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Formal modelling of dialogue: how words interact (not only in the dictionary!)

EMLex lecture series/Séminaire de l'ATILF

Maxime Amblard

March, 30th 2018



Introduction

First Order Logic

Semantic Calculus

From Montague to Dynamic Semantics

A dynamic example

Summary

SLAM

Toward a formal treatment

Perspectives

Introduction

- Phonology, morphology, syntax, semantics, pragmatic

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LANGUAGE ←————→ WORLD

- Phonology, morphology, syntax, semantics, pragmatic

LANGUAGE ←————→ WORLD

- Distributional / Lexical / Logic

- Phonology, morphology, syntax, **semantics**, pragmatic

LANGUAGE ←————→ WORLD

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First Order Logic



“The only way to rectify our reasonings is to make them **as tangible as those of the Mathematicians**, so that we can find our error at a glance, and when there are disputes among persons, we can simply say : Let us calculate, without further ado, to see who is right.”

The Art of Discovery, 1685



- mathematical inspiration thanks to precise calculus
- the ideal view of Leibniz is partially realized from the end of 19^{ieme} with the works of Frege, Peano, Russell, *etc.*
- formal notations + rules of manipulation = formal logic
- use of First Order Logic(FOL)

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- Many **computer tools** (theorem provers, model builders, model checkers) exist to work with the LPO.
- But more importantly, the FOL allows you to talk about anything.
(temps, modalités, pluriel, événements,...)

1. vocabulary symbols (the **non-logical** symbols of the language).
2. **variables** x, y, z, w, \dots
3. boolean operators \neg (**negation**), \rightarrow (**implication**), \vee (**disjunction**), \wedge (**conjunction**).
4. quantifiers \forall (**universal**) and \exists (**existential**).
5. the **equal** symbol $=$
6. **parenthesis** ')' and '(' and point '.'

The semantic turn

Around the 1930s, the syntactic vision was extended with the development of model theory.



Tarski (Polish logician): introduction of the famous definition of **satisfaction** and **model theory**

A theory is valid if there exists a model in which it is true

⇒ introduction to the concept of **truth**

[tarski1944] [tarski1956]

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- represent the meaning of the statements using logical formulas (proposition, first order, classical, intuitionist, etc.)

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- fundamental techniques to construct semantic representations:
 λ -calculus

- why use representations? Why not use natural language directly?

Challenges

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- can they be useful for pragmatics? In particular can they really take into account that language is whatever we use?

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- why use representations? Why not use natural language directly?
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- if these approaches have practical advantages, do they have a philosophical, cognitive or conceptual reality? Does that define what we understand? Or is it just a way to play with symbols?
- and indeed, is it so practical? Logical reasoning is mathematically difficult.



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The meaning of the whole is a function of the meaning of the parts.



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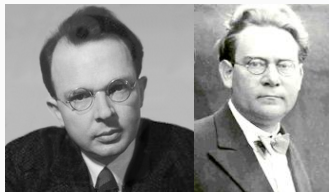
- lexical items = logical representation
- semantics in parallel with syntax

Historically, it's a fairly recent idea

Frege and Tarski were very septic about the use of logic for natural languages, preferring a perspective based on **analogy**.

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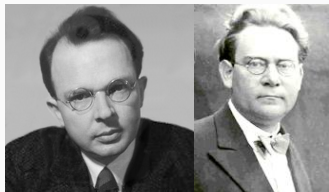
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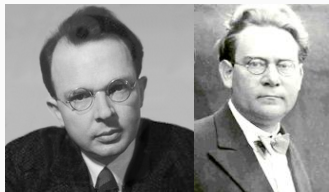


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50's - 60's: many philosophers have argued against a shared approach to logic and natural language



In 3 articles (end of 60's) Montague opens the modern semantics of natural languages:

- English as a Formal Language
- The Proper Treatment of Quantification in Ordinary English
- Universal Grammar

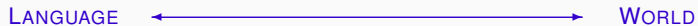


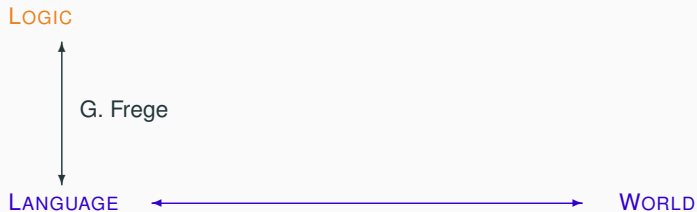
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He replaces analogy with algorithmic

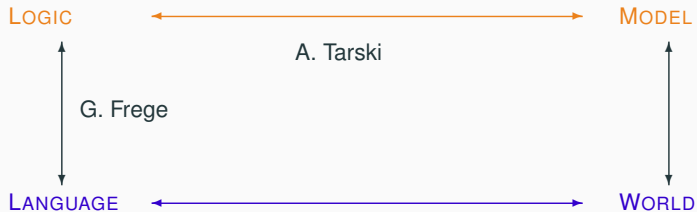
Semantic Calculus





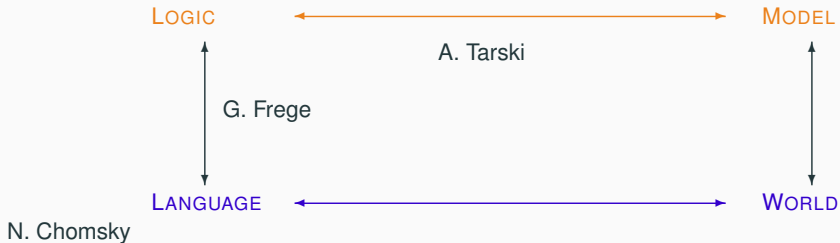
Compositionnality principle

Semantic Calculus



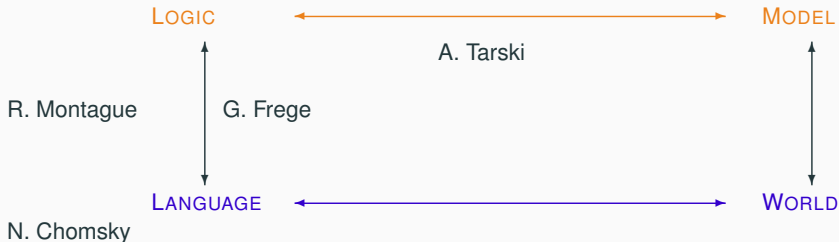
Compositionnality principle
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Compositionnality principle
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Computational Linguistic

Semantic Calculus



Compositionality principle
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- intentional logic
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- first model of the scope ambiguity of quantifiers
- definition of a rigorous syntax semantics interface

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- **task1** definition of a fragment of English [with categorical grammars]
- **task2** specification of the meaning of lexical items [with λ -calcul]
- **task3** exhibit how to build **semantics representations** [with functional application and β -réduction]

[Task1] Categorical Grammars

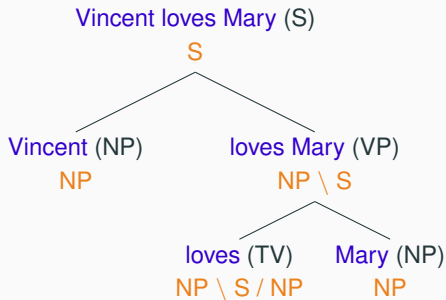
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[Task1] Categorical Grammars

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Functional view of the computation:

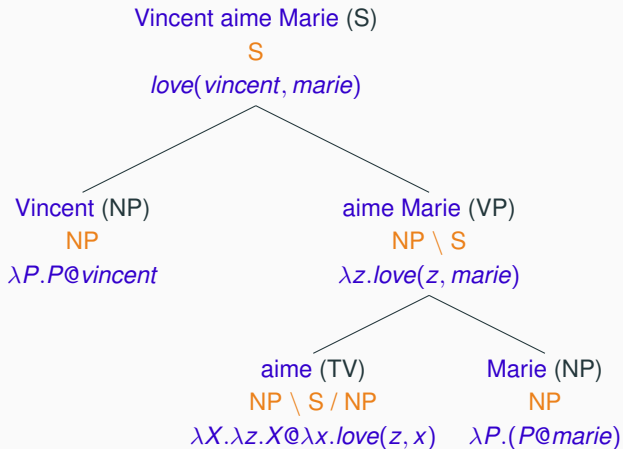
- variables are linked by the λ

$$\lambda x. man(x)$$

- they are markers in formulas
- two terms are composed by the functional application
- β -conversion, α -conversion and η -expansion perform the calculus

$$((\lambda x. man(x)) \textcircled{\text{O}} (vincent)) \rightsquigarrow man(Vincent)$$

[Task3] Curry-Howard Isomorphism



But there is still much to do

- Proper name

Vincent vs $\lambda P.P@Vincent$

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- Pronoms

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- ...

We add information:

- time, tense and aspect: Allen logic, Reichenbach, van Benthem
- event, Davidson
- plural
- modalities
- ...

- Donkey sentences

Every farmer who owns a donkey beats it

$$(\exists x \exists y. (\text{farmer } x \wedge \text{donkey } y \wedge \text{own } x \ y)) \rightarrow \text{beat } x \ y$$

- inter-sentential anaphora

A man walks in the park. He whistle.

$$\exists x. (\text{man } x \wedge \text{walk_in_the_park } x) \wedge (\text{whistle } x)$$

From Montague to Dynamic Semantics

- **Context Change Potential (CCP)** [Heim1983]

The interpretation is done **in context** and the context is modified by the interpretation.

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- **Dynamic Predicate Logic (DPL)** [Groenendijk1991]

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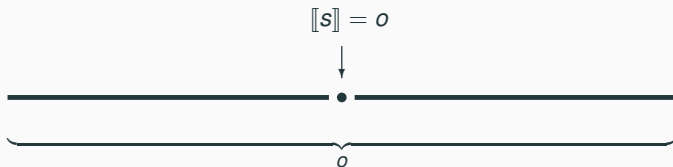
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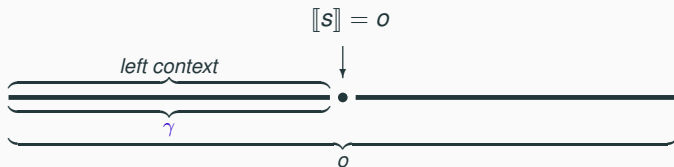
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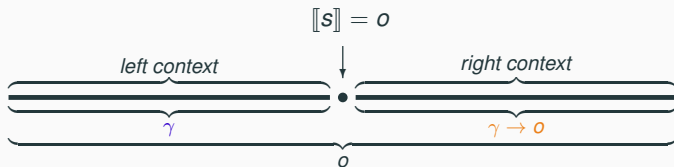
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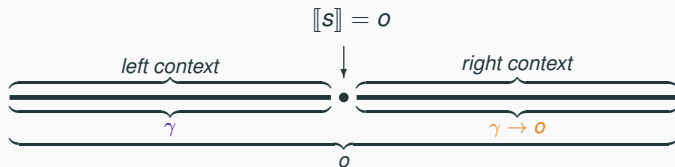
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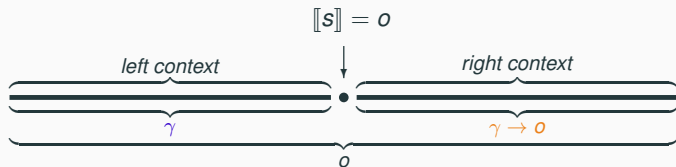
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$$[[s]] = \gamma \rightarrow (\gamma \rightarrow o) \rightarrow o$$

$$\lambda e \phi. \exists x. \mathbf{candidate}(x) \wedge \phi(x :: e)$$

- types :

MG
[[s], [d]] : *o*

TTDL
 $\Omega \triangleq \gamma \rightarrow (\gamma \rightarrow o) \rightarrow o$

- types :

	MG	TTDL
$\llbracket s \rrbracket, \llbracket d \rrbracket :$	o	$\Omega \triangleq \gamma \rightarrow (\gamma \rightarrow o) \rightarrow o$
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- composition to build a discourse:

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- context manipulation (variable list):
 - “::” context update
 - “sel” pick a variable from a left-context

$$\iota \rightarrow \gamma \rightarrow \gamma$$

$$\gamma \rightarrow \iota$$

$$\bar{\wedge} \triangleq \mathbf{update}_{TTDL} = \lambda A B e \phi. A e (\lambda e'. B e' \phi)$$

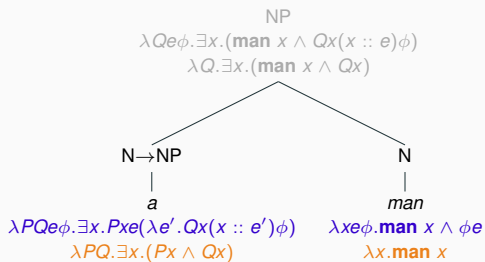
$$\bar{\exists} \triangleq \lambda P e \phi. \exists x. P x (x :: e) \phi$$

$$\mathbf{stop} \triangleq \lambda e. \top$$

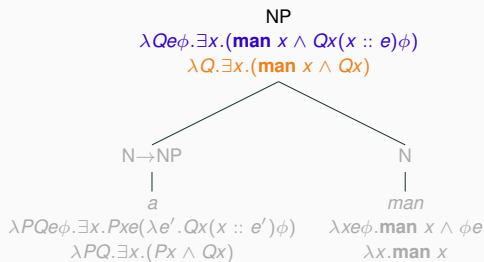
$$\bar{\neg} \triangleq \lambda A e \phi. \neg (A e \mathbf{stop}) \wedge \phi e$$

A dynamic example

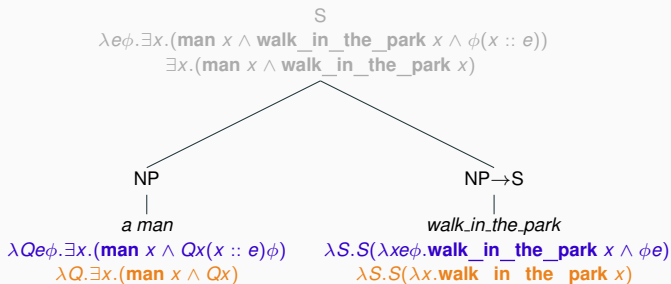
A man_i walks in the park. He_i whistles.



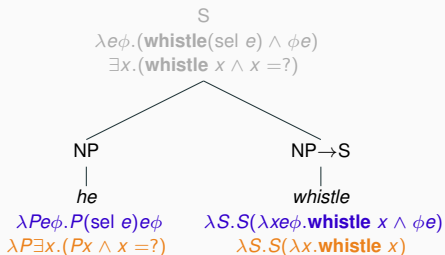
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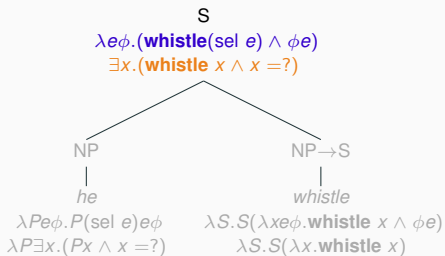
A man_i walks in the park. He_i whistles.



A man_{*j*} walks in the park. He_{*j*} whistles .

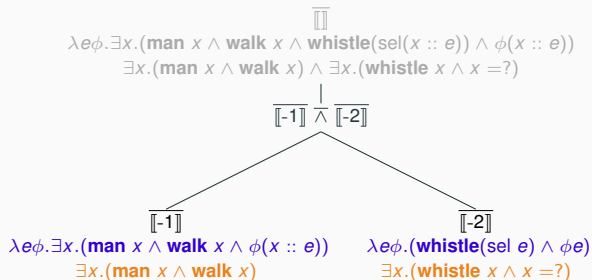


A man_j walks in the park. He_j whistles.

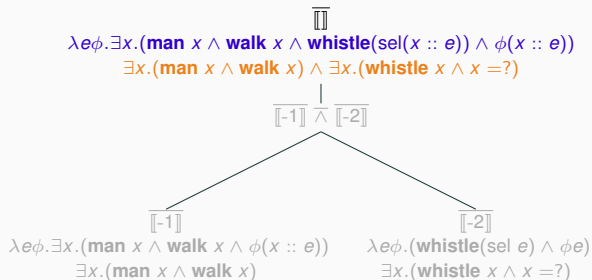


A man_{*i*} walks in the park.

He_{*j*} whistles.



A man_{*i*} walks in the park. He_{*j*} whistles.



Summary

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love(John, Mary)

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- Cognitive reality, conceptual reality? ...

Can we understand madness?

The SLAM project - Schizophrenia and Language: Analyse and Modelling



SLAM

- Linguistic studies of mental diseases (Chaika 1974) and (Fromkin 1975)
- Pragmatic discontinuities in performing verbal interaction (Trognon and Musiol 1996)
- Discontinuities **definitive** (Musiol 2009): pathological use of discourse planning for patients with schizophrenia (paranoid)

The project aims to systematize the **study of pathological conversations** under **interdisciplinary approaches**

- Building of a linguistic resource on mental pathology

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 - semi-supervised interviews
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 - double eye-trackers
- Epistemological and philosophical studies (norm, madness, rationality)
- Identify these purposes with:
 - formal models
 - NLP methods and tools

- Corpus
- Formalization
- Epistemology

- Corpus
 - organize the interviews
 - transcription and tagging
 - analyse different linguistic levels
- Formalization

- Epistemology

- Corpus
- Formalization
 - question the cognitive reality of semantico-pragmatic models,
 - automatically identify unusual uses of the language
- Epistemology

- Corpus
- Formalization
- Epistemology
 - question the normative concepts of rationality and logicity
 - study interpretation under linguistic interaction, and the status of implicit norms

Discontinuity example

- B124 OH OUAIS (↑) ET PIS COMPLIQUÉ (↓) ET C'EST VRAIMENT TRÈS TRÈS COMPLIQUÉ (→) LA POLITIQUE C'EST QUELQUE CHOSE QUAND ON S'EN OCCUPE FAUT ÊTRE GAGNANT PARCE QU'AUTREMENT QUAND ON EST PERDANT C'EST FINI QUOI (↓)
Oh yeah (↑) and complicated (↑) and it's really very very complicated (→) politics, it's really something when you get into it, have to win or else when you lose, well, you're finished (↓)
- A125 OUI
Yes
- B126 J. C. D. EST MORT, L. EST MORT, P. EST MORT EUH (...)
JCD is dead, L is dead, P is dead uh (...)
- A127 ILS SONT MORTS PARCE QU'ILS ONT PERDU À VOTRE AVIS (↑)
So you think they're dead because they lost (↑)
- B128 NON ILS GAGNAIENT MAIS SI ILS SONT MORTS, C'EST LA MALADIE QUOI C'EST C'EST (→)
No they won but if they're dead, it's their disease well it's it's (→)
- A129 OUAIS C'EST PARCE QU'ILS ÉTAIENT MALADES, C'EST PAS PARCE QU'ILS FAISAIENT DE LA POLITIQUE (↑)
Yeah it's because they had a disease, it's not because they were in politics (↑)
- B130 SI ENFIN (→)
Yes I mean (→)
- A131 SI VOUS PENSEZ QUE C'EST PARCE QU'ILS FAISAIENT DE LA POLITIQUE (↑)
Yes you think it's because they were in politics (↑)
- B132 OUI TIENS OUI IL Y A AUSSI C. QUI A ACCOMPLI UN MEURTRE LÀ (→) IL ÉTAIT PRÉSENT LUI AUSSI QUI EST À B. MAIS ENFIN (→) C'EST ENCORE À CAUSE DE LA POLITIQUE ÇA
Yes, so well yeah there was C too who committed murder, uh huh (→) he was there too, the one in B but well (→) it, that, it's because of politics again

Discontinuity example

- B124 OH OUAIS (↑) ET PIS COMPLIQUÉ (↓) ET C'EST VRAIMENT TRÈS TRÈS COMPLIQUÉ (→) LA POLITIQUE C'EST QUELQUE CHOSE QUAND ON S'EN OCCUPE FAUT ÊTRE GAGNANT PARCE QU'AUTREMENT QUAND ON EST PERDANT C'EST FINI QUOI (↓)
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Yes, so well yeah there was **C too who committed murder**, uh huh (→) he was there too, the one in B but well (→) it, that, it's because of politics again

Conversation example (english only)

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(→) **politics**, it's really something when you get into it, **have to win** or else
when you lose, well, you're finished (↓)

A125 Yes

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B128 No they won but if they're dead, it's **their disease** well it's it's (→)

A129 Yeah it's because they had a disease, it's not because they were in
politics (↑)

B130 Yes I mean (→)

A131 Yes you think it's because they were in politics (↑)

B132 Yes, so well yeah there was **C too who committed murder**, uh huh (→)
he was there too, the one in B but well (→) it, that, it's because of politics
again

The schizophrenic switch twice from a theme to another one:

The schizophrenic switch twice from a theme to another one:

- politic death (symbolic)
- death (literal)

Discontinuity example

The schizophrenic switch twice from a theme to another one:

- politic death (symbolic)
- death (literal)

The two themes are related but they express two different realities.

A relatively large corpus

	La Rochelle			Lyon			Total
	♂	♀	tot	♂	♀	tot	
Schizophrenics	15	3	18	22	9	31	49
Controls	15	8	23	4	4	8	31
Total	30	11	41	26	13	39	80

A relatively large corpus

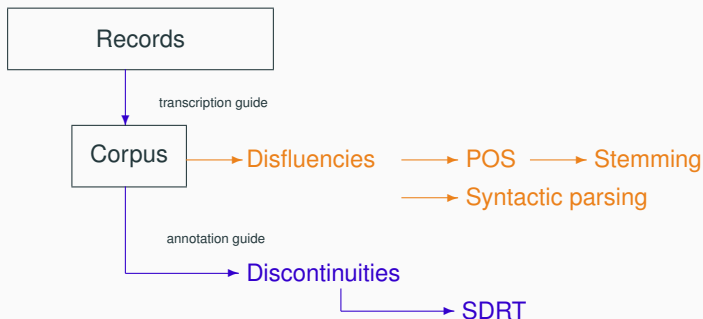
	La Rochelle			Lyon			Total
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31 575 speeches / 375 000 words

	La Rochelle				Lyon			
	# speeches		# words		# speeches		# words	
S	3 863	11 145	46 859	119 762	4 062	4 433	66 725	79 081
T	7 282		72 903		371		12 356	
P + S	3 819	11 517	30 293	138 571	4 098	4 480	33 686	37 842
P + T	7 698		108 278		382		4 156	
Total	22 662		258 333		8 913		116 923	

- A lot of administrative steps:
 - CPP of the area of the medical institution (including a finalise description of the all protocol)
 - CNIL
- Data should not be use for/against the patient
- Patient involvement (significant loss of participation >55%)
- Heavy protocol

- Interview(s) (hand transcription with a guide)
- Neuro-cognitive tests:
 - Wechsler Adult Intelligence Scale-III (IQ)
 - California Verbal Learning Test (strategy and cognitive abilities)
 - Trail Making Test (deprecation of cognitive flexibility and inhibition).
- Oculomotor behavior (double Eye-Trackers)
- Brain activity (EEG)



Talking with patient with schizophrenia

[AMR TALN 2011] [AMR Evol. Psychiatrique 2012] [AMR congrès de linguistique romane 2013]
[AMR Dialogue, Rationality and Formalism Springer 2014] [AMR Philosophie et langage 31 2014]

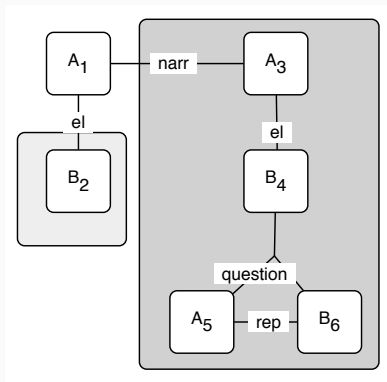
Two interlocutors, thus two (spontaneous) views on the exchange.

Discourse interpretation by	
normal subject (3 rd person)	Schizophrenic (1 st person)
hypothesis: pragmatic correctness ↓ semantics incorrectness	pragmatic incorrectness ↑ hypothesis : semantic correctness
contradictory contents: <i>look like a contradiction</i>	coherent content: <i>possibility of interpretation</i>

⇒ The representation *need more* than logical semantics

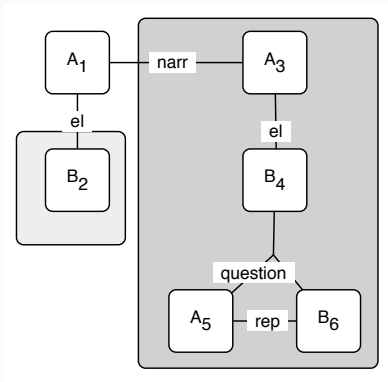
Representation

Use of SDRT + thematic boxes (grey ones)



Representation

Use of SDRT + thematic boxes (grey ones)



They are thematic islands

Two conjectures

- Schizophrenics are **logically consistent**.

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Hence discontinuities appear in the process which produce the representation, thus at the pragmatic level.

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Two conjectures

- Schizophrenics are **logically consistent**.
Hence discontinuities appear in the process which produce the representation, thus at the pragmatic level.

- Underspecification (ambiguity) plays a central role
Slogan: “A choice is never a definitive one!”
Phonological, morphological, lexical, discourse, ...

Guy experienced a lovely evening last night

Elaboration

He had a fantastic meal

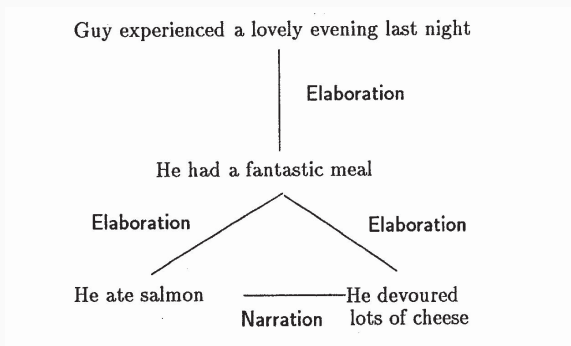
Elaboration

Elaboration

He ate salmon

Narration

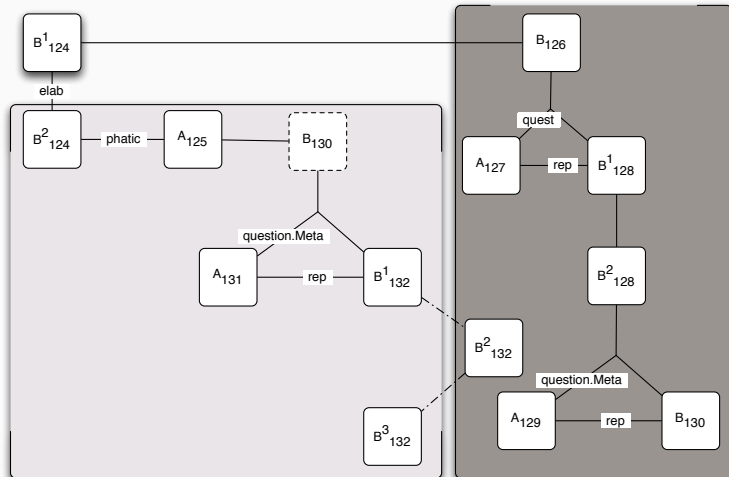
He devoured
lots of cheese



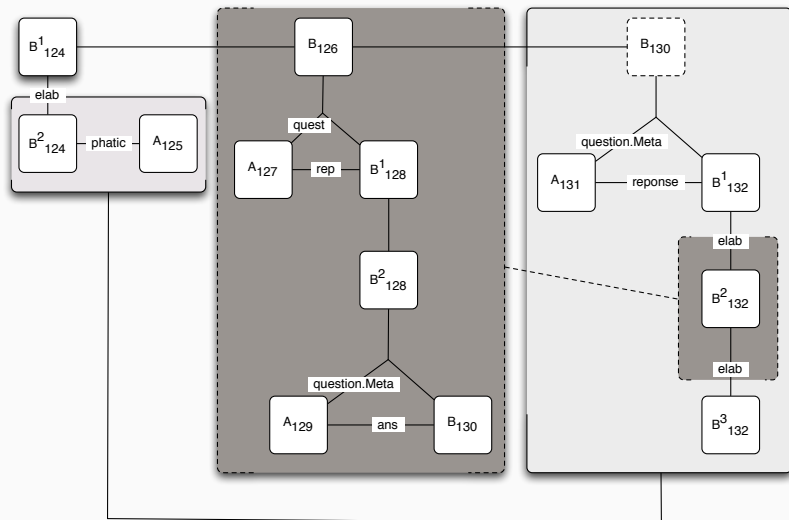
Constraints on attachment: right frontier rule

“He found **it** really marvelous”

Patient understanding



Psychologist understanding



Rise without attachement 1/2

G82 l'an dernier euh (→) j'savais pas comment faire j'étais perdue et pourtant j'avais pris mes médicaments j'suis dans un état vous voyez même ma bouche elle est sèche j'suis dans un triste état

I didn't know what to do. I was lost.

V83 Vous êtes quand même bien (↑)

G84 J pense que ma tête est bien mais on croirait à moitié (↓) la moitié qui va et la moitié qui va pas j'ai l'impression de ça vous voyez (↑)

V85 D'accord

G86 Ou alors c'est la conscience peut être la conscience est ce que c'est ça (↑)

V87 Vous savez ça arrive à tout le monde d'avoir des moments biens et des moments où on est perdu

Everybody is lost at times.

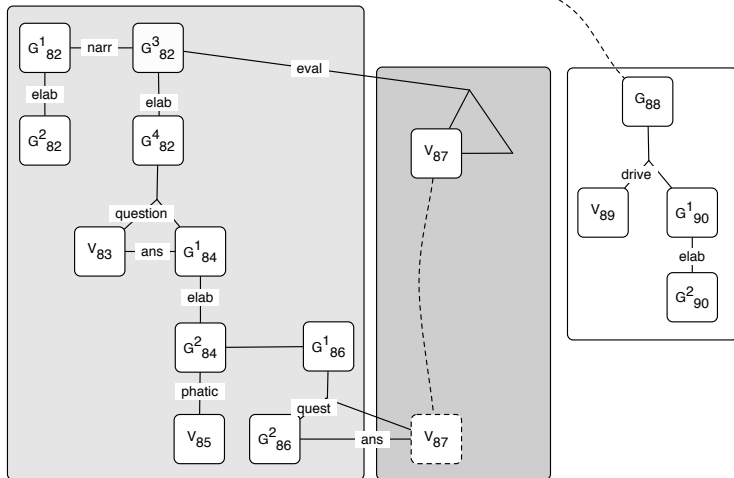
G88 Oui j'ai peur de perdre tout le monde

Yes I am afraid I lose everybody.

V89 Mais ils vont plutôt bien vos enfants (↑)

G90 Ils ont l'air ils ont l'air mais ils ont des allergies ils ont (→) mon petit fils il s'est cassé le bras à l'école tout ça

Rise without attachement 2/2



Organization of 3 human annotation campaigns

- Identification of decisive discontinuities
- SDRT representation

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- Identification of decisive discontinuities
- SDRT representation

Results

- Huge difficulties for discontinuities
- Relative consensus for SDRT

SDRT annotations with Glozz on pretreated texts.

Début

B1 : J'aimerais savoir ce que font les personnes qui sont à l'hôpital

ce que vous faites la journée par exemple...

A2 : Je suis très amoureuse de Florence M.

B3 : De Florence M.

A4 : Oui superbe la...

comment elle s'appelle Florence R.

elle a tué quand même plus de un million de de personnes

B5 : Qui ça ?

A6 : Florence R.

B7 : C'est qui cette dame là ?

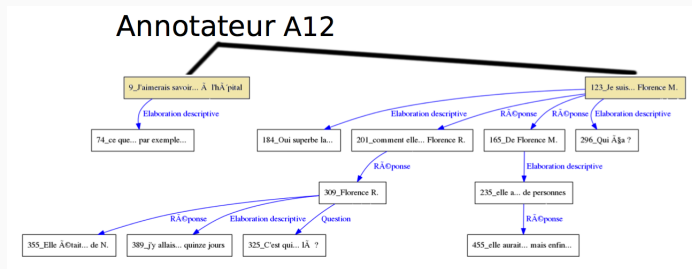
A8 : Elle était psychiatre 40 rue de N.

j'y allais une fois par semaine ou deux fois tous les quinze jours

elle aurait pu me tuer mais enfin...

Analyse of the annotations (ongoing work)

46 annotators on 3 extracts (+ one training text)



- Impossibility of disidentification
 - Task with a small context: randomise speeches
 - Inability to anonymize the history and the geography
- Patient reality
 - Formal analysis of language = define a standard
 - Deviate = dysfunction
 - But, every speaker is confronted daily with language disorders from healthy people
 - The diagnosis can not suffer from approximations

Toward a formal treatment

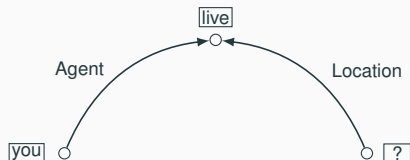
Processing dialogue: **access to subparts** of the interaction for **update**.

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A₁ Where do you live?

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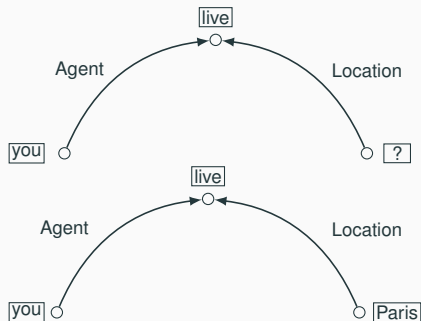
A₁ Where do you live?



Processing dialogue: **access to subparts** of the interaction for **update**.

A₁ Where do you live?

B₂ In Paris.



Use of :

- TTDL for compositionality
- Frame Semantics for representation of the content

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- TTDL for compositionality
- Frame Semantics for representation of the content
- Ongoing work: defining such a framework and apply it to the SLAM corpus

Features extraction

- a feature v
- type of frames: γ

$$find_v : \gamma \rightarrow v \times (v \rightarrow \gamma)$$

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- a feature v
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$$find_v : \gamma \rightarrow v \times (v \rightarrow \gamma)$$

Example:

$$\llbracket A_1 \rrbracket = \begin{bmatrix} LIVE \\ Ag: A \\ Loc: Paris \end{bmatrix}$$

$find_{Loc}$ to A_1 :

$$(Paris, \lambda l. \begin{bmatrix} LIVE \\ Ag: A \\ Loc: l \end{bmatrix})$$

assertion

$$\llbracket u \rrbracket = \gamma \rightarrow \gamma$$

question

$$\llbracket q_v \rrbracket = \gamma \rightarrow v \times (v \rightarrow \gamma)$$

answer

$$\llbracket a_v \rrbracket = v \times (v \rightarrow \gamma) \rightarrow \gamma$$

Example 1/2

A₁ I live in Paris.

B₂ How long have you been living there?

A₃ For five years.

A₁ I live in Paris.

B₂ How long have you been living there?

A₃ For five years.

$$\begin{aligned} \llbracket A_1 \cdot^q B_2 \cdot^a A_3 \rrbracket c_e &= \lambda c. \llbracket A_3 \rrbracket \left(\llbracket B_2 \rrbracket (\llbracket A_1 \rrbracket c) \right) c_e \\ &\rightarrow_\beta \llbracket A_3 \rrbracket \left(\llbracket B_2 \rrbracket (\llbracket A_1 \rrbracket c_e) \right) \end{aligned}$$

Example 2/2

$$\llbracket A_1 \rrbracket_{c_e} = \begin{bmatrix} \text{LIVE} \\ \text{Ag: } A \\ \text{Loc: } \textit{Paris} \end{bmatrix} = \textcircled{1}$$

$$\llbracket B_2 \rrbracket \textcircled{1} = \lambda t. \begin{bmatrix} \text{LIVE} \\ \text{Ag: } A \\ \text{Loc: } \textit{Paris} \\ \text{Tmp: } t \end{bmatrix} = \textcircled{2}$$

$$\llbracket A_3 \rrbracket \textcircled{2} = \begin{bmatrix} \text{LIVE} \\ \text{Ag: } A \\ \text{Loc: } \textit{Paris} \\ \text{Tmp: } \textit{Five years} \end{bmatrix}$$

Perspectives

- Increase the phenomena analyzed in SLAM_{tk}
Especially work on syntax and lexical statistics
- Try DDN approaches on the SLAM corpus
Need more ressources in French
- Deeply study the human annotations of the corpus
- Increase the coverage of the corpus in volume and number of pathologies studied
Collection of data at the Montperrin Hospital of Aix-En-Provence
- Define remedial help process
- Refine the analysis of dysfunction, opening towards a cognitive interpretation and give more complex context for the interpretation

- Defining robust semantics grammars for TTDL
- Definition of a TTDL for dialogue framework
 - Ongoing work on questions and answers with Maria Boritchev
- (French translation of Fracas)

Thanks!

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Modélisation sémantique

Événements, négations et modalités

co-encadrement thèse Sai Qian avec Philippe de Groote

[Qian et Amb. LACL 2011] [Qian et Amb. LENLS 2012] [Qian et Amb. LNAI 2013] [Qian, de Groote, Amb. LiLT 2016]

(3) Jean n'a pas de voiture_j. * Elle_j est rouge.

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(4) Il n'est pas vrai que Jean n'a pas de voiture_{*j*}. Elle_{*i*} est rouge.

- Structure de couple

- (3) Jean n'a pas de voiture_{*j*}. * Elle_{*i*} est rouge.
- (4) Il n'est pas vrai que Jean n'a pas de voiture_{*j*}. Elle_{*i*} est rouge.
- Structure de couple
- (5) Jean pourrait avoir une voiture_{*j*}. * C'_{*i*} est une Peugeot.

(3) Jean n'a pas de voiture_{*j*}. *Elle_{*i*} est rouge.

(4) Il n'est pas vrai que Jean n'a pas de voiture_{*j*}. Elle_{*i*} est rouge.

- Structure de couple

(5) Jean pourrait avoir une voiture_{*j*}. *C'_{*i*} est une Peugeot.

- Intensionalisation $o_i = s \rightarrow o$

- $T_{env} = o_i \times o_i$

(background \times base)

- $\llbracket s \rrbracket = \gamma_i \rightarrow (\gamma_i \rightarrow o_i) \rightarrow o_i$

Double négation

(4) Il n'est pas vrai que Jean n'a pas de voiture. Elle est rouge.

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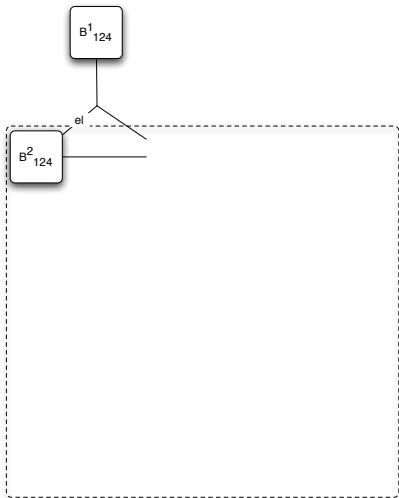
$$\begin{aligned} & \equiv \overline{\overline{\overline{(\overline{(\overline{(\overline{have}})(\overline{a})\overline{car}})}\overline{Jean}})}} \\ & \rightarrow_{\beta} \langle \lambda e \phi. (\exists x. (\mathbf{car} \ x \wedge \mathbf{own} \ \mathbf{jean} \ x \wedge \phi(x :: e))), \\ & \quad \lambda e \phi. (\neg(\exists x. (\mathbf{car} \ x \wedge \mathbf{have} \ \mathbf{jean} \ x)) \wedge \phi e) \rangle \end{aligned}$$

$$\begin{aligned} & \overline{\overline{\overline{être_rouge}}}\overline{elle}} \\ & \rightarrow_{\beta} \lambda e \phi. \langle \mathbf{red} \ (\mathbf{sel} \ e) \wedge \phi e, \neg(\mathbf{red} \ (\mathbf{sel} \ e)) \wedge \phi e \rangle \end{aligned}$$

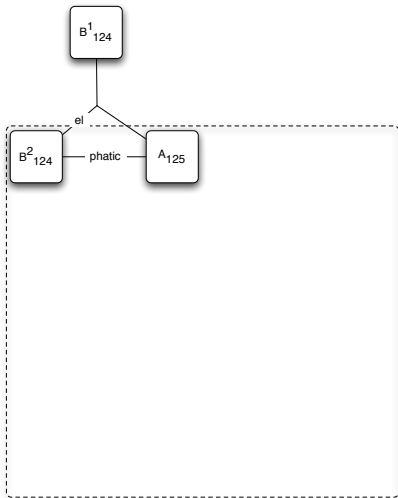
(B124) Oh yeah (↑) and complicated (↑) and it's really very very complicated (→)

B¹₁₂₄

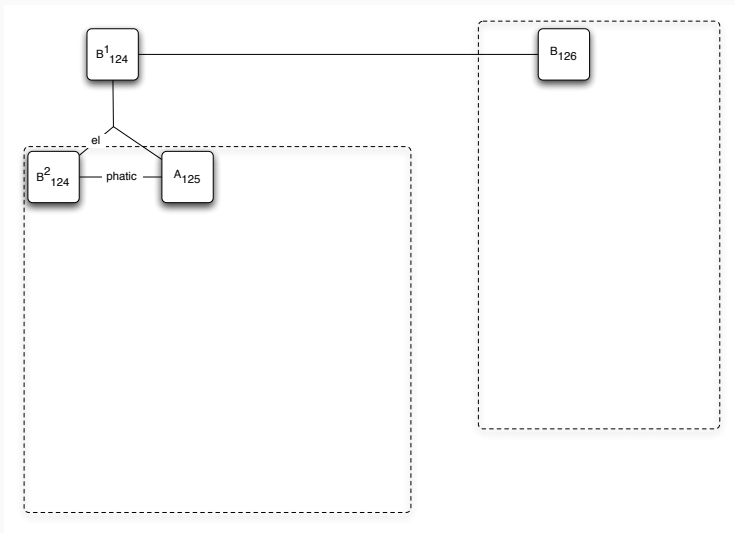
politics, it's really something when you get into it, have to win or else when you lose, well, you're finished (↓)



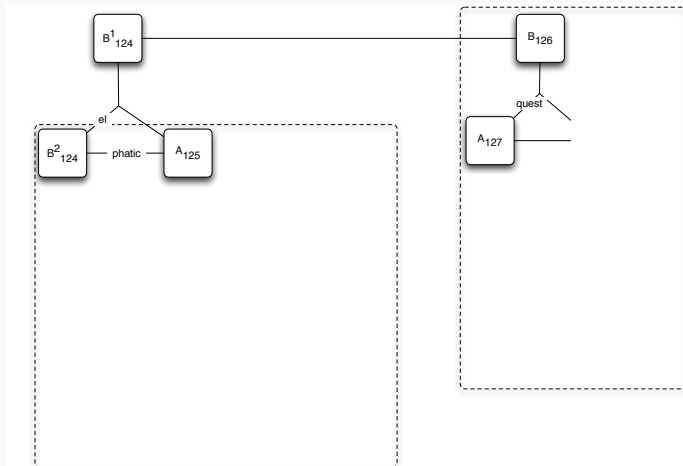
(A125) Yes



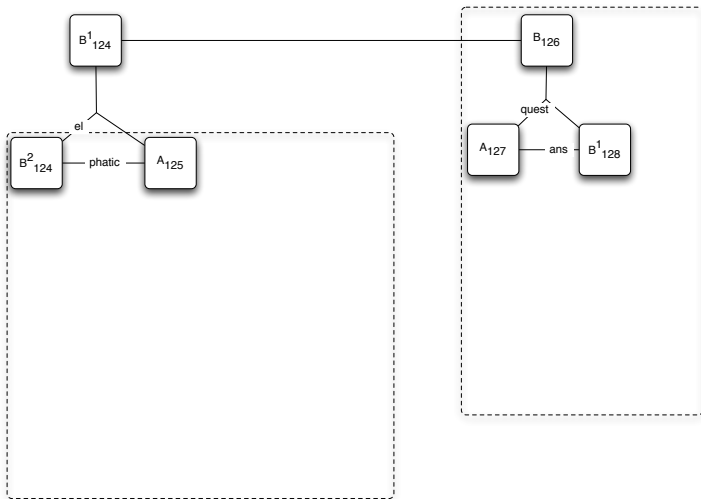
(B126) JCD is dead, L is dead, P is dead uh (...)



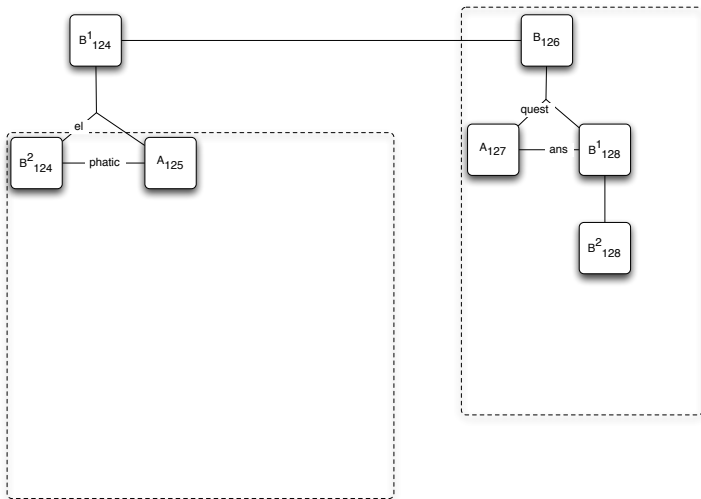
(A127) So you think they're dead because they lost (↑)



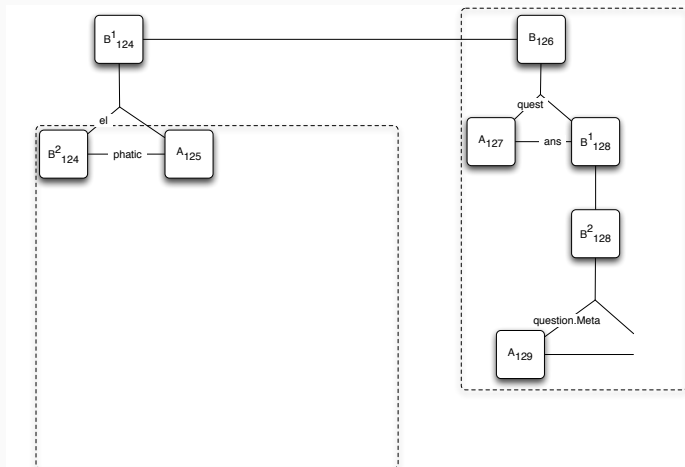
(B128) No they won but if they're dead, it's their disease well it's it's (→)



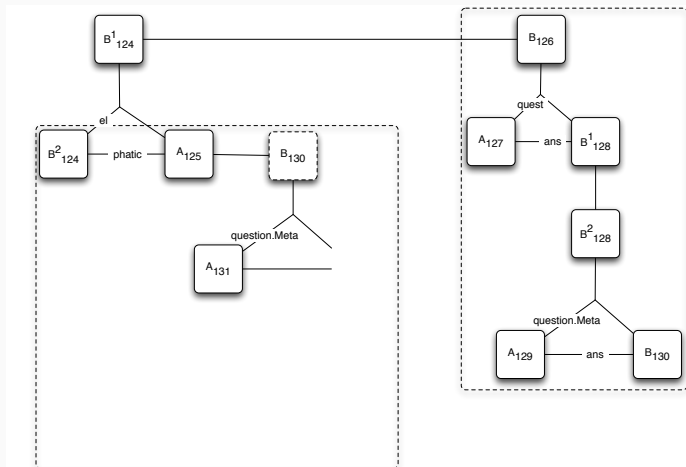
(B128) No they won but if they're dead, it's their disease well it's it's (→)



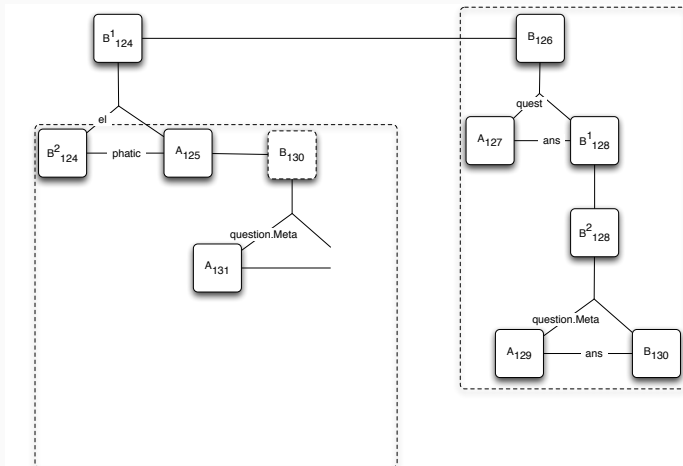
(A129) Yeah it's because they had a disease, it's not because they were in politics (↑)



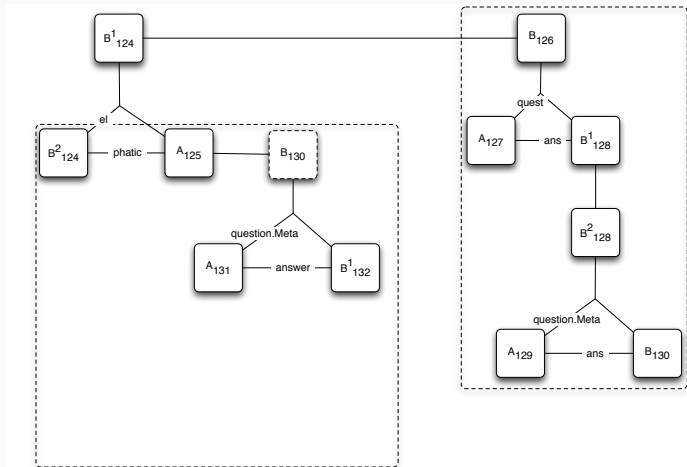
(B130) Yes I mean (→)



(A131) Yes you think it's because they were in politics (↑)

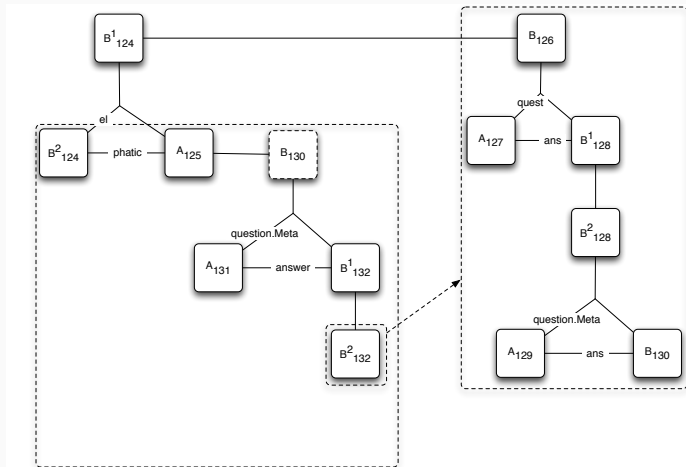


(B132) Yes, so well yeah there was C too who committed murder, uh huh (→) he was there too, the one in B but well
(→) it, that, it's because of politics again



(B132) Yes, so well yeah there was C too who committed murder, uh huh (→) he was there too, the one in B but well

(→) it, that, it's because of politics again



(B132) Yes, so well yeah there was C too who committed murder, uh huh (→) he was there too, the one in B but well

(→) *it, that, it's because of politics again*

