Modelling Dialogue in SDRT

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Introduction: SDRT in a nutshell

- SDRT (Asher 1993, Asher & Lascarides 2003)
  - dynamic semantics + (AI-style) pragmatics
  - DRT + rhetorical relations
    (Hobbs 1985, Mann & Thompson 1987)
  - central notion: *coherence*

Introduction: SDRT in a nutshell

- SDRT (Asher 1993, Asher & Lascarides 2003)
  - task:
    - compute *pragmatically preferred interpretation* of discourse / model *pragmatic competence*:
      - more than what grammar outputs, less than full belief revision

(1) John arrived in Edinburgh.
Peter met him at the platform.

Introduction: SDRT in a nutshell

- SDRT (Asher 1993, Asher & Lascarides 2003)
  - claim:
    - constructing LF should be computable, even if evaluating it isn't.

(2) a. There are unsolvable problems in number theory.
b. Any even number is equal to the sum of two primes, for instance.

Introduction: SDRT in a nutshell

- SDRT (Asher 1993, Asher & Lascarides 2003)
  - hence:
    - constructing LF can't involve full access to the logic for interpreting logical form.
    - construction has only partial access to information from
      - lexical semantics,
      - domain knowledge,
      - cognitive states, etc.

Introduction: SDRT in a nutshell

- SDRT
  - for dialogue
    - = SDRT for monologue + logic(s) for representing & reasoning about cognitive states
    - rhetorical relations understood as *speech act types* (cf. adjacency pairs; speech acts in this theory have anaphoric element)

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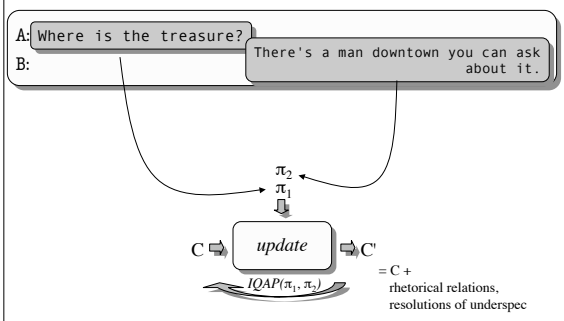

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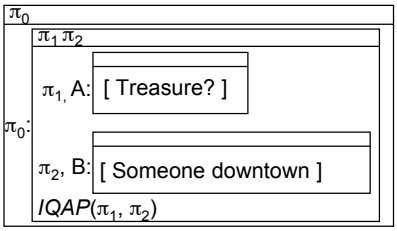

Overview of talk

- Introduction: SDRT in a nutshell
- Basics of SDRT: Logics of Conversation
  - Why DRT isn't enough
  - Claims and Strategy
  - Representing Discourses
  - Computing Logical Form of Discourses
    - Common Sense Entailment
    - Resolving Underspecification
- SDRT and Dialogue: Reprstn & Cognitive Modelling
- Application to two dialogue phenomena:
  - Fragments
  - Silences
- Strengths & Weaknesses

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What DRT can do

(2) A farmer owns a donkey.
He beats it.

(3) Every farmer owns a donkey.
??He beats it.

- *Accessibility*

What DRT can't do

(4) John took an engine$_1$ to Dansville.
He picked up a boxcar.
??It$_1$ had a broken fuel pump.

- Accessibility alone is not enough.

What DRT can't do

- "Events always follow their reference point." (Kamp & Reyle 1993, p.528)

(5) Max fell. John helped him up.
e_α e_β $e_\alpha < e_\beta$

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- Order of events does *not* always correspond to textual order.

Missing element: disc. structure

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(4) John took an engine$_1$ to Dansville. — *Narration*
He picked up a boxcar. —
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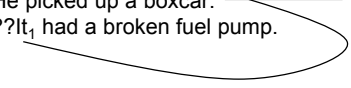

- Accessibility alone is not enough.
- *Availability* is also needed.
(Right frontier constraint)

Missing element: disc. structure

(5) Max fell. John helped him up.
e_α e_β $e_\alpha < e_\beta$

(6) Max fell. John pushed him.
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Missing element: disc. structure

Narration

(5) Max fell. John helped him up.
e_α e_β $e_\alpha < e_\beta$

Explanation

(6) Max fell. John pushed him.
e_α e_β $e_\beta < e_\alpha$

- Temporal order is determined by rhetorical structure.

SDRT: claims

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  - 'shallow' representations of lex. sem., domain knowledge, cognitive states…

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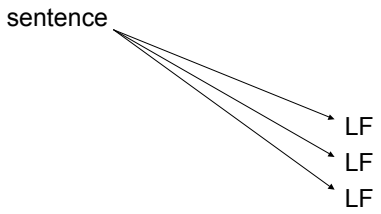
- *glue logic*: construct LF for disc. via *default reasoning* over
  - L_{ulf} formulae for clauses generated by grammar
  - 'shallow' representations of lex. sem., domain knowledge, cognitive states…
- Glue logic entails more consequences about content than grammar does: *Implicatures*

Logics of Conversation

Detour: Underspecification



Detour: Underspecification

sentence

is generated by grammar

is satisfied by

represents

ULF → LΣS → LF

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Detour: Underspecification

Every man loves a woman.

∃(y, woman(y), ∀(x, man(x), loves(x,y))

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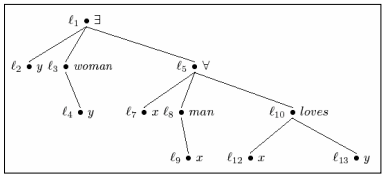

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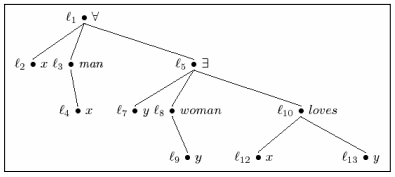

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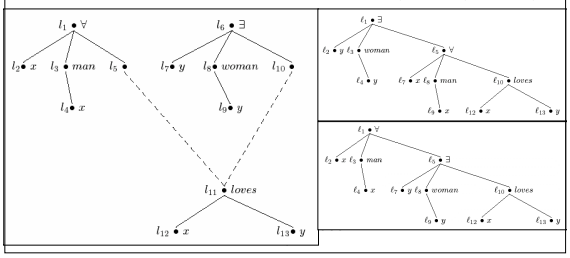

Detour: Underspecification

- ULF: (partial) description of *form* of base language formula
- hence *Underspecification Logic* only "knows" about *form* of described formulae, not entailments.
- e.g. $\exists x\phi \not\Rightarrow \neg\forall x\neg\phi$

Logics of Conversation

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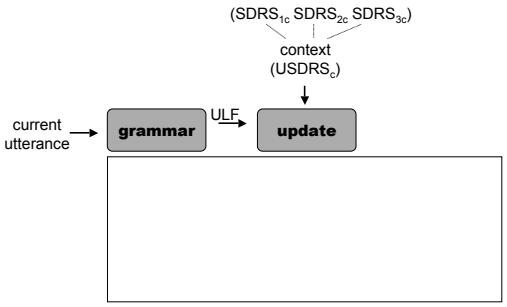

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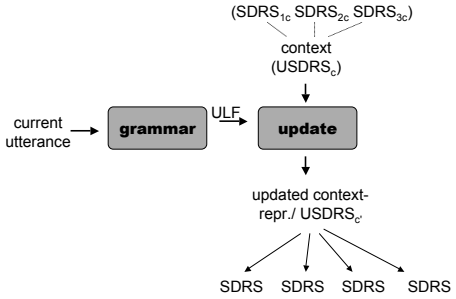

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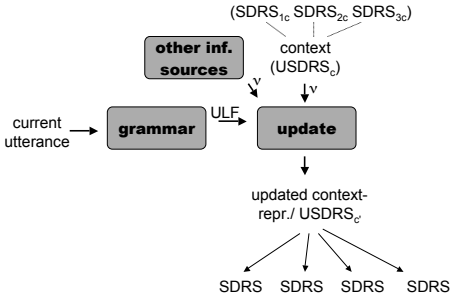

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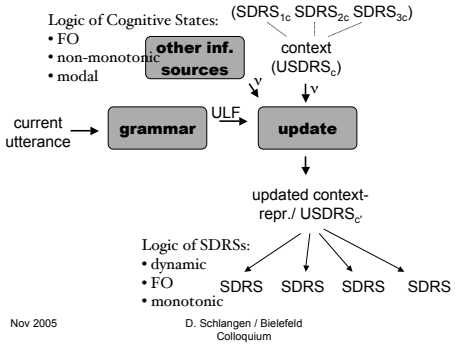

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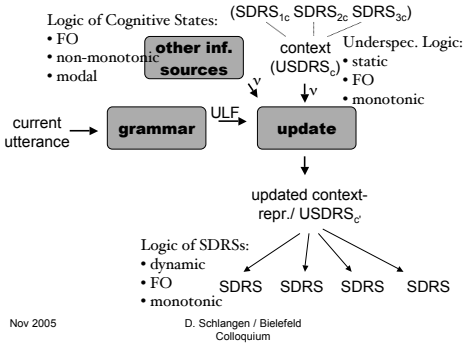

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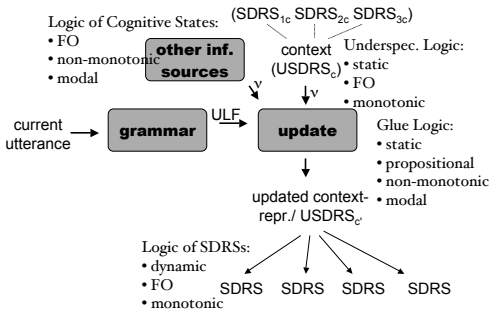

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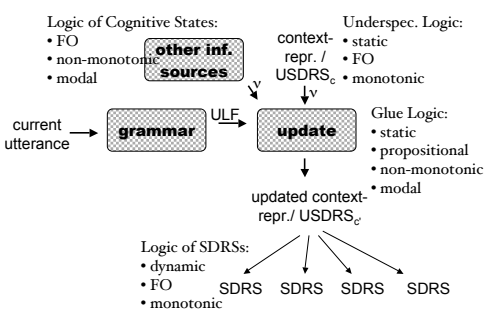
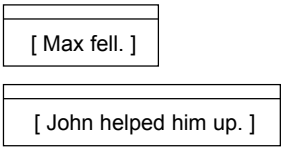


SDRT: Logic of Content

(5) Max fell.
John helped him up.



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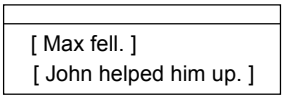

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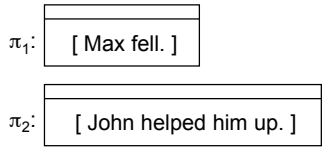

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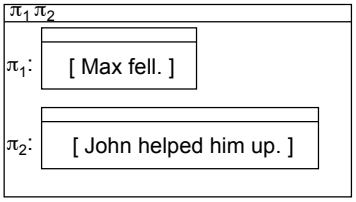

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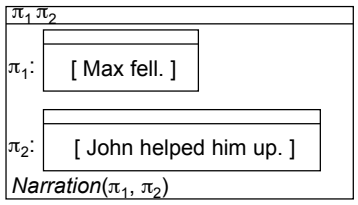

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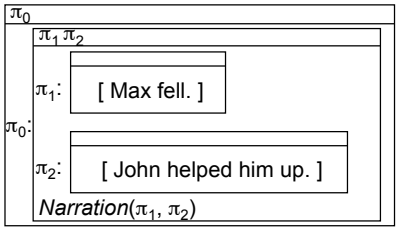

Logic of Content, Semantics

- Satisfaction Schema for veridical relations:

$f \| R(\pi_1, \pi_2) \|_M g$ iff

$f \| K\pi_1 \|_M \circ \| K\pi_2 \|_M \circ \| \phi_{R(\pi 1, \pi 2)} \|_M g$

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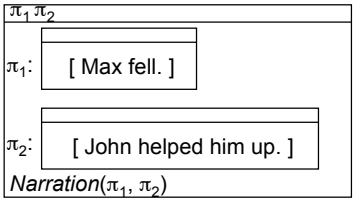

Some Meaning Postulates

content-level relations:

- Axiom on Narration:

$\phi_{Narration(\alpha,\beta)} \Rightarrow$ (a) $e_\alpha < e_\beta$ and
(b) things don't move location between the end of e_α and start of e_β

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- Axiom on Explanation:

$\phi_{Explanation(\alpha,\beta)} \Rightarrow \neg e_\alpha < e_\beta$

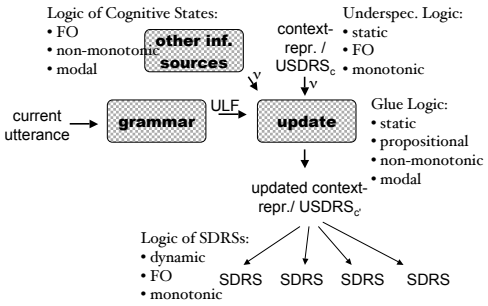
$\phi_{Explanation(\alpha,\beta)} \Rightarrow (\text{event}(e_\alpha) \Rightarrow e_\beta < e_\alpha)$

Another Meaning Postulate

cognitive-level relations:

- Semantics of IQAP (indirect question-answer pair)
  - (a) $IQAP(\alpha,\beta) \Rightarrow K_\beta$
  - (b) K_β contains sufficient content such that when it's added to S(α)'s beliefs, he can nonmonotonically compute a direct answer to his question.

Logics of Conversation



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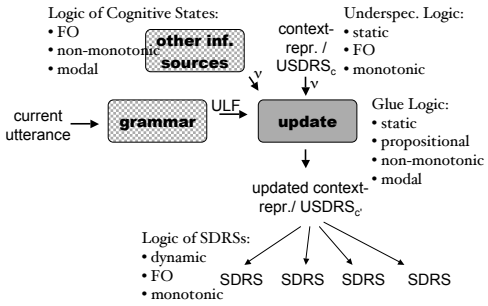

SDRT: Construction

- where do we attach new information?

(10) Peter collects classic cars.
He owns a 1967 Alfa Romeo Spider.
He also collects classical instruments.

SDRT: Construction

- which info is needed to infer rhet. rel.?
  - sometimes it's explicitly signalled:

(11) Max fell.
And then Peter kicked him.

  - most of the times it isn't, and we need WK, knowledge about cognitive states, goals etc.:

(12) Max fell.
Peter pushed him.

(13) Smoke a pack of cigarettes a day and you'll die before you reach 30.

SDRT: Construction

- also: *default* guesses.

(14) John took engine 1 to Dansville.
He picked up a boxcar.

(15) John took engine 1 to Dansville.
He also picked up a boxcar.

SDRT: Construction

- also: *default* guesses.

(16) Max took an aspirin.
He was sick.

(17) Max took an aspirin overdose.
He was sick.

logic must be able to handle conflicting information.

SDRT: Construction

- another desideratum: logic must be decidable.

⇒ use *Common-sense Entailment* (Asher 1997; Morreau 1994), a non-monotonic propositional logic.

- Axiom schema for inferring rhet. rels:

$(?(\alpha,\beta,\lambda) \wedge [\textit{some info}..]) > R(\alpha,\beta,\lambda)$

"A > B" means "if A then *normally* B"

Glue logic: how is info accessed?

- Axiom schema for inferring rhet. rels:

$(?(\alpha,\beta,\lambda) \wedge [\textit{some info}..]) > R(\alpha,\beta,\lambda)$

- Logic of content is a FOPL, glue logic is propositional. How does info get from content to glue logic?

⇒ transfer function; access to form, not (all) entailments.

Glue Logic: Transfer Function

π_1: Max fell.

π_2: John pushed him.

$[\textit{fall}(e, m)](\pi_1)$

$[\textit{push}(e_2, j, m)](\pi_2)$

Glue Logic: Transfer Function

π_1: Max fell.

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$[\textit{fall}(e, m)](\pi_1)$

$[\textit{push}(e_2, j, m)](\pi_2)$

$[\textit{fall}(e_\alpha, y)](\alpha) \wedge [\textit{push}(e_\beta, x)](\beta) \rightarrow \textit{cause}_D(\beta, \alpha)$

$(?(\alpha, \beta) \wedge \textit{cause}_D(\beta, \alpha)) > \textit{Explanation}(\alpha, \beta)$

Glue Logic: Some Axioms

– `IQAP`	$?(\alpha,\beta) \wedge \alpha{:}? > \text{IQAP}(\alpha,\beta)$
– `Q-Elab`	$?(\alpha,\beta) \wedge \beta :? > \text{Q-Elab}(\alpha,\beta)$
– `QAP`	$?(\alpha,\beta) \wedge \alpha{:}? \wedge \textit{qap-sat}(\alpha,\beta) > \text{QAP}(\alpha,\beta)$
– `Elab`	$?(\alpha,\beta) \wedge \textit{subtype}_D(\beta,\alpha) > \text{Elab}(\alpha,\beta)$
– `Expl`	$?(\alpha,\beta) \wedge \textit{cause}_D(\beta,\alpha) > \text{Expl}(\alpha,\beta)$

Glue Logic: Some Axioms

– IQAP $?(\alpha,\beta) \wedge \alpha{:}? > \mathrm{IQAP}(\alpha,\beta)$

Semantics of IQAP (indirect question-answer pair)

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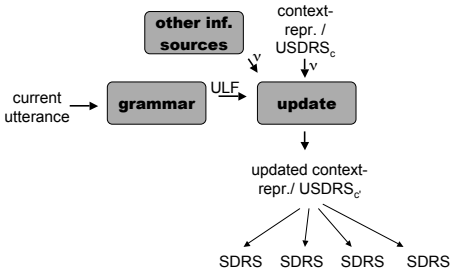
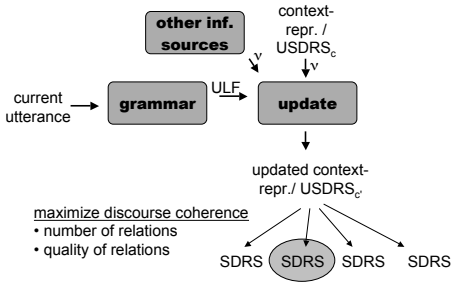


Maximize discourse coherence



Resolving Underspec., Inf. Flow

$\mathrm{USDRS}_c + \mathrm{USDRS}_n = \mathrm{USDRS}_{c'}$

… SDRS SDRS SDRS SDRS ...

glue-logic

speech act → add. info that resolves underspec.

e.g. infer IQAP on basis of sentence moods; add consequences to SDRS.

Resolving Underspec., Inf. Flow

$\mathrm{USDRS}_c + \mathrm{USDRS}_n = \mathrm{USDRS}_{c'}$

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glue-logic

speech act → add. info that resolves underspec.

maximize discourse coherence

resolution → allows inf. to speech act, making this SDRS preferred.

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SDRT and Dialogue

- same *relations* as monologue:
  - *Narration*, *Explanation*, etc.

(1) A: Max fell.
B: John pushed him.

SDRT and Dialogue

- same *constraints* as monologue:
  - accessability and availability

(1) A: How can I get to 6th street?
B: You can ask someone downtown.
B': There's someone downtown you could ask.
A: What's his name?

SDRT and Dialogue

- and then some *more relations*
  - *IQAP*, *Q-Elab*, etc. (defined in terms of goals etc.)

(1) A: Did Peter come to the party?
B: The one at Joe's?
A: Yeah.
A: No. Sandy was there.

SDRT and Dialogue

- ... & *more constraints*:
  - agent's *goals* constraining anaphora

(1) A: Can we meet next weekend?
B: How about Saturday afternoon?
A: I'm busy then.
??How about 3pm?

Dial. SDRT: Representation

- whose SDRS is it anyway?
  - one for each dialogue participant
  - DPs strive to align representations
  - represent "what the dialogue so far means"
- needed:
  - representation of who said what;
  - labels for utterances (already there);
  - operators for beliefs, etc.

Dial. SDRT: semantics, one expl.

- Semantics for $IQAP$:
  $(w,f) \| IQAP(\pi_1, \pi_2) \|_M (w',g)$ iff
  - $w=w'$, $(w,f) \| K_\beta \| (w',g)$, and
  - there is a p such that:
    - $(w,f) \| Answer(\hat{}K_\alpha, p) \| (w,f)$
    - $(w,f) \| {}^\vee p \| (w,f)$
    - $(w,f) \| B_{S(\alpha)}(K_\beta > {}^\vee p) \| (w,f)$

= "K_β contains sufficient content such that when it's added to S(α)'s beliefs, he can nonmonotonically compute a direct answer to his question."

Dial. SDRT: *divergent* relations

(1) π_1 A: Hey, what happened?
π_2 B: I got the climb.] *QAP*

Dial. SDRT: *divergent* relations

(1) π_1 A: Hey, what happened?
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π_3 A: No you didn't. I saw you fall off.] *Correction*

Dial. SDRT: *divergent* relations

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π_4 B: No. First time I fell off. Next time I got it.] *Correction*

Dial. SDRT: *divergent* relations

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π_3 A: No you didn't. I saw you fall off.] *Dis(Correction)*
π_4 B: No. First time I fell off. Next time I got it.] *Correction*

- + structural notion of *settledness*
  (roughly, everything that's not available for correction anymore)

Dial. SDRT: some more relations

- *Plan-Correction*(α,β)
  - indicates that Ag(β) won't take on SARG(α)
- *Q-Elab*(α,β)
  - β is question that helps achieve SARG(α)

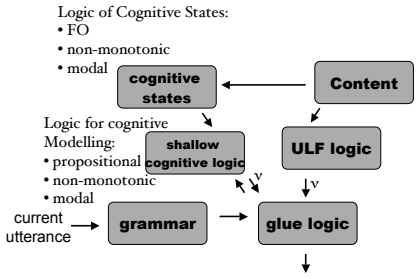
Dial. SDRT: Construction

- how can these relations be recognised?
- Cognitive Modelling necessary.
- Problem:
  - cognitive states should be represented w/ logic as powerful as that of content
  - that would make reasoning about these states undecideable

Dial. SDRT: Construction

- Solution:
  - separate full logic for reasoning about CS & shallow logic for reasoning about discourse structure

Dial. SDRT: Construction



Dial. SDRT: some axioms of CM

- `Cooperativity:`
  (a) $\mathcal{I}_A(\delta\phi) > \mathcal{I}_B(\delta\phi)$
  (b) $(\mathcal{I}_A(\delta\phi) \wedge \neg\mathcal{I}_B(\delta\phi)) > \mathcal{I}_B\mathcal{B}_A\neg\mathcal{I}_B(\delta\phi)$
- `SARGs to Intentions:` $\text{SARG}(\alpha,\phi) > \mathcal{I}_{Agent(\alpha)}(\delta\phi)$
- `Intentions to SARGs:`
  If *Done*(*Say*(α)) $\wedge$ *Info*(τ)$\mid\sim\mathcal{I}_{Agent(\alpha)}(\delta\phi)$, then
  Done(*Say*(α)) $\wedge$ *Info*(τ)$\mid\sim\text{SARG}(\alpha,\phi)$
- `Question Related Goals (QRG):`
  Sanswer$(\alpha,p) > \text{SARG}(\alpha,\mathcal{B}_{Agent(\alpha)}p)$
- `Known Answers:`
  (*Sanswer*$(\alpha,p) \wedge \mathcal{B}_{Agent(\alpha)}p) > \neg\text{SARG}(\alpha,\mathcal{B}_{Agent(\alpha)}p)$

Dial. SDRT: some axioms of CM

- `Default Schema:` Suppose *Info*(τ) $\wedge$ *Done*(*Say*(β))$\mid\sim R(\alpha,\beta,\lambda)$.
  Then:
  Info(τ) $\wedge$ *Done*(*Say*(β))$\mid\sim\text{SARG}(\beta,\mathcal{B}_A R(\alpha,\beta,\lambda))$
  I.e., The SARG of an utterance is that the semantic effects of its rhetorical connection to the context be believed.
- `Axioms are Mutually Believed:` $MB_{A,B}(\text{DICE})$, $MB_{A,B}(\text{COGNITIVE-MODELLING})$
- `Mutual Belief:`
  $MB_{A,B}\phi \rightarrow (\mathcal{B}_A(\phi \wedge MB_{A,B}\phi) \wedge \mathcal{B}_B(\phi \wedge MB_{A,B}\phi))$

Dial. SDRT: some axioms of CM

- `Sincerity:` $R(\alpha,\beta,\lambda) > \mathcal{B}_{Agent(\beta)}R(\alpha,\beta,\lambda)$
  (note this is stronger than the usual rendition of Sincerity).
- `Competence:` $\mathcal{B}_A\phi > \mathcal{B}_B\phi$
- `Practical Syllogism (PS):`
  (a) $(\mathcal{I}_A(\delta\psi) \wedge$
  (b) $\mathcal{B}_A((\phi > \psi) \wedge$ *choice*$_A(\phi,\psi)) >$
  (c) $\mathcal{I}_A(\delta\phi)$
- `Rationality of Action` *Done*(a) $> \mathcal{I}_{Agent(a)}(a)$
- `Attachment to Utterance:` $\langle\tau,\alpha,\beta,\lambda\rangle \rightarrow$ *Done*(*Say*(β))

Dial. SDRT: some axioms of CM

- these axioms allow for example to turn:

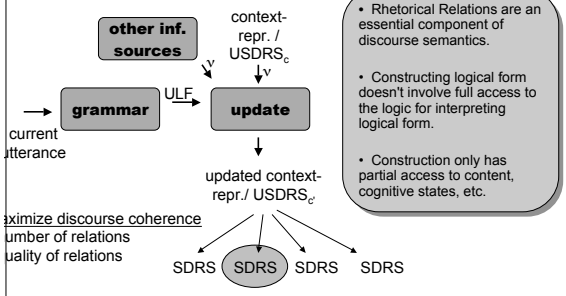
  Semantics of IQAP (indirect question-answer pair)

  (a) $IQAP(\alpha,\beta) \Rightarrow K_\beta$

  (b) K_β contains sufficient content such that when it's added to S(α)'s beliefs, he can nonmonotonically compute a direct answer to his question.

- into:
  - `IQAP:` $?(\alpha,\beta) \wedge \alpha{:}? > \mathrm{IQAP}(\alpha,\beta)$

The picture is complete (... -ish)



- Rhetorical Relations are an essential component of discourse semantics.
- Constructing logical form doesn't involve full access to the logic for interpreting logical form.
- Construction only has partial access to content, cognitive states, etc.

Overview of talk

- Introduction: SDRT in a nutshell
- Basics of SDRT: Logics of Conversation
  - Why DRT isn't enough
  - Claims and Strategy
  - Representing Discourses
  - Computing Logical Form of Discourses
    - Common Sense Entailment
    - Resolving Underspecification
- SDRT and Dialogue: Reprstn & Cognitive Modelling
- Application to two dialogue phenomena:
  - Fragments
  - Silences
- Strengths & Weaknesses

Fragments

- (Schlangen 2003);
  (Schlangen & Lascarides 2002a,b; 2003)

An Example Dialogue - "I think with a fork"

Paul: Who wants some Wakame?
Mary: Peter.
Peter: How do you eat this?
Paul: I think with a fork.
Mary: Try it. It's good for you.
Lots of vitamins.

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Nov 2005 D. Schlangen / Bielefeld Colloquium

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Paul: I think *you eat this* with a fork.
Mary: Try it. It's good for you. — Expl
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Paul: Who wants some Wakame?
Mary: Peter *wants some Wakame*. *(resolution via identity)*
Peter: How do you eat this?
Paul: I think *you eat this* with a fork.
Mary: Try it. It's good for you. *(resolution via inference)*
It contains lots of vitamins.

- non-sentential form, but "sentential meanings"
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- syntactic reconstruction approach doesn't work.

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- non-sentential form, but "sentential meanings"
- meaning depends on context.
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- syntactic reconstruction approach doesn't work.
- but there is some syntactic influence from context on fragment. (Morgan 1973, Ginzburg 1998)

What kind of resolution?

- *some* syntactic influence from context on fragment:
(Morgan (1973), Ginzburg (1998))

(7) A: Wem hast Du geschmeichelt? *(Who_{DAT} did you flatter?)* | Wen hast Du gelobt? *(Who_{ACC} did you praise?)*
B: Dem Schüler. #Der / Den Schüler. | Den Lehrer. #Der / Dem Lehrer.

Resolution - res-via-id Example

(1) A: Who wants some Wakame? → QAP
B: Peter.

`IQAP` $?(\alpha,\beta) \wedge \alpha{:}? > \mathrm{IQAP}(\alpha,\beta)$
`Frag IQAP->QAP` $\mathrm{IQAP}(\alpha,\beta) \wedge \mathrm{frg}(\beta) \rightarrow \mathrm{QAP}(\alpha,\beta)$
`Frag-QAP-c->rvi` $\mathrm{QAP}(\alpha,\beta) \wedge \mathrm{aq}(\alpha) \rightarrow \mathrm{res\text{-}v\text{-}id}(\alpha,\beta)$

information flow:
speech act → resolution

subcat-information is transferred into context-representation, as well as category information of fragments

⇒ some (limited) syntactic information is accessible to dialogue interpretation

Resolution - res-via-inf

(3) A: Peter left very early. → Expl
B: Exams.

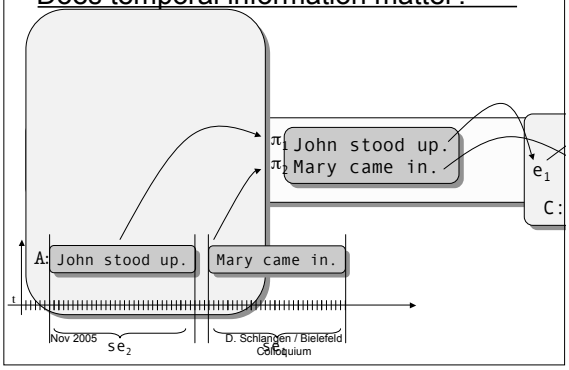
`Expl` $?(\alpha,\beta) \wedge \mathit{cause}_D\,(\beta,\alpha) > \mathrm{Expl}(\alpha,\beta)$

- here we need world knowledge about exams (e.g. scripts), about Peter, etc.…
- the machinery is there to deal with this kind of information.

Timing in Dialogue

- (Schlangen 2005; in prep.)
- SDRT abstracts away from details of temporal realisation of dialogue (apart from linear order)

Does temporal information matter?



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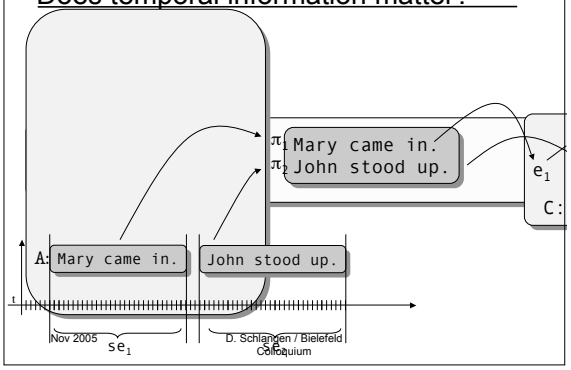

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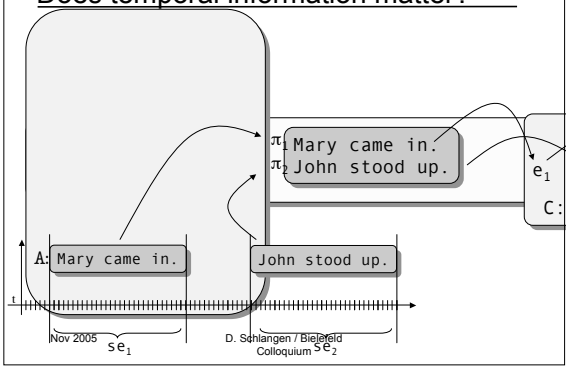
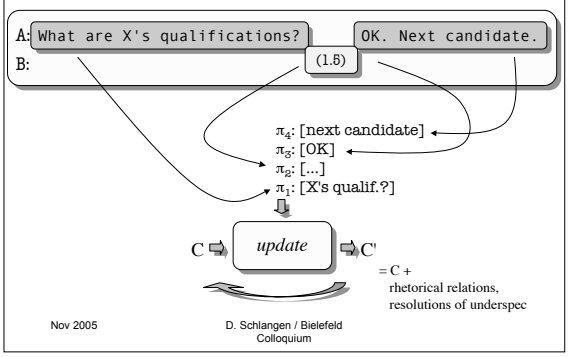
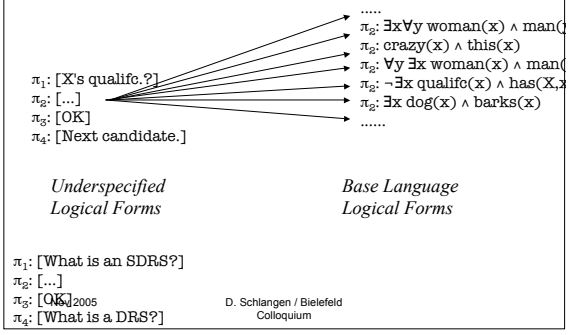


Timing Module



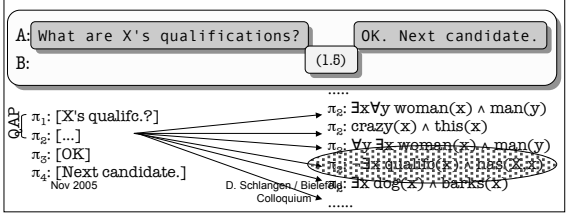
The LF of silence...



Interpreting refusal-t silence

- glue-logic rule for inferring rhetorical relation for refusal-type silence:

$?(\alpha,\beta,\lambda) \wedge \alpha{:}? \wedge \beta{:}\ldots_r \wedge Top(\sigma,\alpha) \wedge disp_{D+WK}(\sigma,\alpha,\beta) > QAP(\alpha,\beta,\lambda)$



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Strengths & Weaknesses

- fine-grained semantic analysis;
- precise model of how linguistic information interacts with information from other sources
- computable (in theory)
- implementable?

Weaknesses / Further Work

- makes dialogue look a lot like monologue (too much?)
- justification for rules & relations? (Baldridge & Lascarides 2005; Asher in pre.)
- needs to be supplemented with model of *interaction management*
  - how is alignment of SDRSs achieved?
  - how can sub-sentential updates be integrated?

The End

Thank you for your attention!

Acknowledgements:
Most work presented here
done by Nick Asher & Alex Lascarides!
(Asher & Lascarides 2003)
Thanks to them for collaboration on
and discussions about SDRT

CE: Inference Patterns

A > B means "If A then normally B"

Closure on the right:

A > B, B → C ⊢ A > C

Lions normally walk.
Things that walk have legs.
Lions normally have legs.

CE: Inference Patterns

Defeasible Modus Ponens:

A > B, A $\mid\sim$ B

If Tweety is a bird, then normally Tweety flies
Tweety is a bird
Tweety flies

A, A>B, ¬B $\not\mid\sim$ B

If Tweety is a bird, then normally Tweety flies
Tweety is a bird
Tweety does not fly
*Tweety flies

CE: Inference Patterns

Knowledge Conflict:

Penguin Principle:

$C \rightarrow A$,
$A > B$,
$C > \neg B$, $C \mid\!\sim \neg B$

If Tweety is a penguin, then Tweety is a bird.
If Tweety is a bird, then normally Tweety flies.
If Tweety is a penguin, then normally Tweety doesn't fly
Tweety is a penguin.

Tweety doesn't fly.

Nixon Diamond:

$A > B$, $C > \neg B$, A, $C \not\sim B$ (or $\neg B$)

If Nixon is a Quaker, then normally he's a pacifist.
If Nixon is a Republican, then normally he's non-pacifist.
Nixon is a Quaker.
Nixon is a Republican.

?