

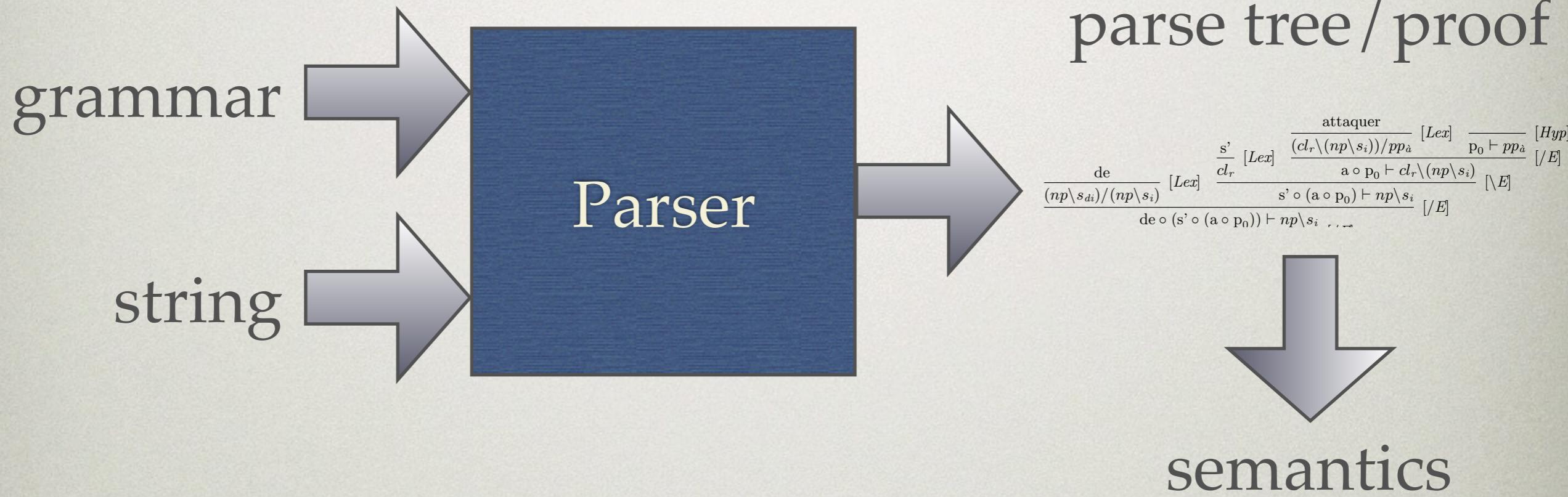
COMPUTATIONAL SEMANTICS FOR DEBATES

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(CNRS, LABRI)
NASSLLI 2016/SALMOM

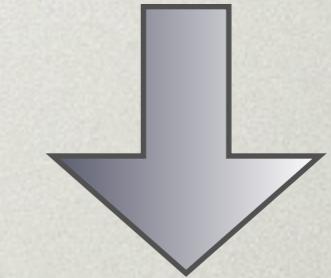
INTRODUCTION

- Can a computer understand natural language well enough for useful applications?
- Many applications require deep representation of the meaning of a sentence.
- Method: combination of symbolic and non-symbolic methods

ARCHITECTURE OVERVIEW



$$\frac{\frac{\frac{de}{(np \setminus s_{di}) / (np \setminus s_i)} [Lex] \quad \frac{s' [Lex]}{cl_r} \quad \frac{\frac{attaquer}{(cl_r \setminus (np \setminus s_i)) / pp_a} [Lex] \quad \frac{p_0 \vdash pp_a}{[Hyp]_1}}{p_0 \vdash pp_a} [/E]}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} [\setminus E]}{s' \circ (a \circ p_0) \vdash np \setminus s_i} [/E]$$



semantics

$(\lambda x. \exists y. (x y) \lambda z. ((\lambda v. \lambda w. \mathbf{shot}(v, w) z) \mathbf{vito}))$

e_1	y_1
e_2	e_3
$x_3 = ?$	
$\mathbf{aider_à}(e_2, x_0, x_3, e_3)$	
$\mathbf{partir}(e_3, x_3)$	
$\mathbf{demander}(e_1, y_0, x_0, y_1)$	

QUESTION ANSWERING NATURAL LANGUAGE INTERFACE

“ I am going to jump off a bridge and die ”

I found 4 bridges a little ways from you:

Greenleaf Avenue Bridge of Faith Upscale...	26 miles
South Berendo Street La Bridges Berendo	38 miles
West Manchester Avenue Bridge Consultants Inc	48 miles

AT&T 3G 5:45 PM 90%

“ I think I have alcohol poisoning what do I do ”

I found 7 liquor stores fairly close to you:

Garver Street Spirit Shop	1.5 miles
12th Avenue Thunderbird Liquors	1.5 miles
West Main Street Cellar Wine & Spirits	1.5 miles



QUESTION ANSWERING NATURAL LANGUAGE INTERFACE

Wanted for general evilness; last seen at the tower of Barad-Dur; it's a giant eye, folks, kinda hard to miss



QUESTION ANSWERING NATURAL LANGUAGE INTERFACE

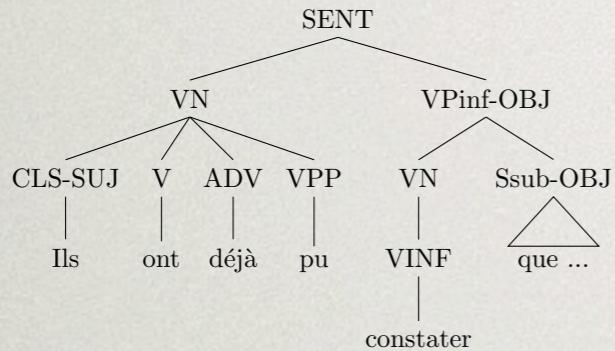
U.S. Cities

Its largest airport is named for a World War II hero; its second largest, for a World War II battle



OUTLINE

French Treebank



Grammar Extraction

$$\frac{\frac{de}{(np \setminus s_{di}) / (np \setminus s_i)} [Lex] \quad \frac{\frac{s'}{cl_r} [Lex] \quad \frac{\frac{attaquer}{(cl_r \setminus (np \setminus s_i)) / pp_a} [Lex] \quad \frac{[Lex]}{p_0 \vdash pp_a} [Hyp]_1}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} [/E]}{s' \circ (a \circ p_0) \vdash np \setminus s_i} [/E]$$

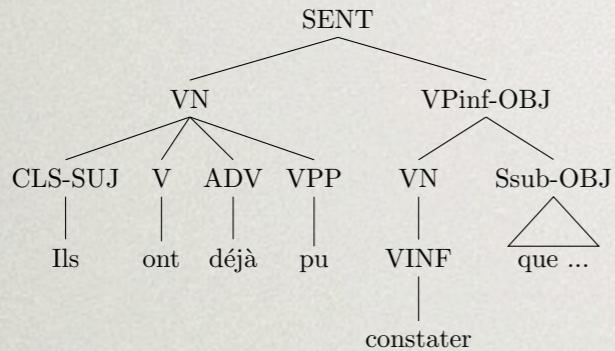


Applications

$e_1 \ y_1$
$y_1 :$
$e_2 \ e_3 \ x_3$
$x_3 = ?$
$\text{aider_à}(e_2, x_0, x_3, e_3)$
$\text{partir}(e_3, x_3)$
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Grammar Extraction

$$\frac{\frac{\frac{de}{(np \setminus s_{di}) / (np \setminus s_i)} [Lex]}{\frac{s'}{cl_r} [Lex] \frac{\frac{attaquer}{(cl_r \setminus (np \setminus s_i)) / pp_a} [Lex]}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} [Hyp]_1} [E]}{s' \circ (a \circ p_0) \vdash np \setminus s_i} [/E]$$

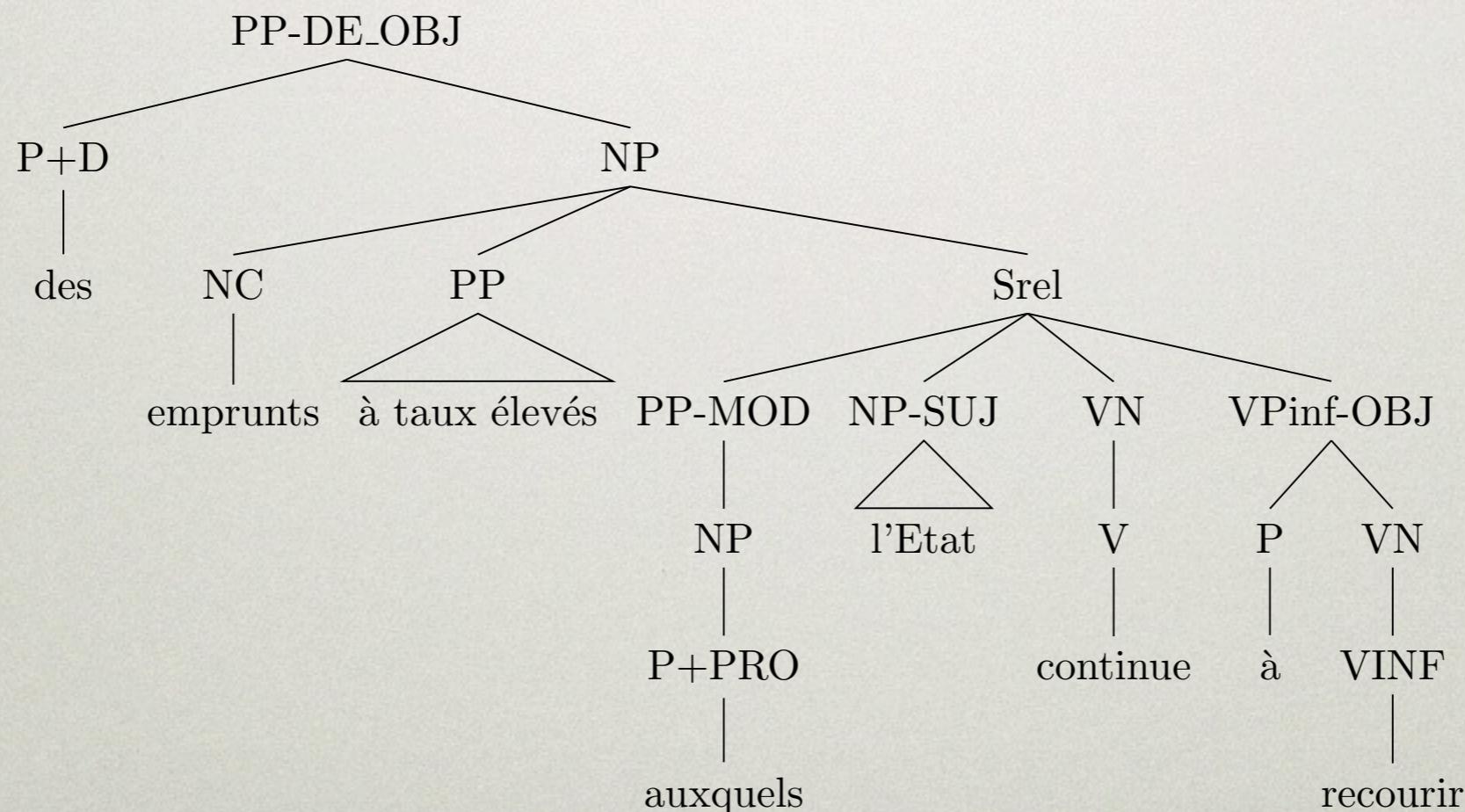


Applications

$e_1 \ y_1$
$e_2 \ e_3 \ x_3$
$y_1 : \quad x_3 = ?$
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THE FRENCH TREEBANK

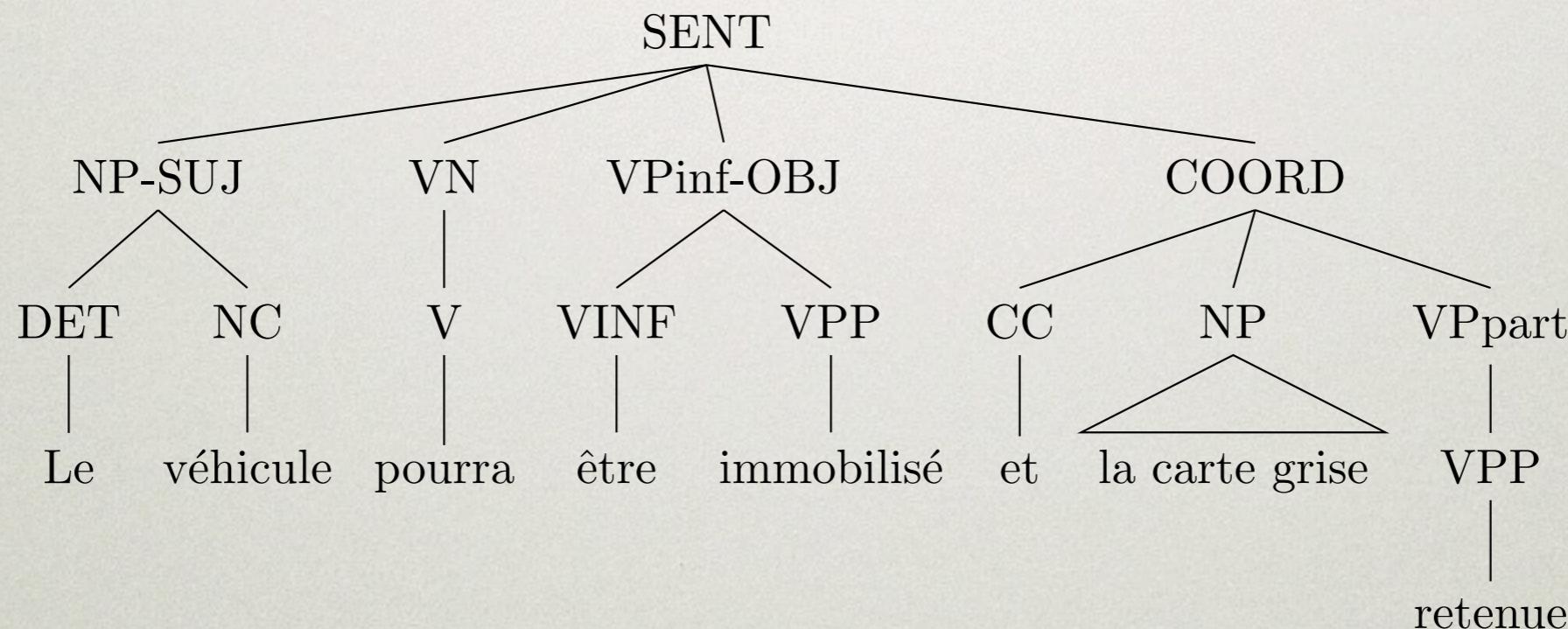
Example PP from the corpus (slightly simplified)



≈ `continue_to_resort_to(state,loans)`

THE FRENCH TREEBANK

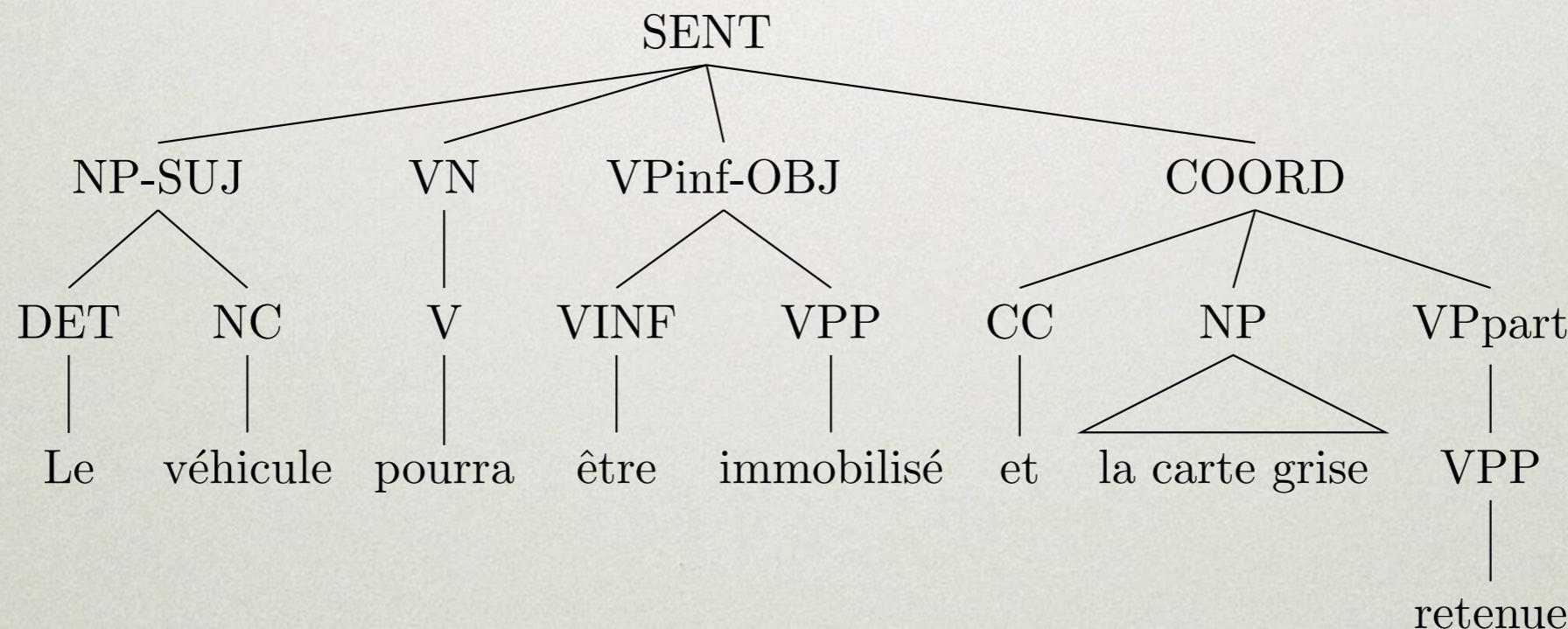
Example from the corpus (slightly simplified)



“The car could be immobilized and
the car registration (could be) withheld”

THE FRENCH TREEBANK

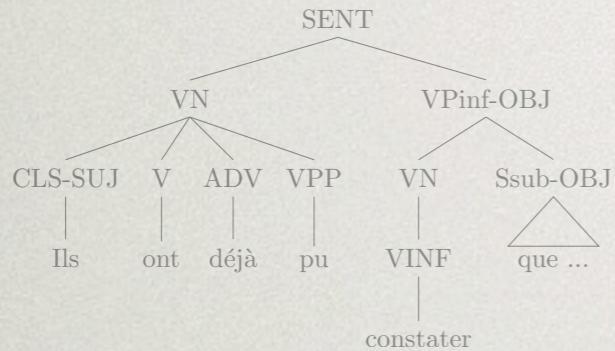
Example from the corpus (slightly simplified)



$\approx \exists x. \text{pourvoir}(\text{immobiliser}(x, \text{véhicule})) \wedge$
 $\exists y. \text{pouvoir}(\text{retenir}(y, \text{cart_grise}))$

OUTLINE

French Treebank



Grammar Extraction

$$\frac{\frac{de}{(np \setminus s_{di}) / (np \setminus s_i)} [Lex] \quad \frac{s'}{cl_r} [Lex] \quad \frac{\frac{attaquer}{(cl_r \setminus (np \setminus s_i)) / pp_a} [Lex] \quad \frac{p_0 \vdash pp_a}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} [Hyp]_1}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} [/E]}{s' \circ (a \circ p_0) \vdash np \setminus s_i} [/E]$$



Applications

$e_1 \ y_1$
$y_1 :$
$e_2 \ e_3 \ x_3$
$x_3 = ?$
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$demander(e_1, y_0, x_0, y_1)$

AB GRAMMARS AND ELIMINATION RULES

- atomic formulas np , n , pp , s , Sinf , Spass ,
 Sppart , Swhq , ...
- if A and B are formulas, then
 A/B and $B\backslash A$ are formulas as well

$$\frac{A/B \quad B}{A} [/E]$$

$$\frac{B \quad B\backslash A}{A} [\backslash E]$$

AB GRAMMARS

- ◆ np ◆ Jean, l'étudiant, ...
- ◆ n ◆ étudiant, économie, ...
- ◆ s ◆ Jean dort, Jean aime Marie
- ◆ np \ s ◆ dort, aime Marie
- ◆ np / n ◆ un, chaque, l'
- ◆ (np \ s) / np ◆ aime, étudie

EXAMPLE

un	étudiant	dort		
np/n	n	np\s	$\frac{A/B}{A}$	$\frac{B}{A}$
			[/E]	[\'E]

EXAMPLE

un	étudiant	dort	$\frac{A/B \quad B}{A} [/E]$	$\frac{B \quad B \setminus A}{A} [\backslash E]$
np/n	n	$np \setminus s$		
$\frac{}{np}$				

EXAMPLE

un étudiant
np/n n dort
————— [/E]
np np \ s
————— [/E]
S

$$\frac{A/B}{A} \quad \frac{B}{A} \quad \frac{B}{A} \quad \frac{B \setminus A}{A}$$

[/E]

A

B \ A

[\E]

FROM AB GRAMMARS TO TYPE-LOGICAL GRAMMARS

- though AB grammars work well enough for simple cases, getting the semantics right requires a somewhat richer system
- introduction rules (“traces” and their semantics)
- structural rules (“movement”, essentially restricted tree rewrite operations)

FROM AB GRAMMARS TO TYPE-LOGICAL GRAMMARS

.... [B]ⁱ

[B]ⁱ ...

$$\frac{A}{A/B} [/I]^i$$

$$\frac{A}{B/A} [\backslash I]^i$$

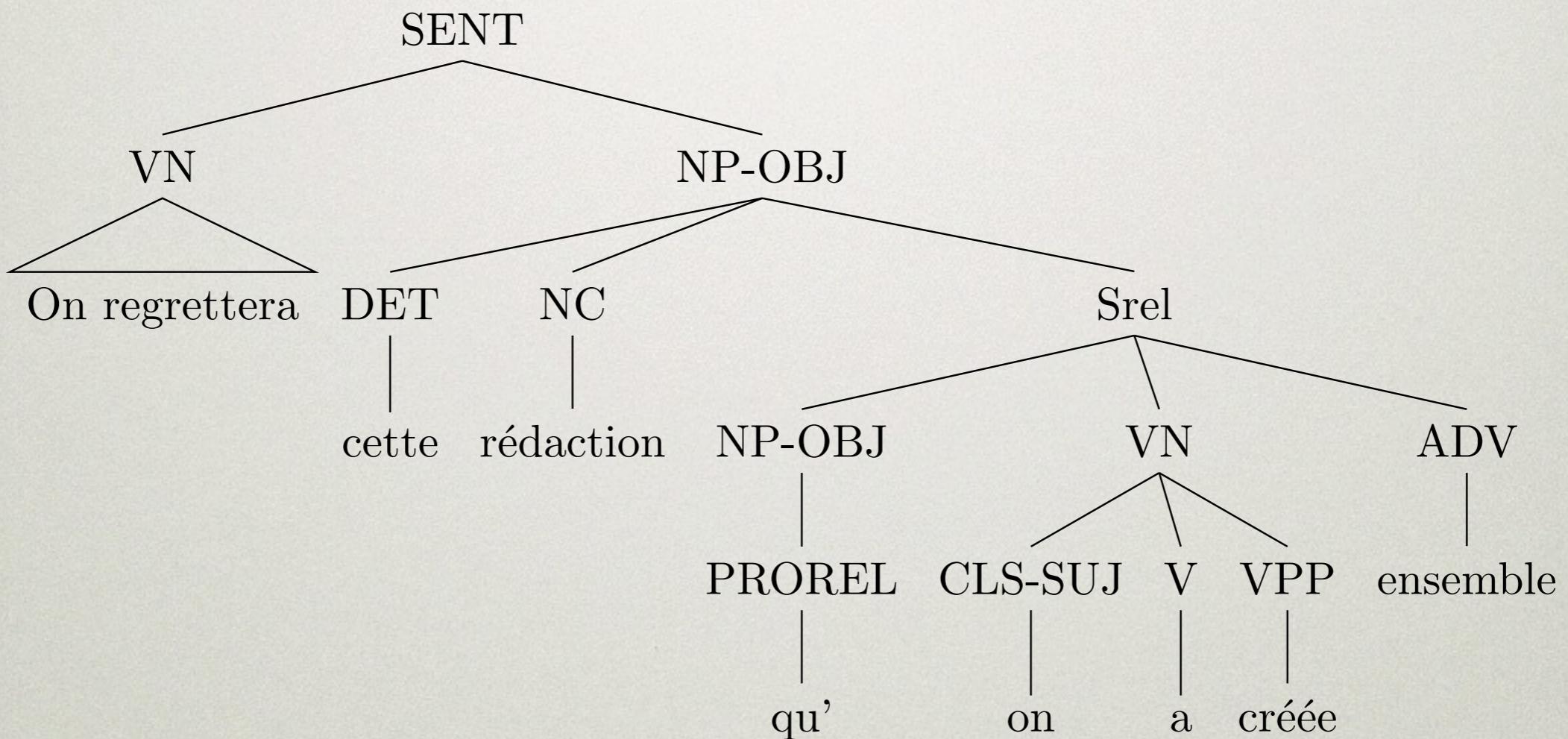
[B] is the rightmost free hypothesis in the proof

[B] is the leftmost free hypothesis in the proof

“...” contains at least one other non-discharged formula

Each introduction rule discharges exactly one formula.
A unique integer *i* links the rule application with this formula

INTRODUCTION RULES: EXAMPLE



INTRODUCTION RULES: EXAMPLE

redaction	qu'	on	a	créée
n	(n\n)/(s/np)	np	(np\s)/(np\s _{ppart})	(np\s _{ppart})/np

INTRODUCTION RULES: EXAMPLE

redaction	qu'	on	a	créée	
n	(n \ n)/(s / np)	np	(np \ s)/(np \ s _{ppart})	(np \ s _{ppart}) / np	np

INTRODUCTION RULES: EXAMPLE

redaction	qu'	on	a	créée	
n	$(n \setminus n) / (s / np)$	np	$(np \setminus s) / (np \setminus s_{ppart})$	$\frac{(np \setminus s_{ppart}) / np}{np \setminus s_{ppart}}$	[/E]

INTRODUCTION RULES: EXAMPLE

redaction	qu'	on	créée
n	(n\n)/(s/np)	np	a
			$\frac{(np \setminus s_{\text{ppart}}) / np}{np \setminus s_{\text{ppart}}} [/E]$
			$\frac{(np \setminus s) / (np \setminus s_{\text{ppart}})}{np \setminus s_{\text{ppart}}} [/E]$

INTRODUCTION RULES: EXAMPLE

redaction	qu'	créée
n	(n\n)/(s/np)	
on	a	$\frac{(np \setminus s_{\text{ppart}}) / np}{np \setminus s_{\text{ppart}}} [/E]$
	$\frac{(np \setminus s) / (np \setminus s_{\text{ppart}})}{np \setminus s_{\text{ppart}}} [/E]$	
np		$\frac{np \setminus s}{[\setminus E]}$
	s	

INTRODUCTION RULES: EXAMPLE

redaction	qu'	créée
n	(n\n)/(s/np)	
on	a	$\frac{(np \setminus s_{\text{ppart}}) / np}{np \setminus s_{\text{ppart}}} [np]^1 [/E]$
np	$\frac{(np \setminus s) / (np \setminus s_{\text{ppart}})}{np \setminus s} [/E]$	
	$\frac{s}{s/np} [/I]^1$	

INTRODUCTION RULES: EXAMPLE

redaction

n

$$\frac{\text{on} \quad \frac{(np \setminus s) / (np \setminus s_{\text{ppart})}}{np}}{np \setminus s} \quad \frac{\begin{array}{c} \text{a} \\ \frac{(np \setminus s_{\text{ppart}) / np}{np \setminus s_{\text{ppart}}} \end{array}}{[\setminus E]} \quad [/ E] \quad [/ E]$$

qu'

$$\frac{(n \setminus n) / (s / np)}{n \setminus n} \quad \frac{s}{s / np} \quad \frac{[/ I]^1}{[/ E]}$$

INTRODUCTION RULES: EXAMPLE

			créée	
	a	$\frac{(np \setminus s_{\text{ppart}}) / np}{np \setminus s_{\text{ppart}}} [np]^1$		
on	$\frac{(np \setminus s) / (np \setminus s_{\text{ppart}})}{np} [/ E]$	$np \setminus s_{\text{ppart}}$	[/ E]	
np		$np \setminus s$	[\setminus E]	
qu'		s	[/ I] ¹	
redaction	$\frac{(n \setminus n) / (s / np)}{s / np} [/ E]$	s / np	[/ E]	
n		n \setminus n	[\setminus E]	
	n			

BEYOND AB GRAMMARS

INTRODUCTION RULES

qu'	on	a	créée	ensemble
(n\n)/(s/np)	np	(np\s)/(np\s _{ppart})	(np\s _{ppart})/np	(np\s)\(np\s)

BEYOND AB GRAMMARS

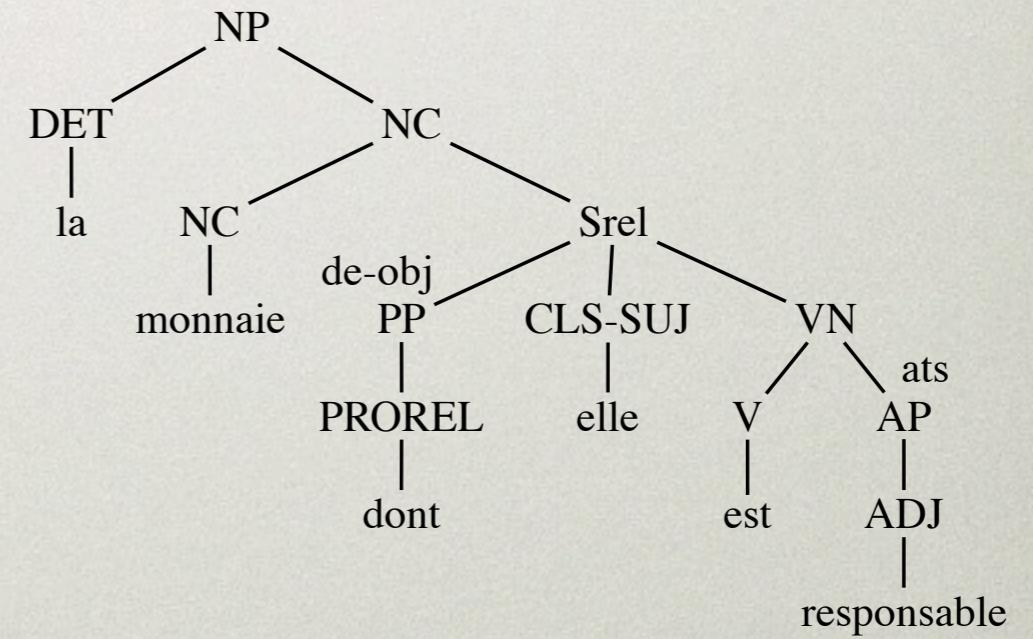
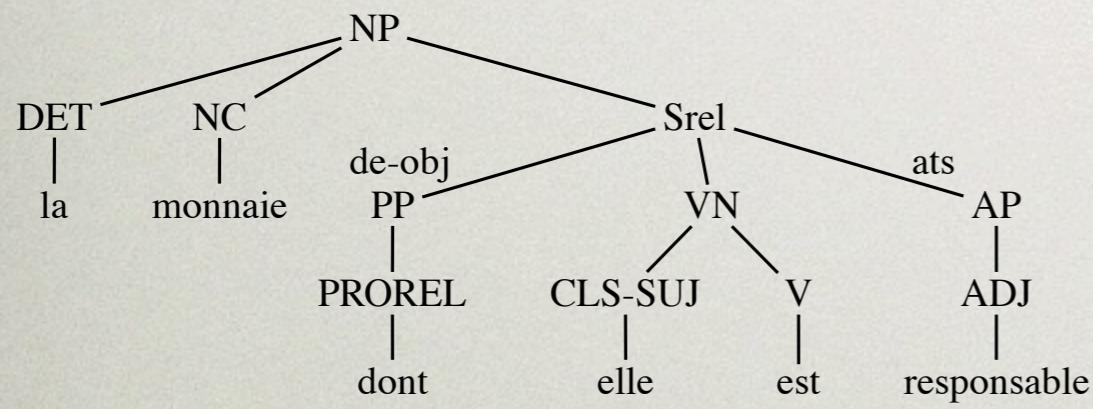
INTRODUCTION RULES

.... [B]ⁱ

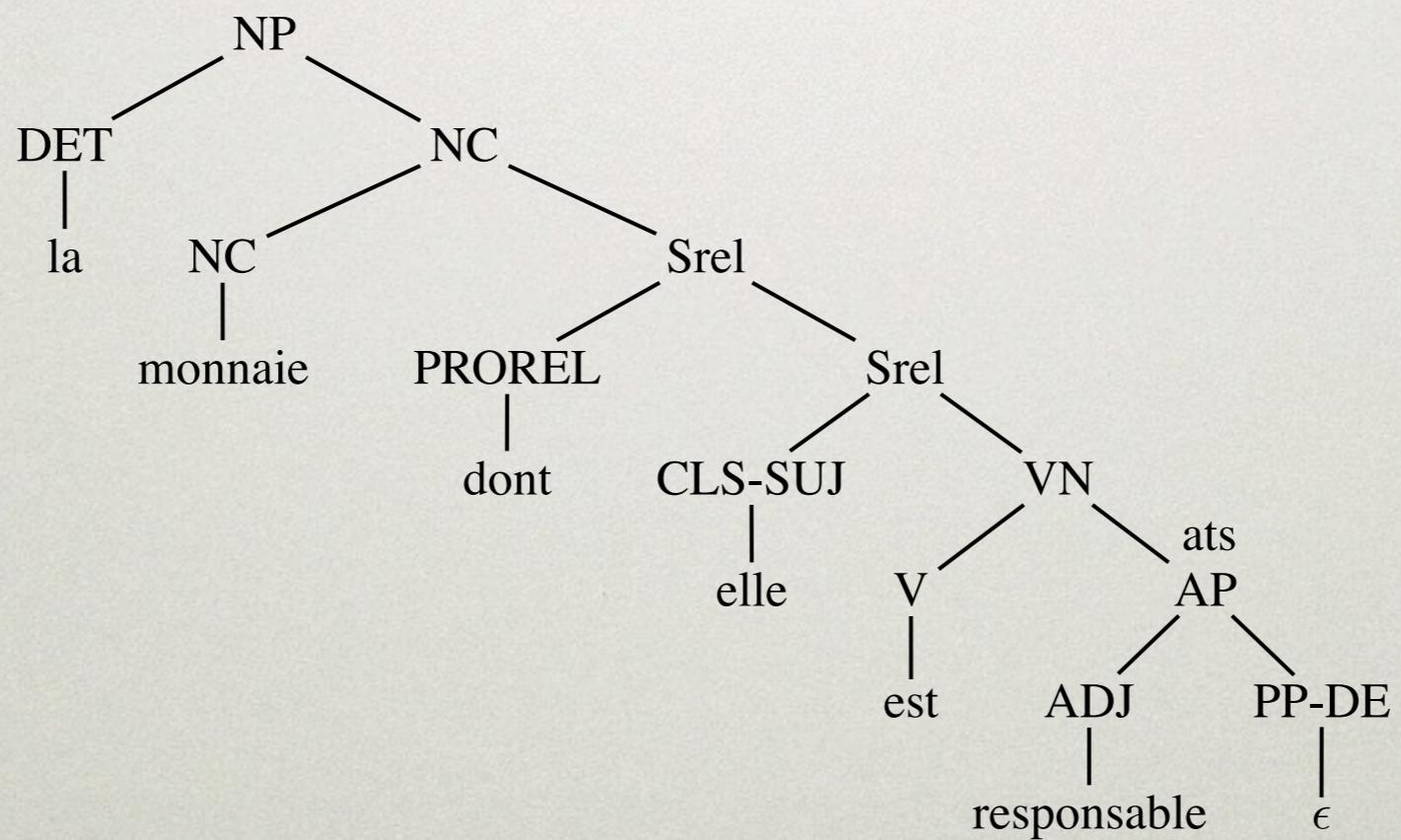
$$\frac{A}{A/\diamond\Box B} [/I]^i$$

qu'	on	a	créée	ensemble
(n\n)/(s/\diamond\Box np)	np	(np\s)/(np\s _{ppart})	(np\s _{ppart})/np	(np\s)\(np\s)

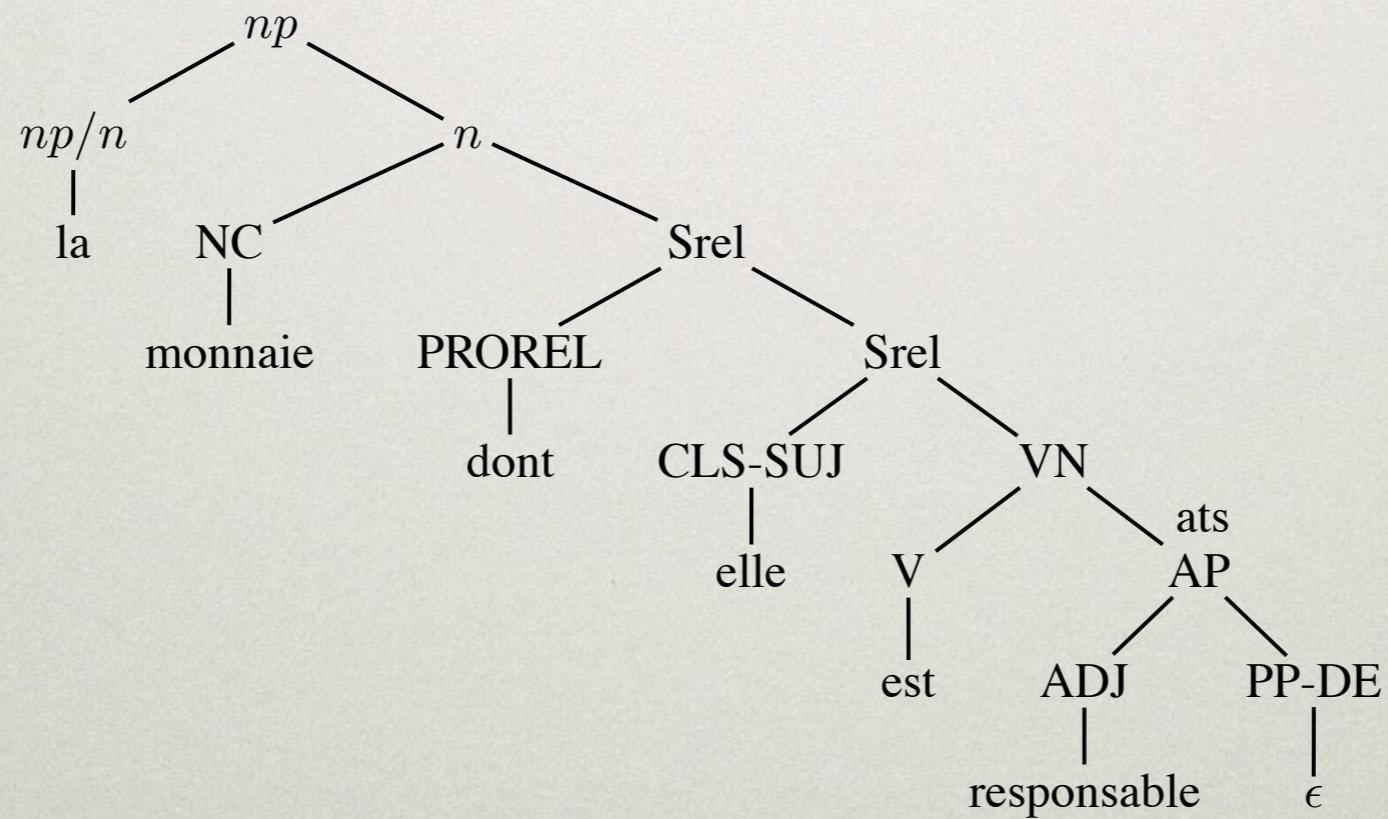
TREEBANK EXTRACTION



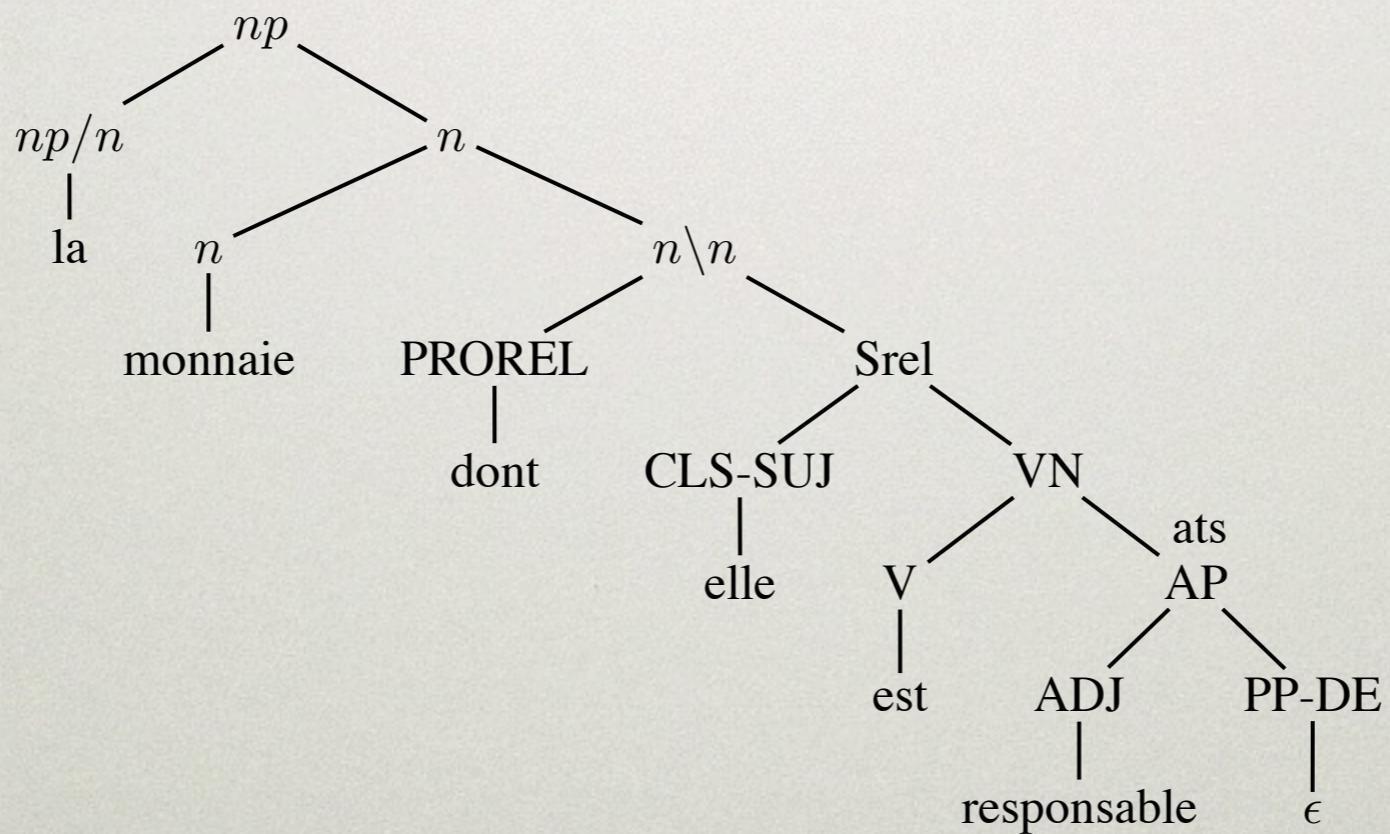
TREEBANK EXTRACTION



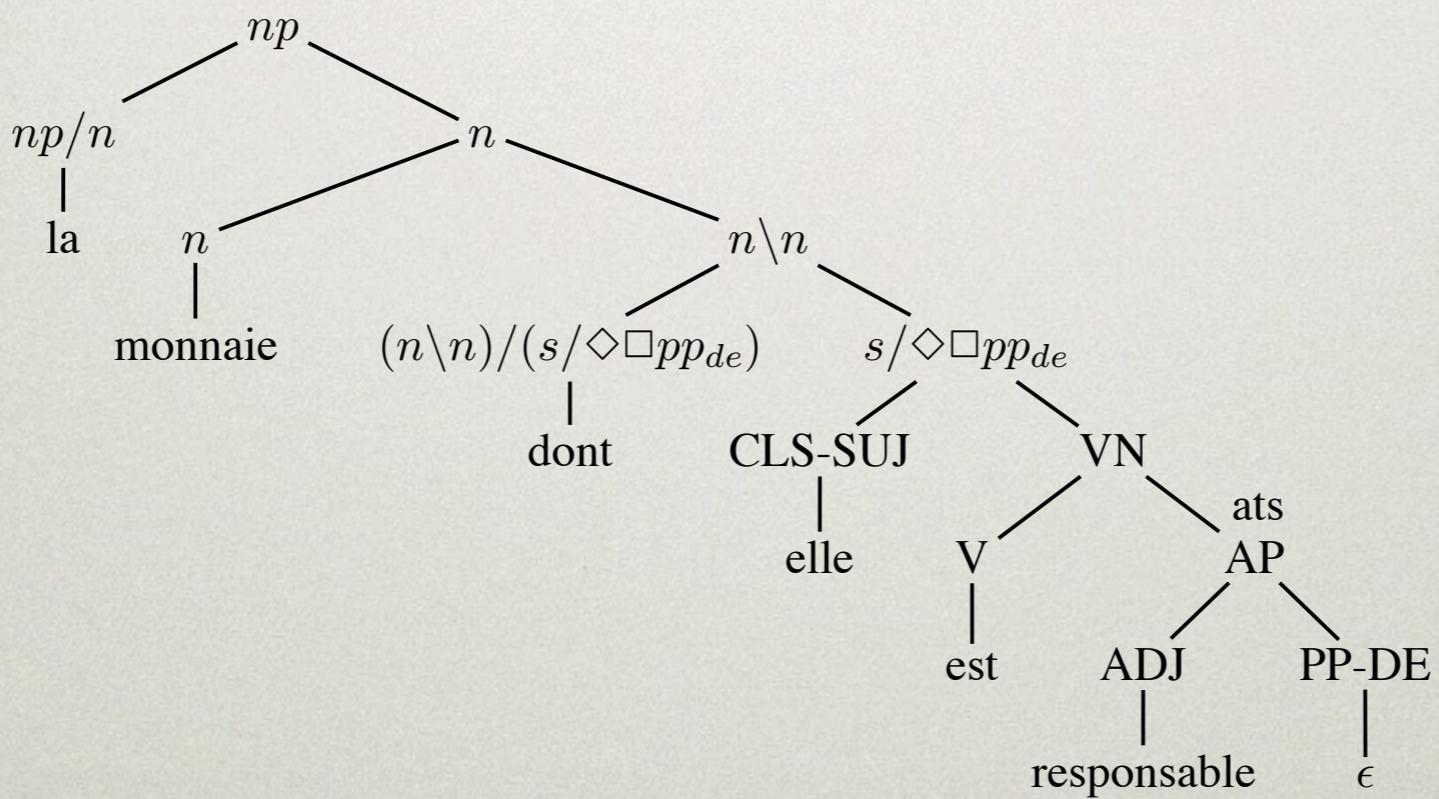
TREEBANK EXTRACTION



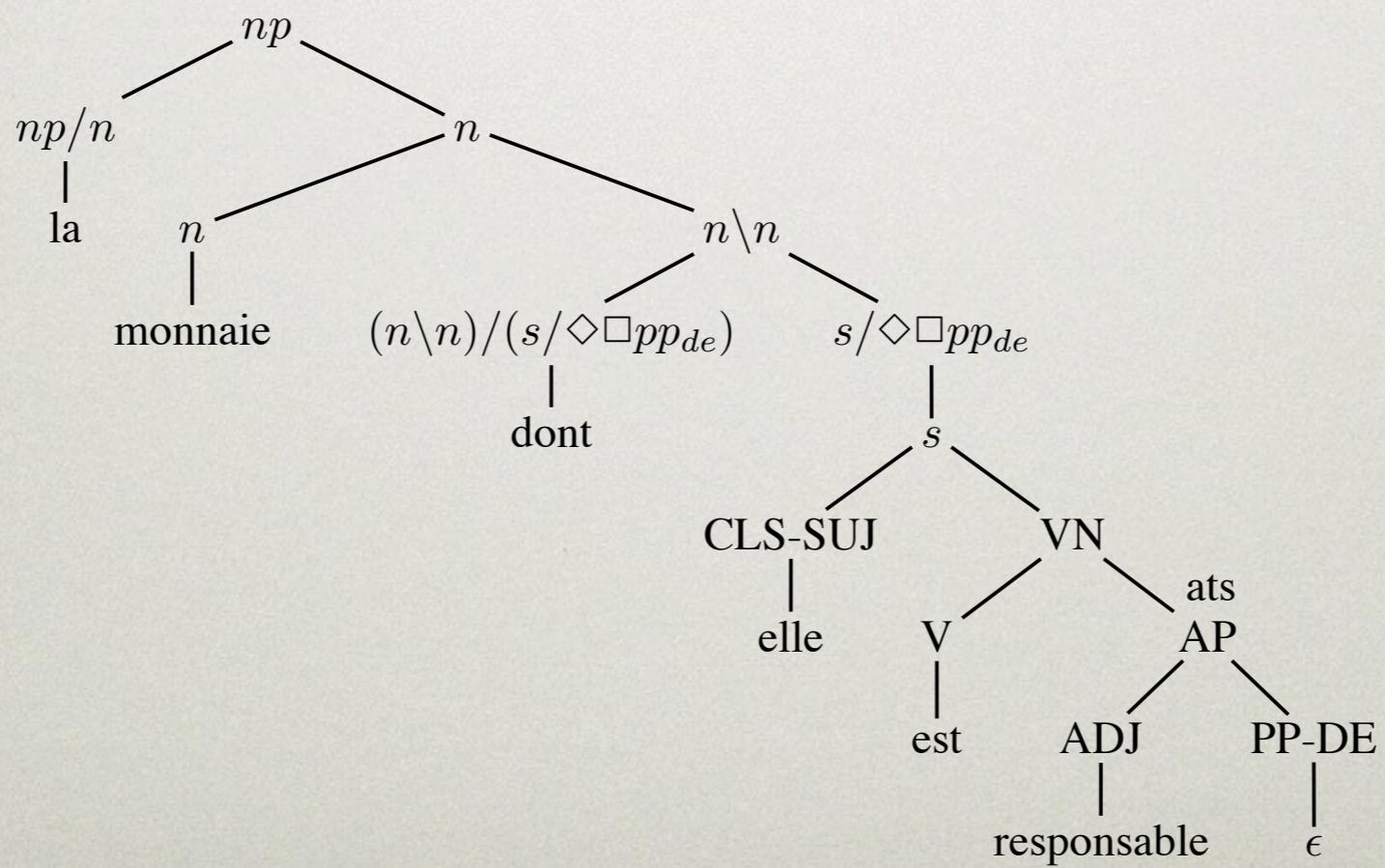
TREEBANK EXTRACTION



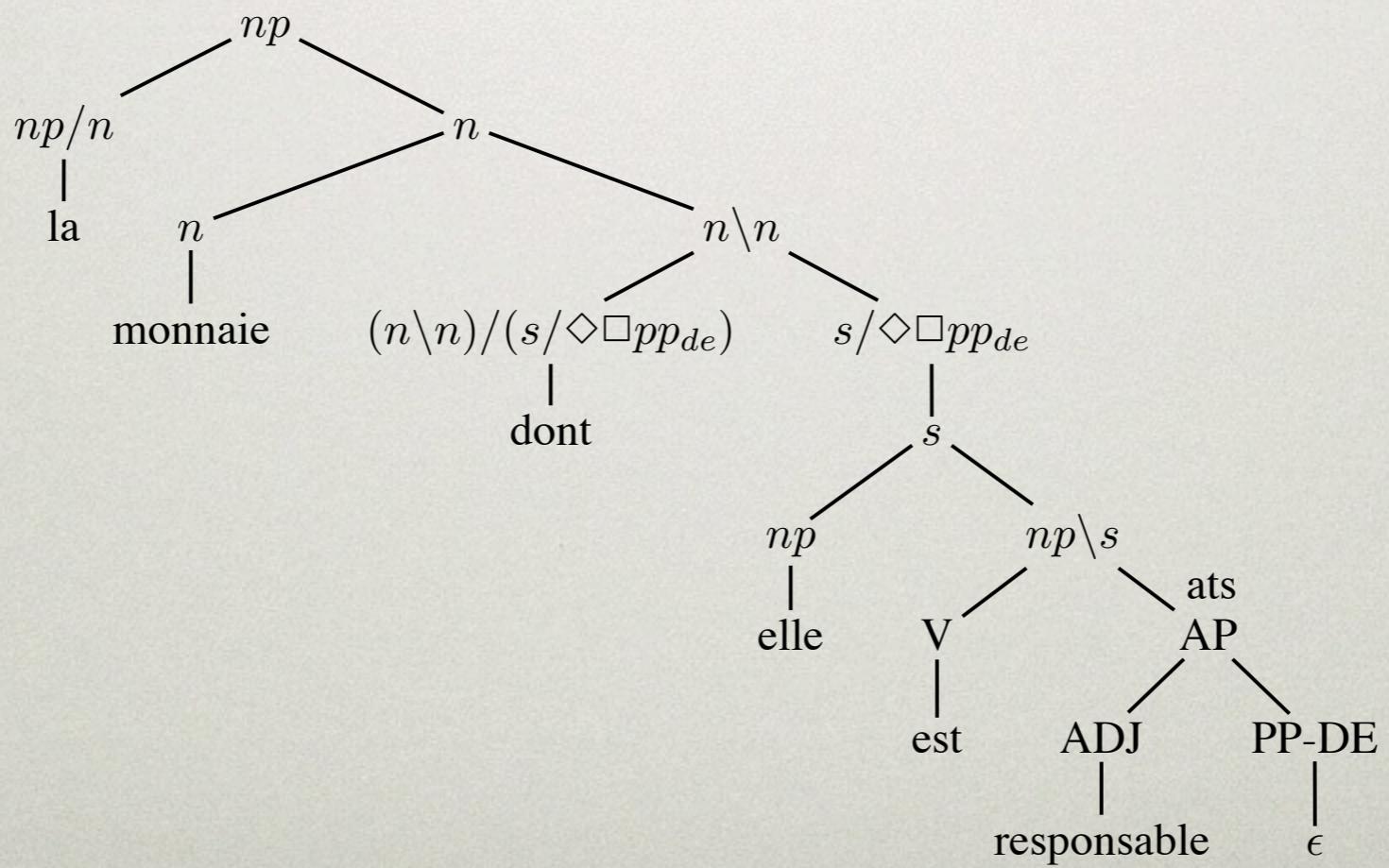
TREEBANK EXTRACTION



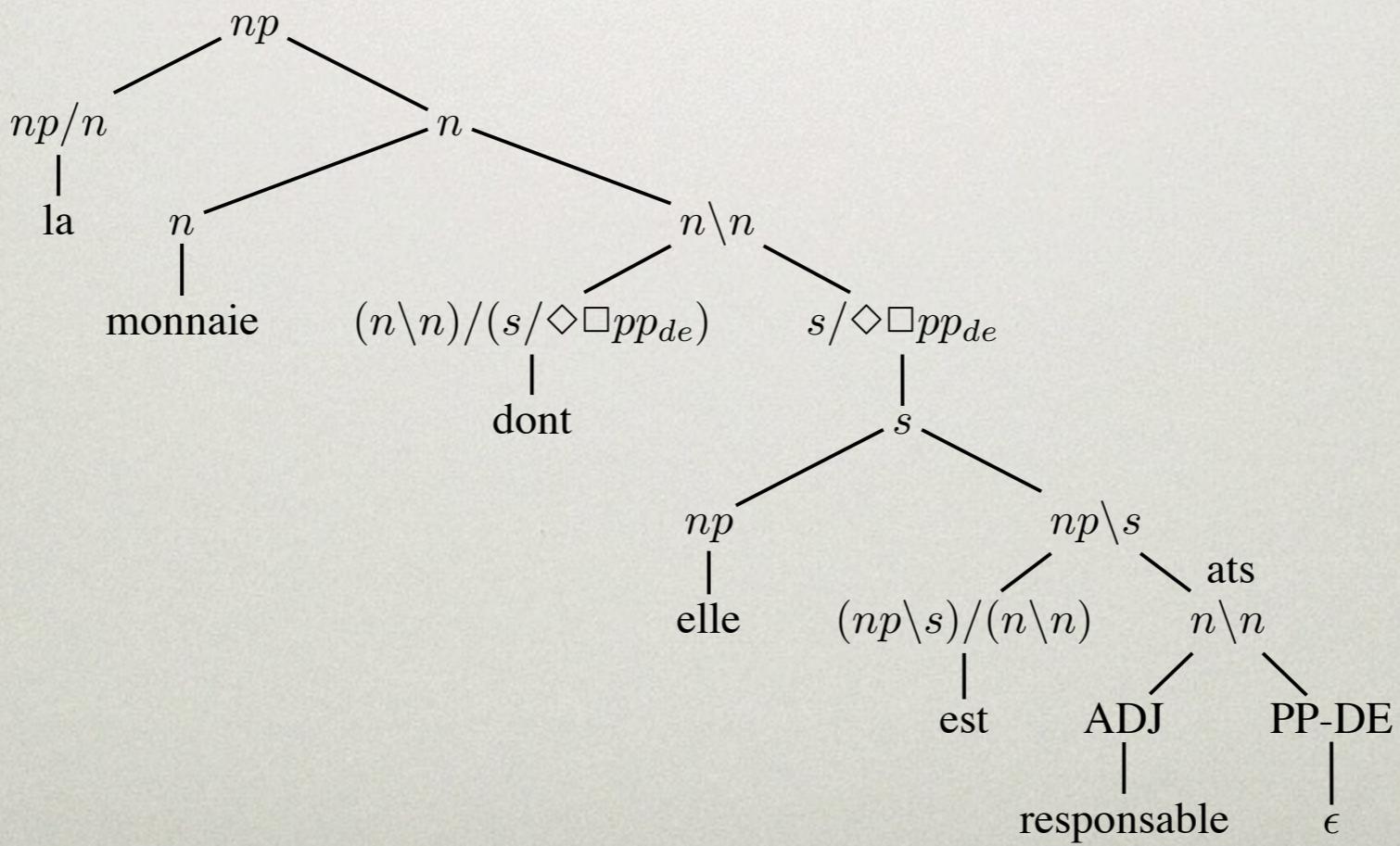
TREEBANK EXTRACTION



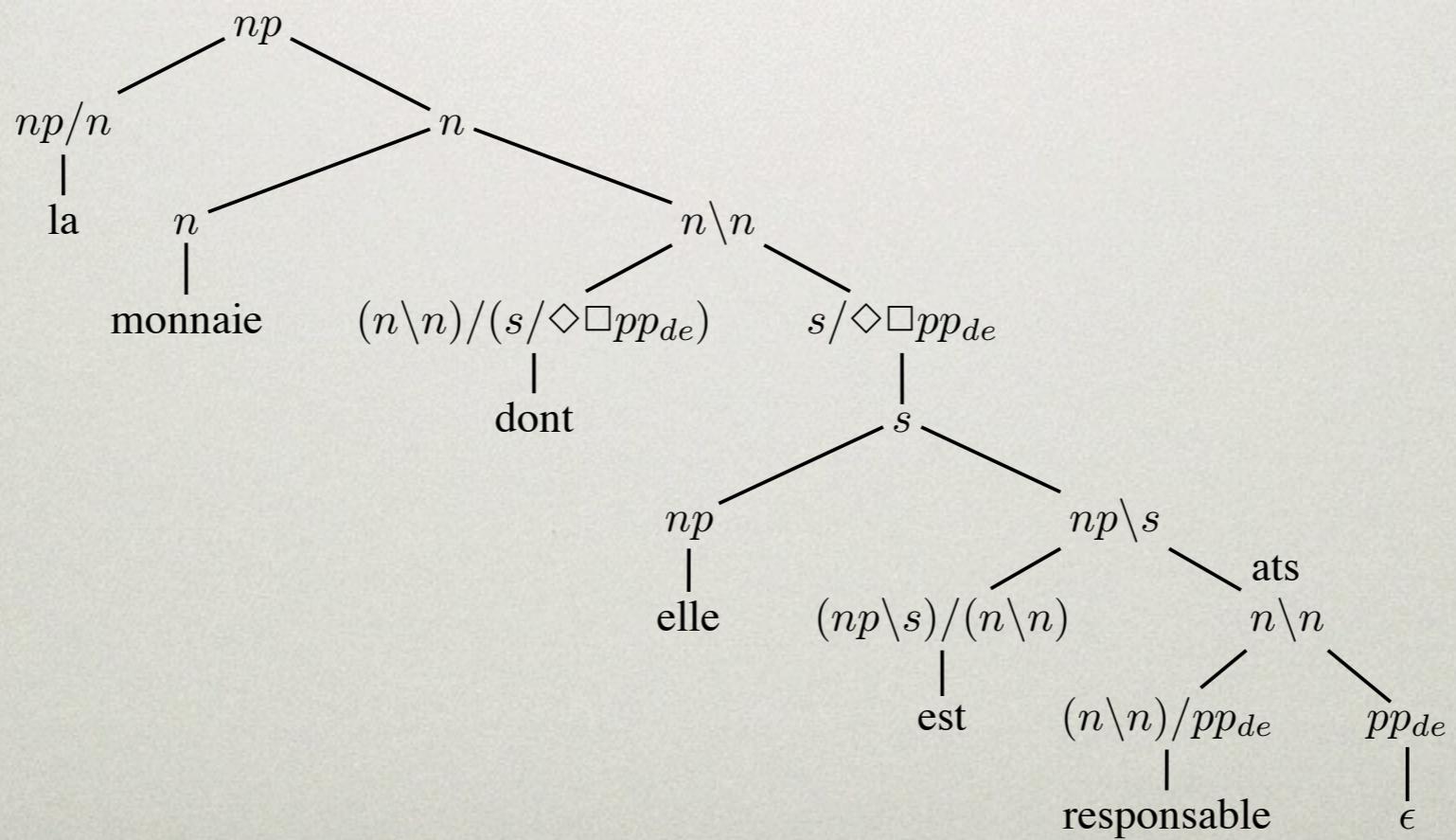
TREEBANK EXTRACTION



TREEBANK EXTRACTION



TREEBANK EXTRACTION



TREEBANK EXAMPLE



TREEBANK EXAMPLE: ZOOM 1

$\frac{\text{emprunter} \quad [Lex]}{(np \setminus s_{inf}) / np \quad [Lex] \quad [p_1 \vdash np]^4} \quad [E]$
$\frac{\text{cette} \quad [Lex] \quad n}{(s_{inf} \setminus 1s_{inf}) / n \quad [Lex] \quad n} \quad [E]$
$\frac{\text{année} \quad [Lex]}{cette \circ année \vdash s_{inf} \setminus 1s_{inf} \quad [_1 E]}$
$\frac{q_1 \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})) \vdash s_{inf} \quad [_1 I_5]}{q_1 \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})) \vdash np \setminus s_{inf} \quad [_1 E]}$
$\frac{\frac{l' \quad [Lex] \quad État \quad n \quad [Lex]}{np / n \quad [E]} \quad \frac{\text{devra} \quad [Lex]}{(np \setminus s_{main}) / (np \setminus s_{inf}) \quad [Lex]} \quad \frac{q_1 \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})) \vdash s_{inf} \quad [_1 I_5]}{l' \circ État \vdash np \quad [E]} \quad \frac{q_1 \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})) \vdash np \setminus s_{main} \quad [_1 E]}{devra \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})) \vdash np \setminus s_{main} \quad [_1 E]}$
$\frac{\frac{135 \quad [Lex] \quad milliards \quad [Lex]}{n / n \quad [E]} \quad \frac{de \quad [Lex] \quad francs \quad [Lex]}{(n \setminus n) / n \quad [E]} \quad \frac{que \quad [Lex]}{(n \setminus n) / (s_{main} / \diamond_1 \square_1 np) \quad [Lex]}}{135 \circ \text{milliards} \vdash n \quad [E]} \quad \frac{que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année})))) \vdash s_{main} \quad [_1 I_4]}{(l' \circ État) \circ (devra \circ ((\text{emprunter} \circ p_1) \circ_1 (\text{cette} \circ \text{année}))) \vdash s_{main} / \diamond_1 \square_1 np \quad [_1 E]}$
$\frac{\frac{les \quad [Lex]}{r_0 \vdash np^2 \quad np \setminus s_{inf} \quad [Lex]} \quad \frac{sur \quad [Lex]}{(s_{inf} \setminus 1s_{inf}) / np \quad [Lex]} \quad \frac{np / n \quad [Lex]}{(135 \circ \text{milliards}) \circ (de \circ \text{francs}) \vdash n}}{les \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))) \vdash n \setminus n \quad [E]} \quad \frac{que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))) \vdash n \setminus n \quad [E]}{(l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))) \vdash n \setminus n \quad [E]}$
$\frac{r_0 \circ \text{valoir} \vdash s_{inf} \quad [E]}{sur \circ (les \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))) \vdash s_{inf} \setminus 1s_{inf} \quad [_1 E]} \quad \frac{que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))) \vdash s_{inf} \setminus 1s_{inf} \quad [_1 E]}{(l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))) \vdash s_{inf} \setminus 1s_{inf} \quad [_1 E]}$
$\frac{, \circ à \quad [Lex]}{((n \setminus n) \setminus 1(n \setminus n)) / (np \setminus s_{inf}) \quad [Lex]}$
$\frac{r_0 \circ (\text{valoir} \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash s_{inf} \quad [_1 I_2]}{valoir \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash np \setminus s_{inf} \quad [E]}$
$\frac{, \circ à \circ (\text{valoir} \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash (n \setminus n) \setminus 1(n \setminus n) \quad [E]}{, \circ à \circ (\text{valoir} \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash n \setminus n \quad [E]}$
$\frac{, \circ à \circ (\text{valoir} \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash n \setminus n \quad [E]}{ter \circ_1 (\text{cette} \circ \text{année})))) \vdash np \quad [E]}$
$\frac{, \circ à \circ (\text{valoir} \circ_1 (\text{sur} \circ (\text{les} \circ (((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ ((\text{emprunter} \circ_1 (\text{cette} \circ \text{année})))))))) \vdash n \setminus n \quad [E]}{pp_{de} \quad [E]}$

TREEBANK EXAMPLE: ZOOM2

$$\begin{array}{c}
 \frac{\text{emprunter} \quad [Lex]}{(np \setminus s_{inf}) / np} \quad \frac{[p_1 \vdash np]^4}{\text{emprunter} \circ p_1 \vdash np \setminus s_{inf}} \quad \frac{[/E]}{[\setminus E]} \quad \frac{\text{cette} \quad [Lex]}{(s_{inf} \setminus_1 s_{inf}) / n} \quad \frac{\text{année} \quad [Lex]}{n \quad [\setminus E]} \\
 \frac{[q_1 \vdash np]^5}{q_1 \circ (\text{emprunter} \circ p_1) \vdash s_{inf}} \quad \frac{[/E]}{cette \circ \text{année} \vdash s_{inf} \setminus_1 s_{inf}} \quad [\setminus_1 E]
 \end{array}
 \\[10pt]
 \frac{\frac{l' \quad [Lex] \quad \frac{État \quad [Lex]}{n \quad [/E]} \quad \frac{devra \quad [Lex]}{(np \setminus s_{main}) / (np \setminus s_{inf})}}{l' \circ État \vdash np} \quad \frac{que \quad [Lex]}{(n \setminus n) / (s_{main} / \diamond_1 \square_1^\downarrow np)}}{(l' \circ État) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{année})) \vdash s_{main}} \quad \frac{[/\Diamond_1 \square_1 I]_4}{(l' \circ État) \circ (devra \circ (emprunter \circ_1 (cette \circ \text{année}))) \vdash s_{main} / \diamond_1 \square_1^\downarrow np} \quad [\setminus E]
 \\[10pt]
 \frac{\frac{\frac{135 \quad [Lex] \quad \frac{milliards \quad [Lex]}{n \quad [/E]} \quad \frac{de \quad [Lex]}{(n \setminus n) / n} \quad \frac{francs \quad [Lex]}{n \quad [/E]}}{135 \circ \text{milliards} \vdash n} \quad \frac{que \quad [Lex]}{(n \setminus n) / (s_{main} / \diamond_1 \square_1^\downarrow np)}}{(135 \circ \text{milliards}) \circ (de \circ \text{francs}) \vdash n} \quad \frac{que \circ ((l' \circ État) \circ (devra \circ (emprunter \circ_1 (cette \circ \text{année})))) \vdash n \setminus n}{((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ (emprunter \circ_1 (cette \circ \text{année})))) \vdash n \setminus n} \quad [\setminus E]
 \\[10pt]
 \frac{les \quad [Lex]}{np / n} \quad \frac{((135 \circ \text{milliards}) \circ (de \circ \text{francs})) \circ (que \circ ((l' \circ État) \circ (devra \circ (emprunter \circ_1 (cette \circ \text{année})))) \vdash np}{[\setminus E]}
 \end{array}$$

TREEBANK EXAMPLE: ZOOM3

$\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]$	$\frac{\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} \Box_1^{\downarrow} np} [/E]$
$\frac{\frac{\frac{\text{l'}}{np/n} [Lex] \quad \frac{\text{\'Etat}}{n} [Lex]}{l' \circ \text{\'Etat} \vdash np} \quad \frac{\frac{\text{devra}}{(np \setminus s_{main}) / (np \setminus s_{inf})} [Lex]}{devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee})) \vdash np \setminus s_{main}} [/E]}{devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee})) \vdash s_{main}} [/E]$	$\frac{\frac{\frac{\text{emprunter}}{(np \setminus s_{inf}) / np} [Lex] \quad [p_1 \vdash np]^4}{emprunter \circ p_1 \vdash np \setminus s_{inf}} [/E] \quad \frac{\frac{\text{cette}}{(s_{inf} \setminus_1 s_{inf}) / n} [Lex]}{cette \circ \text{ann\'ee} \vdash s_{inf} \setminus_1 s_{inf}} [/E]}{q_1 \circ (emprunter \circ p_1) \vdash s_{inf}} \quad \frac{\frac{\text{ann\'ee}}{n} [Lex]}{cette \circ \text{ann\'ee} \vdash s_{inf} \setminus_1 s_{inf}} [/E]}{q_1 \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee})) \vdash s_{inf}} [/E]$
$\frac{\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} \Box_1^{\downarrow} np} [/E]$	$\frac{\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} \Box_1^{\downarrow} np} [/E]$
$\frac{\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} \Box_1^{\downarrow} np} [/E]$	$\frac{\frac{\frac{\text{que}}{(n \setminus n) / (s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np)} [Lex]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} / \diamondsuit_1 \Box_1^{\downarrow} np} [/E]}{(l' \circ \text{\'Etat}) \circ (devra \circ ((emprunter \circ p_1) \circ_1 (cette \circ \text{ann\'ee}))) \vdash s_{main} \Box_1^{\downarrow} np} [/E]$

SOME STATISTICS FOR THE EXTRACTED TREEBANK

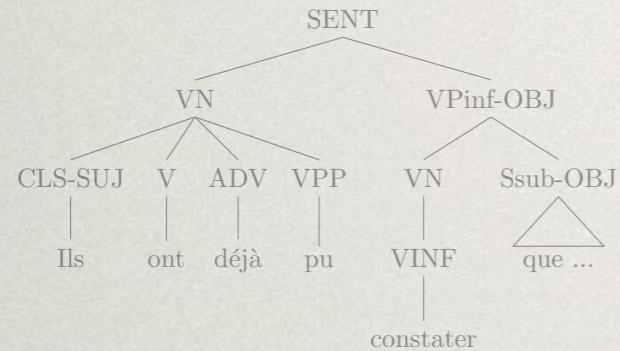
- 15,590 sentences, 425,918 words
- 45,270 distinct lexical entries
- 883 different formulas (with 659 occurring more than once)
- By comparison: 12,617 CFG rules

DIFFERENCES WITH THE CCGBANK

- Different treatment of extraction
- No lexical rules or non-logical axioms
- Coordination is handled in the lexicon
- Interpunction symbols can be assigned coordination-like formulas

OUTLINE

French Treebank



Grammar Extraction

$$\frac{\frac{de}{(np \setminus s_{di}) / (np \setminus s_i)} [Lex] \quad \frac{s'}{cl_r} [Lex] \quad \frac{\frac{attaquer}{(cl_r \setminus (np \setminus s_i)) / pp_a} [Lex] \quad \frac{[Lex]}{a \circ p_0 \vdash cl_r \setminus (np \setminus s_i)} \quad \frac{p_0 \vdash pp_a}{[Hyp]_1} [Hyp]_1}{a \circ p_0 \vdash np \setminus s_i} [/E]}{de \circ (s' \circ (a \circ p_0)) \vdash np \setminus s_i} [/E]$$



Applications

$e_1 \ y_1$
$y_1 :$
$e_2 \ e_3 \ x_3$
$x_3 = ?$
$\text{aider_à}(e_2, x_0, x_3, e_3)$
$\text{partir}(e_3, x_3)$
$\text{demander}(e_1, y_0, x_0, y_1)$

APPLICATIONS

- Wide-coverage parsing for French
- Wide-coverage semantics for French
- Toward analysis of debates

WIDE-COVERAGE PARSING

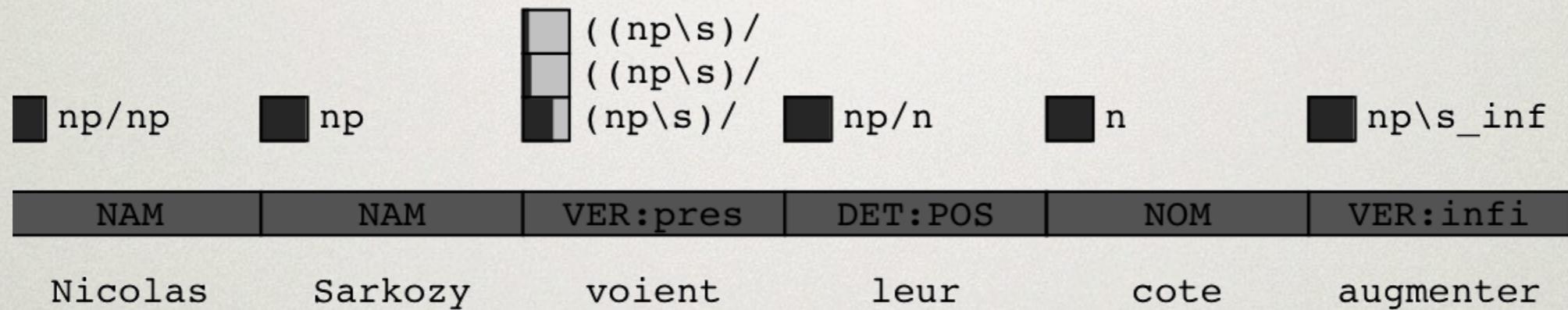
- How can we parse very big grammars efficiently?
- Bottlenecks: lexicon size, grammatical combinatorics

LEXICON SIZE

- Many frequent words occur with very many different formulas
- Classic solution: supertagging

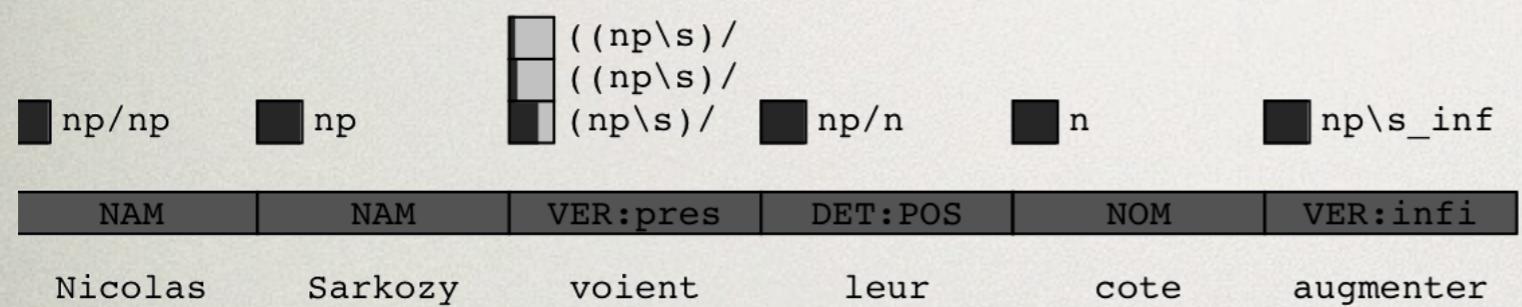
est - “is”	
(np \ s)/np	23,2 %
(np \ s)/(n \ n)	20,6 %
(np \ s)/(np \ s _{pass})	16,8 %
(cl _r \(np \ s))/(cl _r \(np \ s _{ppart}))	10,8 %
(np \ s)/pp	8,1 %
(np \ s)/(np \ s _{ppart})	6,3 %
(np \ s)/(np \ s _{infX})	2,8 %
((np \ s)/s _q)/(n \ n)	2,2 %

WHAT SUPERTAGGING DOES



- Supertagging = statistical finite state approximation of lexical lookup
- Assigns each word the contextually most likely (set of) formulas

WHAT SUPERTAGGING DOES



voient:
 $(np \setminus s) / np$ (65.8%)
 $((np \setminus s) / np) / pp$ (15.9%)
 $((np \setminus s) / (np / s_{inf})) / np$ (10.7%)

- Supertagging = statistical finite state approximation of lexical lookup
- Assigns each word the contextually most likely (set of) formulas

SUPERTAGGER PERFORMANCE

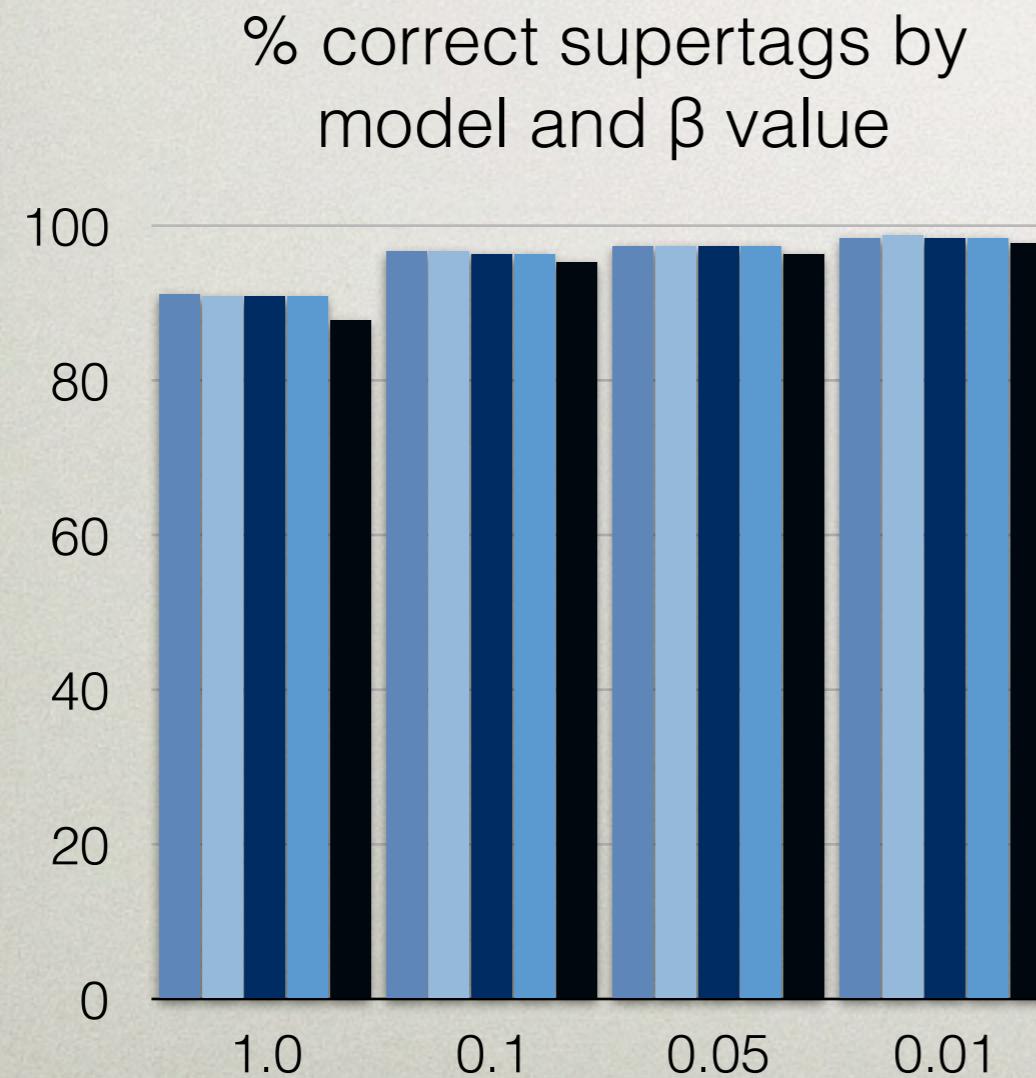
Corpus	POS	Super	0,1	0,01	F / w
FTB	97,8 %	90,6 %	96,4 %	98,4 %	2,3

SUPERTAGGER PERFORMANCE

Corpus	POS	Super	0,1	0,01	F / w
FTB	97,8 %	90,6 %	96,4 %	98,4 %	2,3
Le Monde 2010	97,3 %	89,9 %	95,8 %	97,9 %	2,2
Sequoia	97,3 %	88,1 %	94,8 %	97,6 %	2,4
Itipy	95,7 %	86,7 %	93,8 %	97,1 %	2,6

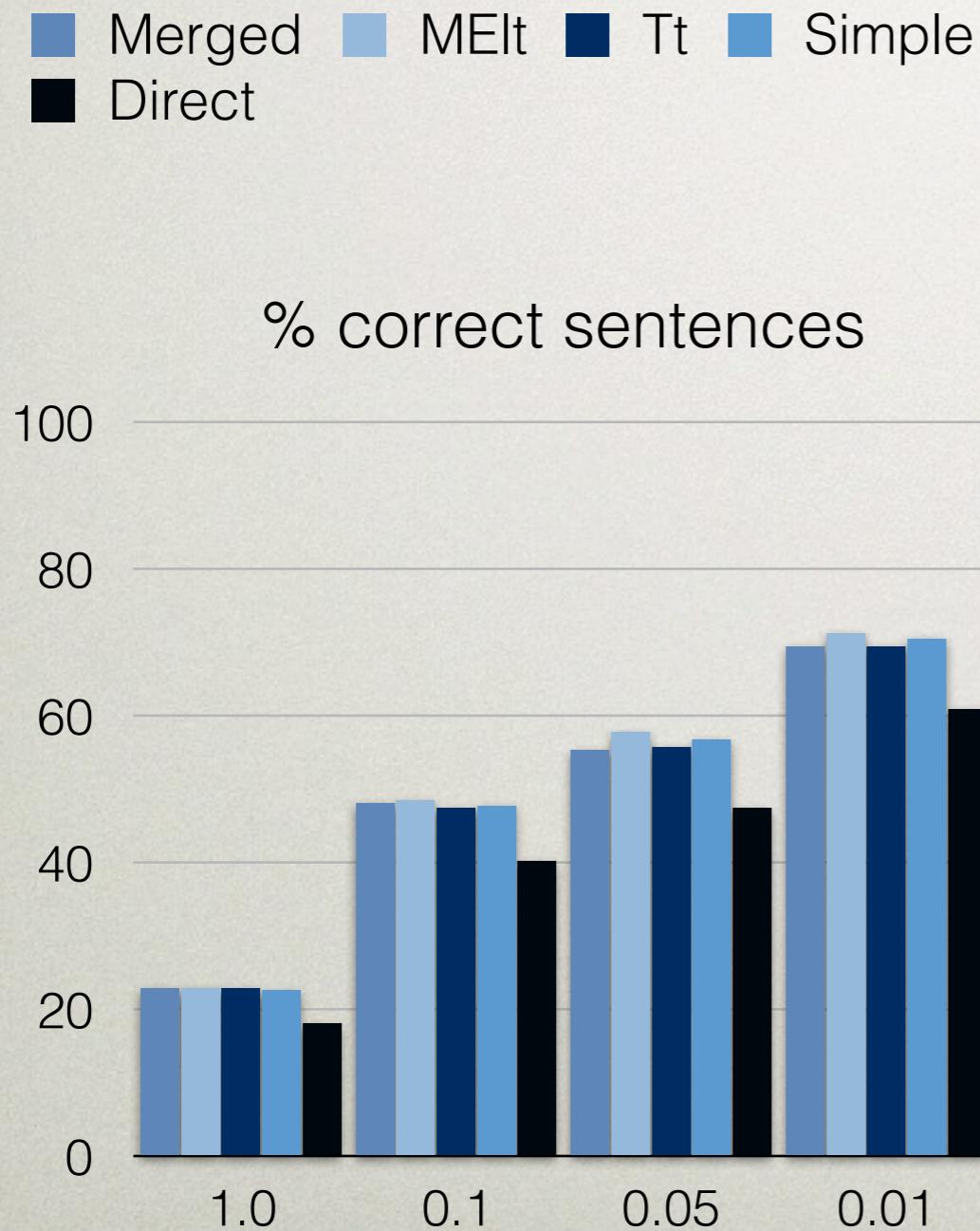
DETAILED PERFORMANCE

Merged MElt Tt Simple
Direct



- ◆ Results with the use of different values of β .
- ◆ In a sense, the β value allows us to trade coverage for efficiency: at higher values of β , we parse more sentences, but we do so more slowly.

DETAILED PERFORMANCE



- ◆ Finally, here is the percentage of sentences which are assigned the correct sequence of supertags for the different settings of β and the different POS models.
- ◆ Note that the number of sentences for which a parse is found is actually better (close to 90% at $\beta=0.01$)

CHART-PARSING TYPE-LOGICAL GRAMMARS

- Prototype exhaustive chart parser for Type-Logical Grammars, strongly inspired by Shieber e.a. (1995)
- Fine-tuned for grammars in the restricted form as produced by the extraction algorithm
- LaTeX output (natural deduction proofs and semantics)

CHART-PARSING TYPE- LOGICAL GRAMMARS

$$\begin{array}{c}
 \frac{\text{Alain} \quad [Lex] \quad \text{Jupp\'e} \quad [Lex]}{\frac{\text{np}/\text{np} \quad np \quad [/E]}{\text{Alain} \circ \text{Jupp\'e} \vdash np \quad [/E]}} \quad \frac{\text{et} \quad [Lex]}{\frac{(np \setminus np)/np \quad [Lex]}{\frac{\text{et} \circ (\text{Nicolas} \circ \text{Sarkozy}) \vdash np \setminus np}{(\text{Alain} \circ \text{Jupp\'e}) \circ (\text{et} \circ (\text{Nicolas} \circ \text{Sarkozy})) \vdash np \quad [\backslash E]}}}} \\
 \frac{\text{Nicolas} \quad [Lex] \quad \text{Sarkozy} \quad [Lex]}{\frac{\frac{np/np}{np} \quad np \quad [/E]}{\frac{\text{Nicolas} \circ \text{Sarkozy} \vdash np}{(\text{np} \setminus np)/np \quad [/E]}}} \quad \frac{\text{voient} \quad [Lex]}{\frac{((np \setminus s_{main})/(np \setminus s_{inf}))/np \quad [Lex]}{\frac{\text{voient} \circ (\text{leur} \circ \text{cote}) \vdash (np \setminus s_{main})/(np \setminus s_{inf})}{(\text{voient} \circ (\text{leur} \circ \text{cote})) \circ \text{augmenter} \vdash np \setminus s_{main} \quad [\backslash E]}}}} \\
 \frac{\text{leur} \quad [Lex] \quad \text{cote} \quad [Lex]}{\frac{\frac{np/n}{n} \quad np \quad [/E]}{\frac{\text{leur} \circ \text{cote} \vdash np \quad [/E]}{\frac{\text{augmenter} \quad [Lex]}{\frac{np \setminus s_{inf}}{np \setminus s_{inf}} \quad [/E]}}}} \\
 \end{array}$$

(1) $\frac{\text{((Alain} \circ \text{Jupp\'e}) \circ (\text{et} \circ (\text{Nicolas} \circ \text{Sarkozy}))) \circ ((\text{voient} \circ (\text{leur} \circ \text{cote})) \circ \text{augmenter}) \vdash s_{main}}{[\backslash E]}$

SEMANTICS

- Type-logical grammar proofs are a subset of intuitionistic proofs, which correspond to lambda-terms.
- Lexical substitution followed by beta normalization gives us the full sentence meaning

FORMULAS AS TYPES

- ◆ This is the standard way of assigning types to formulas in categorial grammar.
- ◆ Exception 1: np is lifted from e to $(e \rightarrow t) \rightarrow t$
- ◆ Exception 2: pp is assigned the same type as np

Formula	Type
type(np)	$(e \rightarrow t) \rightarrow t$
type(pp)	$(e \rightarrow t) \rightarrow t$
type(n)	$e \rightarrow t$
type(s)	t
type(B / A)	$\text{type}(A) \rightarrow \text{type}(B)$
$\text{type}(A \setminus B)$	$\text{type}(A) \rightarrow \text{type}(B)$

PROOFS AS TYPED LAMBDA TERMS

- ◆ Proofs in categorial grammar correspond to lambda terms
- ◆ These lambda terms abstract away from the directions of the implications.

$$\frac{\begin{array}{c} t:A/B \\ u:B \end{array}}{(t\ u):A}$$
$$\frac{\begin{array}{c} u:B \\ t:B\setminus A \end{array}}{(t\ u):A}$$
$$\frac{\begin{array}{c} [x:B] \\ \vdots \\ t:A \end{array}}{A/B:\lambda x.t}$$
$$\frac{t:A}{B\setminus A:\lambda x.t}$$

LEXICAL SEMANTICS

- Montague-style semantics, where the meaning of *love* is *love'*
- Has the advantage of being scaleable, since many lexical entries follow a specific pattern
- Uses DRT

SEMANTICS

Example entries (slightly simplified)

marché: $\lambda x.$

$\lambda x.$
$\lambda x.$

$\lambda x.$

Marie: $\lambda P.$

$\lambda P.$
$\lambda P.$

$\oplus (P \ y)$

$\lambda P.$

chaque: $\lambda P \ \lambda Q. (\lambda z.$

$\lambda z.$
$\lambda z.$

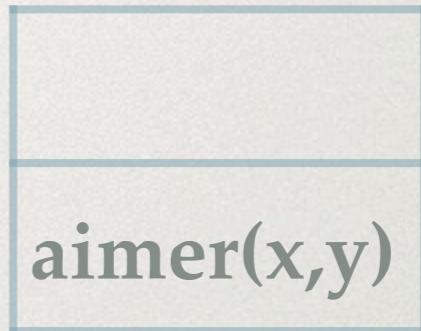
$\lambda z.$

SEMANTICS

Example entries (slightly simplified)

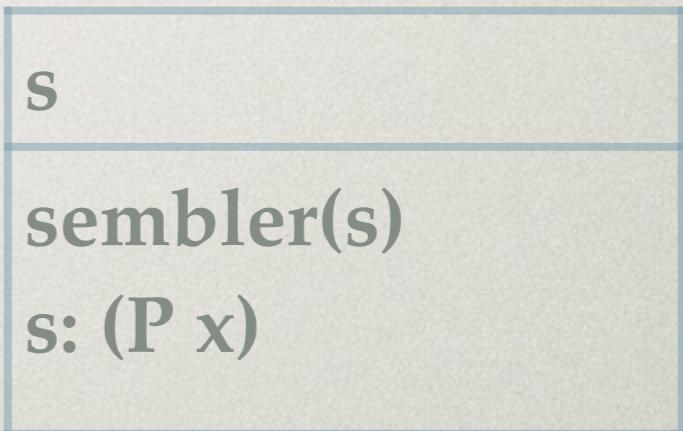
aime: $(np \setminus s) / np$

$\lambda y. \lambda x.$



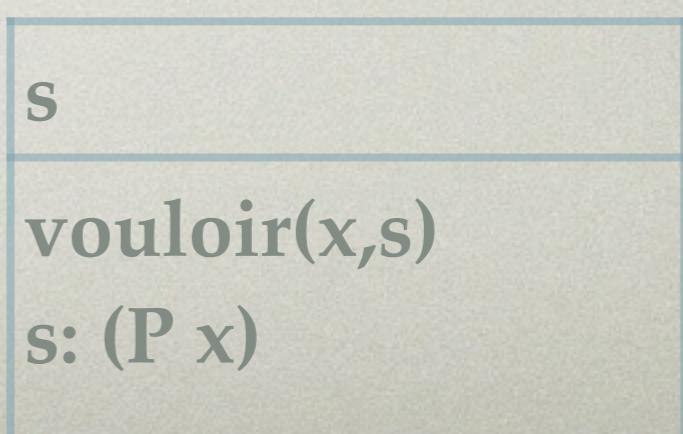
semble: $(np \setminus s) / (np \setminus s_{inf})$

$\lambda P. \lambda x.$



veut: $(np \setminus s) / (np \setminus s_{inf})$

$\lambda P. \lambda x.$



SEMANTICS

- 634 words in the lexicon, with idiosyncratic properties
- 346 lexical schemata, eg. $(\text{np} \setminus \text{s}) / \text{np}$ for word w means semantics w' ($\equiv \lambda y. \lambda x. w'(x, y)$)

GOING FURTHER

- We have a system which, given a natural language sentence provides a representation of its meaning.
- For formal semanticists, the job is done (though more detailed analysis of many phenomena is surely necessary).
- How can we use these meanings?

DISCOURSE AND DEBATE

- Project AREN (started May 2016)
- How do we derive discourse relations, for example as used in SDRT?
- Can we automatically detect logical fallacies or turn an informal argument into a formal argument, for example by suggesting hidden premisses?

DIALOGUEA

- Platform for debates (dialoguea.fr)
 1. select sentence fragment
 2. paraphrase it in your own words
 3. note “agree”, “disagree” or “don’t understand”
 4. argue your position

DIALOGUEA

Forum des débats, *Notarisation de débats numériques et éthiques*

(sélectionner dans le texte pour argumenter)

Diffusion des savoirs faire et des idées, réenchantement du débat public, valoriser les contributions citoyennes dans une démocratie contributive. Éveil de l'esprit critique des citoyens. Favoriser la prise de décision sur un problème de gestion de bien commun au bon niveau.

Arguments négatifs

Risque pour le respect de la vie privée des participants qui dévoilent très largement leurs positions politiques dans les débats.

Risque perte de liberté d'expression.

Difficulté informatique à réaliser le réseau sémantique des contributions numériques aux débats.

Il faut encore inventer et tester outils permettant une régulation du débat numérique respectueuse des contributions de chacun et permettant au débat de prendre de la hauteur par exemple en alliant les savoirs profanes et savants.

Il y a encore des difficultés techniques pour réaliser l'outil permettant à chacun de cerner comment ses idées ont contribué au débat et

Débat

(sélectionner dans "A" — Argumentaire — pour débattre)

[Envoyer une invitation](#)

Celine dimanche 1 février à 06:19

1 commentaire

"pouvoir."

R A l'inverse, quand le débat public est lancé par les pouvoirs publics comme dans le cadre "ambition numérique" dont les débats publics sont menés par le Conseil National du Numérique missionné par le Premier Ministre, le risque est alors que le débat soit instrumentalisé par les pouvoirs publics. En outre, rien n'indique que les pouvoirs publics prendront réellement en compte les résultats des débats.

A Il y a donc un double risque : les débats publics peuvent être ignorés des pouvoirs publics mais à l'inverse, les pouvoirs publics peuvent organiser des débats publics comme garantie d'une démocratie participative, tout en tenant pas compte des résultats de cette expression publique.

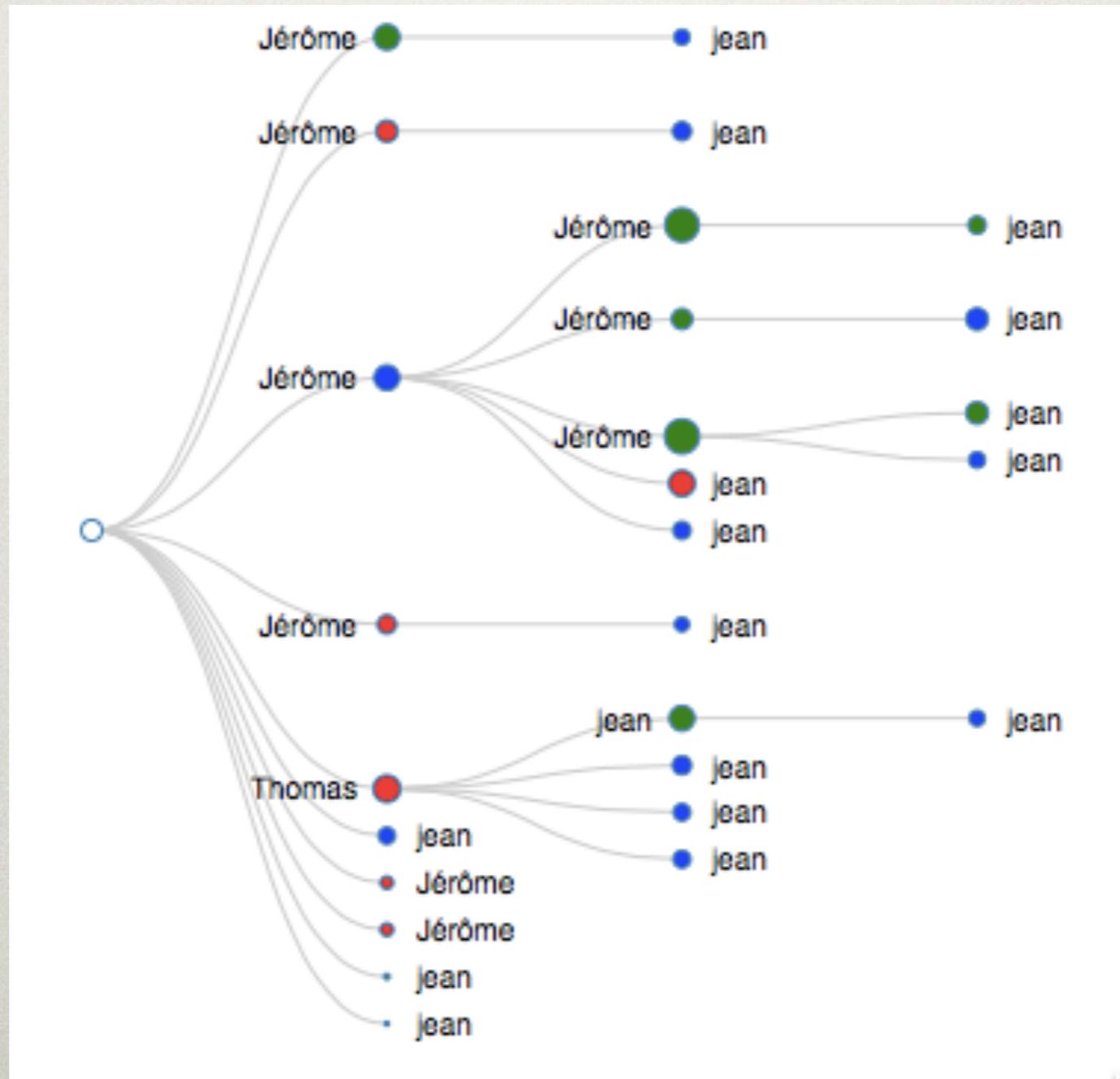
jean dimanche 1 février à 23:39

"Il y a donc un double risque : les débats publics peuvent être ignorés des pouvoirs ..."

R double risque

A C'est effectivement un triple risque, être ignoré quand ils ne viennent pas d'une consultation publique, n'être pas pris en considération ou encore être organisé de façon à être maîtrisé. Voilà des conditions d'échec qui peuvent être anticipées.

DIALOGUEA



PARAPHRASE

- The selected text should entail the paraphrase.
- If the paraphrase entails the text but not inversely then either:
 1. the paraphrase clarifies / makes explicit intended meaning
 2. it is not a paraphrase but a straw man

AGREE, DISAGREE, DON'T UNDERSTAND

- Not understanding is usually accompanied by a request for clarification (possibly giving question/answer pairs, but also possibly pointing to failed entailments)
- Can we determine agreement/disagreement from logical form only? Logical contradiction should imply disagreement

LOGICAL FALLACIES

- Failure of entailment can point to
 1. missing axioms (eg. world knowledge),
 2. error in computing the semantics,or 3. fallacious reasoning
- Of course not all logical fallacies can be automatically detected

WHAT IS ENTAILMENT?

A text T entails a hypothesis H if humans reading T would typically infer that H is most likely true

paraphrased from Dagan e.a. 2013

ENTAILMENT EXAMPLE

T

Google and NASA announced a working agreement, Wednesday, that could result in the Internet giant building a complex of up to 1 million square feet on NASA-owned property, adjacent to Moffett Field, near Mountain View.

H

Google may build a campus on NASA property

ENTAILMENT EXAMPLE

T

Eating lots of foods that are a good source of fiber may keep your blood glucose from rising fast after you eat.

H

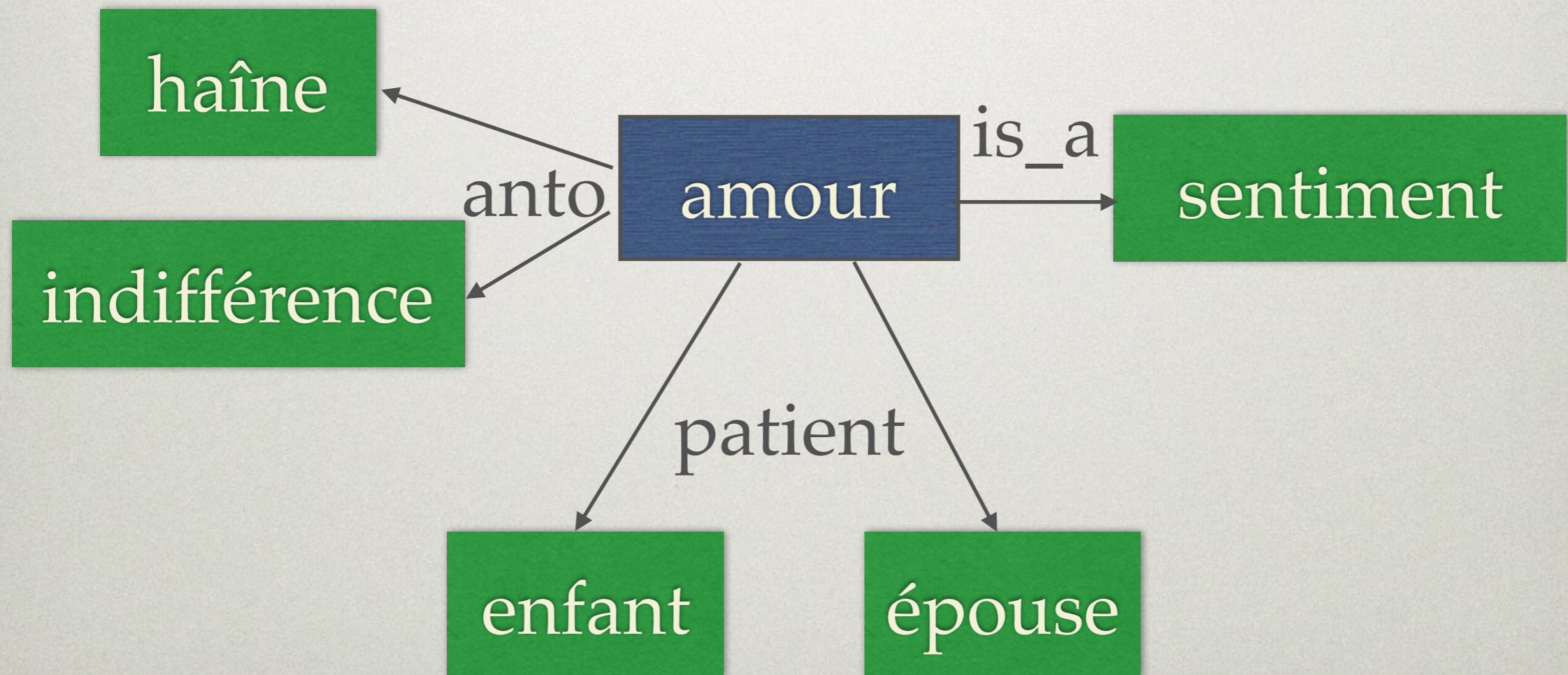
Fiber improves blood sugar control.

WHAT ARE ATOMIC MEANINGS?

- Montague's answer: atomic formulas (ie. the meaning of “*love*” is **love**’).
- Ontology answer: basic meanings are nodes in an ontology.
- Vector space answer: basic meanings are vectors in n -dimensional space.

WHAT ARE ATOMIC MEANINGS?

- Ontology answer: basic meanings are nodes in an ontology.



WHAT ARE ATOMIC MEANINGS?

- Vector space answer: basic meanings are vectors in n -dimensional space.

amour	1.0
tendresse	0.71
bonheur	0.67
amitié	0.59
platonique	0.57

THEOREM PROVING

- different choices of atomic meaning lead to different types reasoning / theorem proving and, as a consequence, to different predictions with respect to entailment
- we explore each of the three options in turn

VANILLA RESOLUTION

- Montague's solution corresponds to plain resolution theorem proving (or your preferred choice of theorem prover)
- We match *identical* positive and negative atomic formulas

VANILLA RESOLUTION THEOREM PROVING

$\text{human}(X) \rightarrow \text{mortal}(X)$

$\text{human}(\text{socrates})$

$\text{mortal}(\text{socrates})$

1. translate to conjunctive normal form
2. add negation of the conclusion
3. derive a contradiction

VANILLA RESOLUTION THEOREM PROVING

$\neg \text{human}(X) \vee \text{mortal}(X)$

$\text{human}(\text{socrates})$

$\neg \text{mortal}(\text{socrates})$

VANILLA RESOLUTION THEOREM PROVING

$\neg \text{human}(X) \vee \text{mortal}(X)$

$\text{human}(\text{socrates})$

$\neg \text{mortal}(\text{socrates})$

$\text{mortal}(\text{socrates})$

DRAWBACKS

- no world knowledge at all
- picky about exact predicates used
- not picky enough about the exact predicates used (eg. word sense disambiguation)

RESOLUTION THEOREM PROVING WITH ONTOLOGY

treat ontology as set of logical claims:

- “p is_a q” corresponds to $p(X) \rightarrow q(X)$,
or equivalently $\neg p(X) \vee q(X)$
- “p anto q” corresponds to $p(X) \rightarrow \neg q(X)$, or equivalently $\neg p(X) \vee \neg q(X)$

RESOLUTION THEOREM PROVING WITH ONTOLOGY

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

RESOLUTION THEOREM PROVING WITH ONTOLOGY

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\neg \text{mammifère}(X) \vee \text{animal}(X)$

$\neg \text{humain}(X) \vee \text{mammifère}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

RESOLUTION THEOREM PROVING WITH ONTOLOGY

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\neg \text{mammifère}(X) \vee \text{animal}(X)$

$\neg \text{humain}(X) \vee \text{mammifère}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

$\neg \text{mammifère}(X) \vee \text{mortel}(X)$

RESOLUTION THEOREM PROVING WITH ONTOLOGY

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\neg \text{mammifère}(X) \vee \text{animal}(X)$

$\neg \text{humain}(X) \vee \text{mammifère}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

$\neg \text{mammifère}(X) \vee \text{mortel}(X)$

$\neg \text{humain}(X) \vee \text{animal}(X)$

ADVANTAGES/DRAWBACKS

- some “light-weight” world knowledge
- different relations are useful in different situations “is_a”, “synonym”, “antonym”, “has_part” etc.
- can at least *identify* that some words have multiple senses

RESOLUTION THEOREM PROVING WITH VECTORS

reasoning by similarity:

- find maximum-weight abduction for the statement
- standard resolution as a base case

RESOLUTION THEOREM PROVING WITH VECTORS

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

RESOLUTION THEOREM PROVING WITH VECTORS

$\neg \text{animal}(X) \vee \text{mortel}(X)$

$\text{humain}(\text{socrates})$

$\neg \text{mortel}(\text{socrates})$

$\neg \text{vétérinaire}(X) \vee \text{animal}(X)$

ADVANTAGES/DRAWBACKS

- weighted deduction / abduction
- computes “most similar” derivation, with standard resolution as a base case
- similarity has a *very* uneasy relation with derivability (though we may infer other weights à la Raina, Ng & Manning 2005)

PUTTING IT ALL TOGETHER

- Can we combine all these components?
- Use weights as preferences but use the ontology to reject combinations

AREN PROJECT

- The AREN project will provide us with numerous structured debates.
- These debates will contain potential entailment pairs and potential question/answer pairs.
- First experiments start soon

CONCLUSIONS

- Categorial grammars produce meanings in the tradition of Montague.
- I've presented some initial exploration of possible uses of wide-coverage semantics to entailment and to the analysis of structured debates.

DEPENDENCIES AND ACKNOWLEDGEMENTS

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