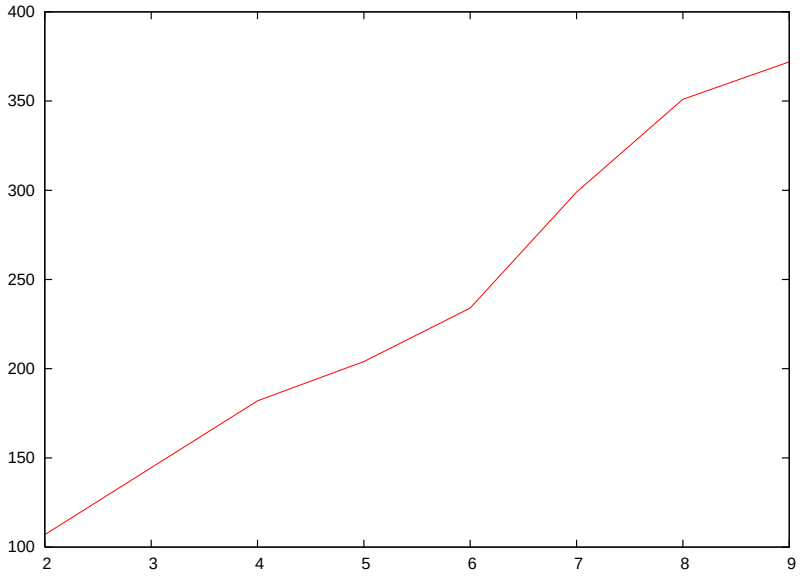
Asking for 5 times each class:

	original	left-corner
rules	5,821	6,413
classes	114	110
variables	137	138
timing	23h	1h12
out trees	190	204
coverage	84%	100%

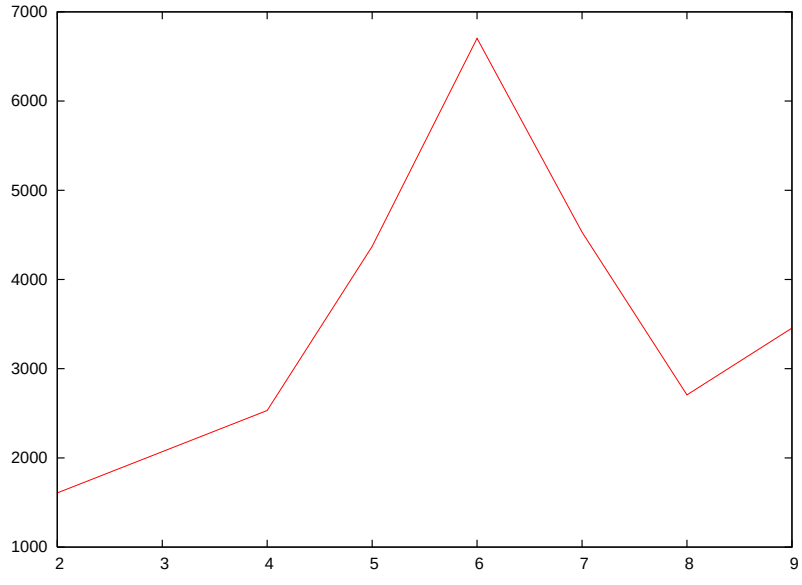
Influence of the Target Bag

Asking for n times each class, in left-corner mode:

Number of output trees



Running time (s)



Random Concluding Remarks

- application of two-level syntax
- opens new issues with error mining
- entropy measures?

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Experiments with Error Mining

test suite 500 trees generated using GenI [Gardent and Kow, 2007]

algorithm adaptation of Sagot and Éric de la Clergerie [2006]
expectation maximization

- bigrams instead of unigrams (capture interactions)
- derivation tree structure constraints
- more smoothing

Experiments with Error Mining

Two Rounds

Compute a suspicion rate for each bigram:

1. normalize at sentence level
2. normalize at test suite level

...and iterate.

Experiments with Error Mining

Issues: Ordering Suspects

```
Worst Form Number: 1    0.220409692766
complexAdvDeDeterminer  s0Pv1post
d7   0.220780944532
Worst Form Number: 2    0.185227187873
AdjectivalPredicativeform  s0Pv1post
d7   0.185539179236
d11  0.185187092097
```

Experiments with Error Mining

Issues: Bigrams

```
Worst Form Number: 5    0.083686136541 8
CanonicalSubject  InvertedNominalSubject
d10  0.083867096696 1
d1   0.083867096696 1
InvertedNominalSubject  RelativeObject
d10  0.083867096696 1
d1   0.083867096696 1
```