Discourse

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Summary from Last Week

We introduced the framework of Discourse Representation Theory:

- Motivating discourse phenomena: pronoun interpretation
- Formal properties of Discourse Representation Structures (DRSs)
- Connection between DRT and First Order Logic
- Semantic construction with λ-DRT
- To do: read Ch. 3 from B&B draft book on pronoun resolution

Plan for Today

Pronoun Resolution: how are pronouns interpreted in discourse?

- DRT and pronoun resolution: determining possible antecedents
- Focus and Centering Theory: ranking possible antecedents

Discourse Referents

As we saw last week, all NPs introduce discourse referents:

a book

x
BOOK(x)

Mia

x
MIA = x

Pronouns introduce a special condition indicating that they need to find a referent in the discourse context:

she

x
x = ?

Recall as well that verbs can be modelled as introducing *event* discourse referents:

read

e
READ(e) AGENT(x,e) PATIENT(y,e)

Pronouns

Natural languages typically contain many kinds of pronouns: personal pronouns, quantified pronouns, demonstratives...

'Vincent saw Mia. She looked at him. Everyone noticed that.'

Pronominal expressions can have different uses:

- Deictic pronouns refer to entities in the extra-linguistic situation: *'I invite you to dinner'* / *'Look at that'*
- Anaphoric pronouns refer to entities introduced in the linguistic context. E.g., in the example above, *'she'*. *'him'*, and *'that'* are anaphors, whose antecedents are *'Mia'*, *'Vincent'*, and some event introduced earlier.
- Cataphoric pronouns refer to entities that are mentioned in the following discourse: *'After he lost the match, Butch left town.'*
- Pleonastic pronouns are non-referential: *'It is spring.'*

We will focus on anaphoric third person singular personal pronouns (he/him/himslef; she/her/herself; it/itself), which might be the simplest pronouns. However, their resolution is not at all trivial.

Constraints on Pronoun Resolution

Pronouns cannot arbitrarily refer to any entity that is part of the discourse context. A number of (language dependent) constraints restrict the set of possible antecedents:

Sortal constraints: gender and number

Mia ordered a five dollar shake. It made her sick.
it = a $5 shake ; her = Mia $\surd$
it = Mia ; her = a $5 shake $\times$

Binding constraints: reflexive vs. non-reflexive pronouns

Butch has a knife. Vincent cut himself with it.
himself = Vincent $\surd$; himself = Butch $\times$
Butch has a knave. Vincent cut him with it.
him = Butch $\surd$; him = Vincent $\times$

Logical constraints:

A woman snorts. She collapses. — she = a woman $\surd$
Every woman snorts. She collapses. — she = every woman $\times$

Mia ordered a five dollar shake. Vincent tasted it. — it = a $5 shake $\surd$
Mia didn't order a five dollar shake. Vincent tasted it. — it = a $5 shake $\times$

Ambiguity

The above constraints are relatively easy to incorporate into a resolution algorithm (especially sortal and binding constraints).

Often, however, there is more than one possible antecedent that does not violate any formal constraints → ambiguity

Butch threw a TV at the window. It broke.	it = a TV / the window ?
John shared an office with Martin. Anna liked him.	him = John / Martin ?

However, all possible antecedents may not be equally preferred. Factors that influence a preference order include world knowledge, selectional restrictions, intonation...

Butch threw a vase at the wall. It broke.	it = a vase ↑ ; it = the wall ↓
The cat did not come down from the tree. It was scared.	it = the cat ↑ ; it = the tree ↓
Jane told Mary she was in danger.	she = Jane ↑ ; she = Mary ↓
Jane told Mary SHE was in danger.	she = Mary ↑ ; she = Jane ↓

Encoding the import of such factors is somewhat more difficult...

DRT and Pronoun Resolution

DRT focuses on the formal constraints on pronoun resolution: it specifies how structural constraints limit the space of potential antecedents.

- Pronouns introduce constraints $x = ?$ indicating that they need to be bound to suitable antecedents.
- Available discourse referents act as potential antecedents.
- A discourse referent can play the role of antecedent for a pronoun only it it is accessible.
- The notion of accessibility is defined with respect to the box structure of DRSs.

DRT can express ambiguity (several compatible discourse referents are accessible) but it is not concerned with ranking the plausibility of potential referents.

Accessibility

If y is a new discourse referent and x is a previously introduced discourse referent, we are only allowed to add the condition y=x if x is accessible from y.

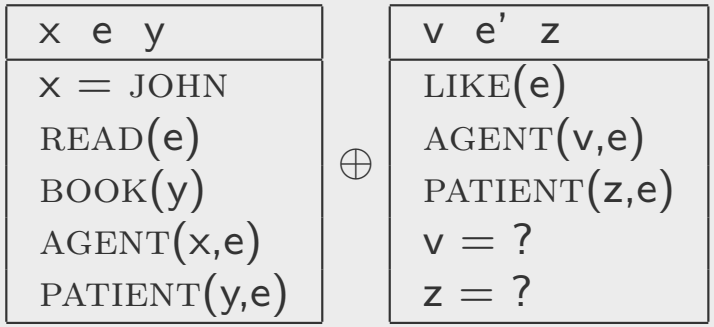
Accessibility can be defined as follows:

- DRS K_1 is accessible from DRS K_2 when K_1 equals K_2 or when K_1 *subordinates* K_2. K_1 subordinates K_2 iff:
  - K_1 *immediately subordinates* K_2.
  - there is some DRS K that is subordinated by K_1 and that subordinates K_2.
- K_1 immediately subordinates K_2 iff:
  - K_1 contains a condition of the form $\neg K_2$; or
  - K_1 contains a condition $K_2 \vee K$ or $K \vee K_2$ for some K; or
  - K_1 contains a condition of the form $K_2 \Rightarrow K$ for some K; or
  - $K_1 \Rightarrow K_2$ is a condition in some DRS K.

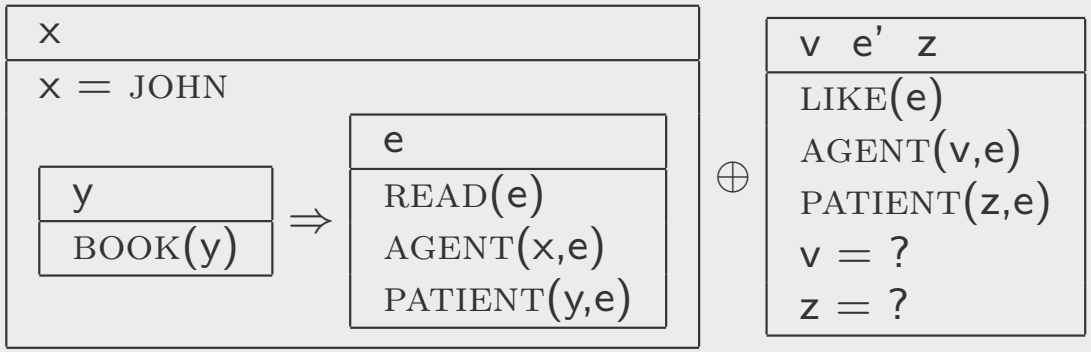
A discourse referent x in the universe of a DRS K_1 is accessible to a discourse referent y in the universe of a DRS K_2 if K_1 is accessible from K_2.

Accessibility: Some Examples

John reads a book. He likes it.



John reads every book. He likes it.



More examples. . .

Vincent did not dance with Mia. She was drunk.
Vincent did not dance with a woman. She was drunk.

Resolution Algorithm: Basics

In DRT, resolving a pronoun amounts to substituting a pronominal condition 'x = ?' for an equality 'x = y' that binds the pronoun to discourse referent y. What ingredients do we need to achieve this?

- Encode sortal and reflexivity information into the grammar.
- Use the enriched grammar to build up DRSs for the discourse context and the incoming sentence.
- For each pronominal condition 'x = ?', find an antecedent that is structurally accessible and that does not violate any grammatical constraints.
- Bind the pronoun to the suitable antecedent.

B&B offer a Prolog implementation of the resolution algorithm. Note however that the description of the code in draft book is not up to date! Have a look at the latest version of the code on their website.

Implementation: Grammar

Information on gender and reflexivity are included into the grammar:

Lexical entries in englishLexicon.pl

```
lexEntry(pro,[symbol:female,ref:no, syntax:[she]]).
lexEntry(pro,[symbol:female,ref:yes,syntax:[herself]]).
```

To represent pronoun conditions such as "x = ?", B&B use a special operator α (alpha)

Semantic Macro in SemLexPresupDRT.pl

It adds a condition specifying the pronoun's gender:

```
semLex(pro,M):-
   M = [symbol:Sym,
        sem:lam(P,alfa(pro,drs([X],[pred(Sym,X)]),app(P,X)))].
```

Reflexivity is added as a property of events:

```
semLex(tv,M):-
 M = [symbol:Sym,ref:no,
        sem:lam(N1,lam(N2,lam(P,app(N2,lam(X,app(N1,lam(Y,merge(drs([E],
       [pred(Sym,E),rel(agent,E,X),rel(patient,E,Y),pred(nonreflexive,E)]),
                                                          app(P,E)))))))))
 M = [symbol:Sym,ref:yes, ....
```

See also the last vp **rule in** englishGrammar.pl

Implementation: Resolution (1)

The main level program is `presupDRT.pl` (`pronounDRT.pl` does not seem to work properly). This code integrates both pronoun resolution and presupposition resolution (which we have not yet covered).

What does `presupDRT` do?

- it first uses the grammar to build a representation that includes merge and alpha operators with `t/3`

```
?- t([sem:Drs], [every, boxer, likes, himself], []).

Drs = drs([],[imp(merge(drs([A],[]), drs([],[pred(boxer,A)])), alfa(pro,
drs([B], [pred(male,B)]), merge(drs([E], [pred(like,E), rel(agent,E,A),
rel(patient,E,B), pred(reflexive,E)]), drs([],[pred(event,E)])))])
```

- it then does merge reduction and pronoun resolution with `resolveDrs/2` by binding alpha referents to accessible referents.

```
?- presupDRT.

> Every boxer likes himself.

1 drs([], [imp(drs([A], [pred(male,A), pred(boxer,A)]), drs([E],
[pred(like,E), rel(agent,E,A), rel(patient,E,A), pred(reflexive,E),
pred(event,E)]))])
```

Implementation: Resolution (2)

The predicate `resolveDrs/2`

- finds alpha DRSs going through the structure of the DRS to find accessible referents (`findAlfaDrs`)
- checks for binding compatibility (`bindingViolationDrs`, see `bindingViolation.pl`)
- unifies the alpha referent with an antecedent (`resolveAlfa`)

See the code for further details. These are the relevant programs:

`presupDRT.pl` main level program
`bindingViolation.pl`
`presupDRTTestSuite.pl`

`englishLexicon.pl` / `englishGrammar.pl`
`semLexPresupDRT.pl` / `semRulesDRT.pl`

Dealing with Ambiguity

As mentioned earlier, DRT is not concerned with disambiguating between several candidate antecedents.

B&B discuss an approach to adding preferences to accessible referents. Their approach is a version of the Focusing Algorithm by Sidner (1986), which is a precursor of Centering Theory.

Sidner (1986) Focusing in the Comprehension of Definite Anaphora, in *Readings in Natural Language Processing*.

They discuss a possible implementation, but note that the program is not included in the latest version of the Prolog code.

We will briefly mention the main ingredients of their approach and then look more closely into Centering Theory.

Focusing Algorithm: Basics

These are the main ingredients of B&B's approach to the Focusing Algorithm:

- The discourse model keeps track of which entities are most salient: the foci, the entities in focus.
- Distinction between an actor focus and a discourse focus:
  - the actor focus is identified with the agent of a sentence
  - the discourse focus with the patient or thematic role.
- Pronouns are resolved to foci:
  - pronouns that act as agents are resolved to the actor focus
  - pronouns that do not act as agents are resolved to the discourse focus (assuming other constraints are not violated)
- The current foci are updated after each utterance: foci are *retained*, or else, if previous foci are not referred to in an utterance, they are *reset*.

Centering Theory

- Aim of Centering Theory: Modelling the local coherence of a discourse segment. Why are some texts perceived as more coherent than others?
- Hypotheses:
  - Discourse coherence depends (at least in part) on the form of the referring expressions used to introduce entities and discuss them.
  - The degree of salience of an entity determines how we can refer to it. This is important for both:
    - reference resolution, and
    - generation of referring expressions
  - different types of referring expressions are associated with different inference loads: badly chosen referring expressions lead to a high inference load $\longrightarrow$ the discourse is perceived as incoherent

Barbara Grosz, Aravind Joshi, and Scott Weinstein (1995) Centering: A Framework for Modelling the Local Coherence of Discourse. *Computational Linguistics*, 2(21).

Coherence and Local Focus

The focus of a discourse segment has to do with the topic under discussion, what occupies our attention.

John went to his favorite music store to buy a piano.
It was a store John had frequented for many years.
He was excited that he could finally buy a piano.
It was closing just as John arrived.

A more coherent discourse...

John went to his favorite music store to buy a piano.
He had frequented the store for many years.
He was excited that he could finally buy a piano.
He arrived just as the store was closing for the day.

Coherence has something to do with *local focus*: Too many focus shifts make a discourse incoherent (cognitive processing of the discourse becomes more diff cult).

Focus and Pronoun Interpretation

Terry really goofs sometimes.
Yesterday was a beautiful day and he was excited about trying his new sailboat.
He wanted Tony to join him on a sailing expedition.
He called him at 6 am.
He was sick and furious at being woken up so early.

The last occurrence of "he" refers to Tony. Since the focal entity is Terry, this leads to higher cognitive load and therefore the discourse is perceived as incoherent. In contrast, the following is a more coherent discourse:

Terry really goofs sometimes.
Yesterday was a beautiful day and he was excited about trying his new sailboat.
He wanted Tony to join him on a sailing expedition.
He called him at 6 am.
Tony was sick and furious at being woken up so early.
He told Terry to get lost and hung up.
Of course, Terry hadn't intended to upset Tony.

Modelling Focus in CT

Each utterance has a backwards looking center C_b and a set of partially ordered forward looking centers C_f.

- The backwards looking center of utterance U_n connects U_n with the preceding utterance U_{n-1}. For discourse initial utterances C_b is undefined.
- The partially ordered set of forward looking centers C_f forms a potential link with the following utterance U_{n+1}.
- The partial order of C_f is determined, among others, by the grammatical role of the referring expression, i.e.,
  - Subject $\prec$ Object $\prec$ Others
- The highest ranking element in the C_f of an utterance is the preferred center C_p.
- The backward looking center C_b of an utterance U_n is the preferred center C_p of U_{n-1}, which is realised in U_n.

Centering and Pronouns

The so-called Rule 1 of Centering Theory:

> If any element of $C_f(U_n)$ is realised by a pronoun in U_{n+1}, then the $C_b(U_{n+1})$ must be realised by a pronoun also.

That is: if there are pronouns in an utterance, then one of them must be the backward looking center of the utterance.

Note that CT makes these two assumptions:

- Each utterance U_n has a unique backward looking center C_b.
- C_b is strictly local: it has to be a member of the forward looking centers C_f of the immediately preceding utterance U_{n-1}.

An Example

John has many problems with organising his holidays.
$C_b = undef$ $C_f = \{John, problems, holidays\}$ $C_p = \{John\}$
He cannot find anybody to take over his duties.
$C_b = \{he = John\}$ $C_f = \{he = John, anybody, duties\}$ $C_p = \{he = John\}$
Yesterday he phoned Mike to make a plan.
$C_b = \{he = John\}$ $C_f = \{he = John, Mike, plan\}$ $C_p = \{he = John\}$
Mike has annoyed him very much recently.
$C_b = \{him = John\}$ $C_f = \{Mike, him = John\}$ $C_p = \{Mike\}$
He phoned John at 5 o'clock in the morning last Friday.
$C_b = \{he = Mike\}$ $C_f = \{he = Mike, John, Friday, 5o'clock\}$ $C_p = \{he = Mike\}$

The following discourse is perceived as incoherent because Rule 1 is violated:

I don't know what's the matter with John.
He has been acting quite odd recently. $[C_b = \{he = John\}]$
He called up Mike yesterday. $[C_b = \{he = John\}]$
John wanted to meet him urgently. $[C_b = \{John\}, him = Mike]$

Note that Rules 1 applies independently of the grammatical function of C_b:

I don't know what's the matter with John.
He has been acting quite odd recently.
He called up Mike yesterday.
He was annoyed by John's call. $[C_b = \{John\}, him = Mike]$

Center Transitions

Transitions from utterance to utterance can be classified according to several transition types, depending on the amount of change in the centers:

	$C_b(U_n) = C_b(U_{n-1})$ or $C_b(U_n) = undef$	$C_b(U_n) \neq C_b(U_{n-1})$
$C_b(U_n) = C_p(U_n)$	continue	smoot-shift
$C_b(U_n) \neq C_p(U_n)$	retain	rough-shift

The type of transition determines the degree of coherence of a discourse. The so-called Rule 2 establishes the following ordering:

$$\text{Continue} \prec \text{Retain} \prec \text{Smooth-Shift} \prec \text{Rough-Shift}$$

Center Transitions: Example

John has many problems with organising his holidays.
$C_b = undef\ C_f = \{John, problems, holidays\}\ C_p = \{John\}$
He cannot find anybody to take over his duties.
$C_b = \{he = John\}\ C_f = \{he = John, anybody, duties\}\ C_p = \{he = John\}$
continue Yesterday he phoned Mike to make a plan.
$C_b = \{he = John\}\ C_f = \{he = John, Mike, plan\}\ C_p = \{he = John\}$
continue Mike has annoyed him very much recently.
$C_b = \{him = John\}\ C_f = \{Mike, him = John\}\ C_p = \{Mike\}$
retain He phoned John at 5 o'clock in the morning last Friday.
$C_b = \{he = Mike\}\ C_f = \{he = Mike, John, Friday, 5o'clock\}\ C_p = \{he = Mike\}$
smooth-shift

Many aspects of Centering Theory were left underspecified in the original formulation. Researchers taking up the theory have proposed different formalisations.

Next week we'll continue discussing aspects of the theory, after reading Poesio et al. (2004).

Homework #4

An assignment will be uploaded to Blackboard later on today. It will involve reading the following papers and aswering a few questions about them.

J. R. Tetreault (2001) A Corpus-Based Evaluation of Centering and Pronoun Resolution, *Computational Linguistics*, 27:507–520.
http://acl.ldc.upenn.edu/J/J01/J01-4003.pdf

I. Hendrickx, G. Bouma, F. Coppens, W. Daelemans, V. Hoste, G. Kloosterman, A. M. Mineur, J. Van Der Vloet, J. L. Verschelde (2008) A Coreference Corpus and Resolution System for Dutch, in *Proceedings of the Sixth Conference on Language Resources and Evaluation*, pp. 144–149.
http://www.lrec-conf.org/proceedings/lrec2008/pdf/49_paper.pdf

The deadline for submission will be next Monday, 11 April.