

IA165

Combinatory Logic for Computational Semantics

Spring 2012

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Summing up: last lecture

- How to apply the combinators to natural language analysis
 - 1) using introduction and elimination rules by beta-reduction of combinators: control heuristic of combinatorial application and bracketing
 - 2) using a syntactic tool for controlling the application of combinators
: CCG assumes the preliminary steps to find a well-structured normal form, that is, a formal semantic structure

Remind 1...

Coordination (Φ)

x:e1 CONJ x:e2
-----> ($>\Phi$)
x: Φ CONJ e1 e2

e1 of type x coordinated with e2 of type x by the conjunction 'and'

(S\NP)/NP:pick CONJ:'and' (S\NP)/NP:eat
-----> ($>\Phi$)
(S\NP)/NP: Φ and pick eat

Extraction asymmetries

1. subject-object asymmetry
2. NP shifted argument
3. type-raised argument
4. leftward extraction of "non-peripheral argument"

=> Such asymmetries exist in SVO languages because of the possibility of "scrambling" arguments across clause boundaries.

1. subject-object asymmetry of English

(1) *Brazil is the team_{*i*} that John knew that t_{*i*} would beat Germany.

(2) Germany is the team_{*i*} that John knew that Brazil would beat t_{*i*}.

Comment: We see in (1) that extraction of the subject from the embedded clause to form the relative clause is ungrammatical, whereas the object is accessible for extraction, as shown in (2). Unlike the situation with many island violations, there is nothing semantically incoherent about a relative clause such as that in (1), and the grammar apparently disallows it for entirely syntactic reasons.

2. NP shifted argument

(1) I shall buy today and cook tomorrow the mushrooms

CONJ:
and

(1') I shall buy the mushrooms today

(1'') I shall cook the mushrooms tomorrow

(Shall and ((today (buy (the mushrooms))) ((tomorrow (cook (the mushrooms))) I)

Semantic classes of adv:

speech-act modifier(peripheral: core as argument), subject-oriented modifier, sentence modifier, VP modifier (non-peripheral: subparts as argument), ...

3. type-raised argument

(1) I will give to my sister an engraving by Rembrandt

The complement object (NPobj) "to my sister" is type-raised.

To + NPobj = PP as determinant of verb give

Type-raising rule with C^*

$X:e_1 (=NPobj)$

----- $\langle C^*$

$y \setminus (y/x): C^*e_1$

y is a variable over categories, ranging over the result types of functions over x .

4. leftward extraction of "non-peripheral argument"

- Cases of non-peripheral extraction

(1) (articles) which I will file tomorrow

(1') I will file the articles tomorrow

(2) an engraving which I will buy today and sell tomorrow

(2') I will buy (an engraving) today and sell an engraving tomorrow

(3) an engraving which I will show to him and give to you

(3') I will show an engraving to him and give an engraving to you

Such non-peripheral extraction is often done with a permutation operator and the introduction of the permutation operator increases the power.

Non-order-preserving composition

Backward crossed composition rule with the combinator B ($\langle Bx$)

$$Y/Z \quad X \backslash Y \quad \Rightarrow \quad X/Z \quad (\langle Bx)$$
$$\begin{array}{l} Y/Z:e1 \quad X \backslash Y:e2 \\ \text{-----} \langle (Bx) \\ x/z: \mathbf{B} \ e2 \ e1 \end{array}$$

allows to consider heavy NP shift and related coordination

Extraction asymmetries analyzed in terms of the combinators-1

1. subject-object asymmetry of English

(1) Germany is the team_i that John knew that Brazil would beat t_i.

1/ NP:Germany (S\NP)/NP:is NP:the team ((NP\NP)/S):that NP:John (S\NP)/NP:knew (NP/(S/NP)):that NP:Brazil ((S\NP)/NP)/((S\NP)/NP):would (S\NP)/NP:beat

2/ **S/(S\NP):(C* Germany)** (S\NP)/NP:is NP:the team ((NP\NP)/S):that **S/(S\NP):C*John** (S\NP)/NP:knew (NP/(S/NP)):that **S/(S\NP):(C* Brazil)** ((S\NP)/NP)/((S\NP)/NP):would (S\NP)/NP:beat (>C*)

3/ **S/NP: B(C* Germany)** is

4/ ((NP\NP)/S):that **S/(S\NP):C*John** (S\NP)/NP:knew (NP/(S/NP)):that **S/(S\NP):C*Brazil** ((S\NP)/NP):would beat

5/ ((NP\NP)/S):that **S/NP: (B(C*John)knew)** (NP/(S/NP)):that **S/NP: (B(C*Brazil) would beat)**

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6/ ((NP\NP)/S):that **S/NP: (B(C*John)knew)** NP:(that **(B(C*Brazil) would beat)**)

6/ ((NP\NP)/S):that S/NP:(B(C*John)knew) NP:(that (B(C*Brazil) would beat))

7/ ((NP\NP)/S):that S:((B(C*John)knew)(that (B(C*Brazil) would beat)))

8/ (NP\NP):(that((B(C*John)knew)(that (B(C*Brazil) would beat))))

9/NP:(((NP\NP):(that((B(C*John)knew)(that (B(C*Brazil) would beat))))))the team)

10/(that((C*John)(knew(that (B(C*Brazil) would beat))))))the team)

11/(that((knew(that (C*Brazil)(would beat)))))(John)the team)

12/(that((knew(that(would beat)(Brazil)))))(John)the team)

Germany is the team that John knew that Brazil would beat
(that((knew(that(would beat)(Brazil)))))(John)
the team)

Extraction asymmetries analyzed in terms of the combinators-2

2. NP shifted argument

(1) I buy today and cook tomorrow the mushrooms

VP=(S\NP)

1/NP:I VP/NP:buy VP\VP:today CONJ:and VP/NP:cook VP\VP:tomorrow NP:
the mushrooms

2/S/(S\NP):C*I

3/ VP/NP:(**Bx** today buy) CONJ:and VP/NP:(**Bx** tomorrow cook) (<**Bx**)

4/ VP/NP: Φ and (**Bx** today buy) (**Bx** tomorrow cook)

5/ S/NP:(**B**(**C***I)(Φ and (**Bx** today buy) (**Bx** tomorrow cook)))

6/ S:(**B**(**C***I)(Φ and (**Bx** today buy) (**Bx** tomorrow cook)))(the mushrooms)

6/ $S: (B(C*I)(\Phi \text{ and } (Bx \text{ today buy}) (Bx \text{ tomorrow cook})))$
(the mushrooms)

7/ $(C*I)((\Phi \text{ and } (Bx \text{ today buy}) (Bx \text{ tomorrow cook}))(the$
mushrooms))

8/ $((\Phi \text{ and } (Bx \text{ today buy}) (Bx \text{ tomorrow cook}))(the$
mushrooms))(I)

9/ $(\text{and } ((Bx \text{ today buy})(the \text{ mushrooms})) ((Bx \text{ tomorrow}$
 $\text{cook})(the \text{ mushrooms})))$ (I)

10/ $(\text{and } (\text{today } (\text{buy}(\text{the mushrooms}))) (\text{tomorrow}$
 $(\text{cook}(\text{the mushrooms}))))$ (I)

I buy today and cook tomorrow the mushrooms



$(\text{and } (\text{today } (\text{buy}(\text{the mushrooms})))$
 $(\text{tomorrow } (\text{cook}(\text{the mushrooms}))))$ (I)

Extraction asymmetries analyzed in terms of the combinators-3

3. type-raised argument

(1) I will give (to my sister) an engraving by Rambrandt

VP=(S\NP)

1/ S/VP:C*I VP/VP:will (VP/PP)/NP:give **(VP\ (VP/PP)):(C*to my sister)**
NP/N:an N:engraving (N\N)/NP: by NP: Rambrandt (**<C***)

2/ S/VP:**B**((C*I) will) (VP/PP)/NP:give **(VP\ (VP/PP)):(to(my sister))**
NP:(an((by Rambrandt) engraving)) (**>B**)

3/ S/VP:**B**((C*I) will) (VP/NP):(**Bx**(to(my sister))give) NP:(an((by
Rambrandt) engraving)) (**>Bx**)

4/ (S/VP):**B**((C*I) will) VP:((**Bx**(to(my sister))give)(an((by Rambrandt)
engraving))) (**>**)

5/ S:(**B**((C*I) will)((**Bx**(to(my sister))give)(an((by Rambrandt)
engraving)))) (**>**)

5/ S:(**B**((**C***I) will)((**Bx**(to(my sister))give)(an((by Rambrandt) engraving)))) (>)

6/ ((**C***I)(will((**Bx**(to(my sister))give)(an((by Rambrandt) engraving)))) (e.**B**)

7/((will((**Bx**(to(my sister))give)(an((by Rambrandt) engraving)))) (I) (e.**C***)

8/ ((will(to(my sister)(give(an((by Rambrandt) engraving)))))(I)) (e.**B**)

I will give to my sister an engraving by Rambrandt

((will(to(my sister)(give(an((by Rambrandt) engraving)))))(I))

Extraction asymmetries analyzed in terms of the combinators-4

4. leftward extraction of "non-peripheral argument"

(1) (articles) which I will file tomorrow

VP=(S\NP)

1/ N: articles (N\N)/(S/NP):which (S/(S\NP)):(C*I) (VP/VP):will
VP/NP:file VP\VP:tomorrow

2/ N: articles (N\N)/(S/NP):which (S/VP):(B(C*I)will) (VP/NP):file
VP\VP:tomorrow

3/ N: articles (N\N)/(S/NP):which (S/VP):(B(C*I)will) (VP/NP):(Bx
tomorrow file) (<Bx)

4/ N: articles (N\N)/(S/NP):which (S/NP):B((B(C*I)will)(Bx tomorrow
file)) (>B)

5/ N: articles (N\N):which (B((B(C*I)will)(Bx tomorrow file))) ¹⁶(>)

6/ N: (which (B((B(C*I)will)(Bx tomorrow file))) articles) (<)

6/ N: (which (B((B(C*I)will)(Bx tomorrow file))) articles) (<)

7/(which ((B(C*I)will)(Bx tomorrow file)) articles)) (e-B)

8/ (which ((C*I)(will(Bx tomorrow file)) articles))) (e-B)

9/ (which (will(Bx tomorrow file)) articles))(I)) (e-C*)

10/ (which (will(tomorrow ((file)articles)))(I)) (e-Bx)

articles which I will file tomorrow
(which(will(tomorrow((file)articles)))(I))

Next week...

- Continue about the application of the combinators to natural language analysis: subordination with ccg tools and passivisation without CCG tools