Discourse and Dialogue

Nicholas Asher

IRIT, UMR 5505,
Université Paul Sabatier, Toulouse

Outline

- discourse and discourse structure
- some alternative views of discourse structure
- some data in favor of integrating discourse structure within interpretation.
- dialogues and structure
- grounding
- complications with grounding
- commitments
- computing commitments
- cognitive implicatures of commitments

- commitments to preferences and strategic reasoning about dialogue

- discourses are more or less coherent, in virtue of how the thoughts expressed ”hang together”.
- Hume’s relations between ideas: resemblance, contiguity, cause.
- Halliday and Hasan (1976), the tradition of functional grammar
- AI and Linguistics: Polanyi (1984, 1988), Grosz and Sidner (1986), Mann and Thompson (1987, 1988), Hobbs (1993), Kehler (1994), Webber (2003), SDRT (Asher 1993, Asher and Lascarides 2003)—modeling coherence in terms of relations between discourse units.
- Cognitive psychology: Kintsch and van Dyke (1977, 1980), Sanders (2003) Kehler (2005). Texts with a clear discourse structure are more easily retained than those that do not.

Two views of discourse structure

- Informational Approach: Understanding Linguistic Structure is sufficient for Discourse Processing
- Intentional Approach: Understanding Speaker Intentions is required for Discourse Processing

Different implementations of these views

- Stalnaker (”Assertion” (1976)): no discourse structure other than the syntactic structures of the constituent sentences; a discourse interpretation is a set of possible worlds:
  $D = S_1; S_2; \ldots S_n$
  $||D|| = ||S_1|| \cap ||S_2|| \cap \ldots \cap ||S_n||$

Discourse structure in classical dynamic semantics

- DRT (Kamp 1981, Kamp and Reyle 1993): a discourse structure is a DRS— a collection of discourse entities (referents) together with a set of conditions (formulas) predicated of them
  interpretation: via an embedding of a DRS in a first order model.
- Dynamic semantics (Groenendijk and Stokhof 1991): no discourse structure other than syntactic structure of sentences; discourse interpretation consists of a relation between world assignment pairs.
  $D = S_1; S_2; \ldots S_n$
  $||D|| = ||S_1|| \circ ||S_2|| \circ \ldots \circ ||S_n||$

Grosz and Sidner

Discourse structure involves 3 levels:

- attentional structure–a stack determined by intentional structure
- intentional structure
- linguistic structure isomorphic to intentional structure

Two relations over discourse/intentional structure:

- DSP1 <u>dominates</u> DSP2 if satisfying DSP2 is intended to provide part of the satisfaction of DSP1
- DSP1 <u>satisfaction-precedes</u> DSP2 if DSP1 must be satisfied before DSP2

An example

(1) a. [C1: I need to travel in May.] *C intends A find a flight for C*

b. [A1: And, what day in May you want to travel? *I(A, C gives date*

c. C2: OK uh I need to be there from the 12th to the 15th.]

d. [A2: And youre flying into what city? *I(A, C gives arrival city*

e. C3: Seattle]

f. [A3: And what time would you like to leave Pittsburgh?] *I(A, C gives departure time*

g. C4: [Uh hmm I dont think theres many options for non-stop *I(C, A finds non stop*

h. A4: Right. Theres three non-stops today.

i. C5: What are they? A5: The first one departs PGH at 10:00 ...

j. C6: OK Ill take the 5ish flight on the night before on the 11th. A6: On the 11th? OK. Departs at 5:55 pm]

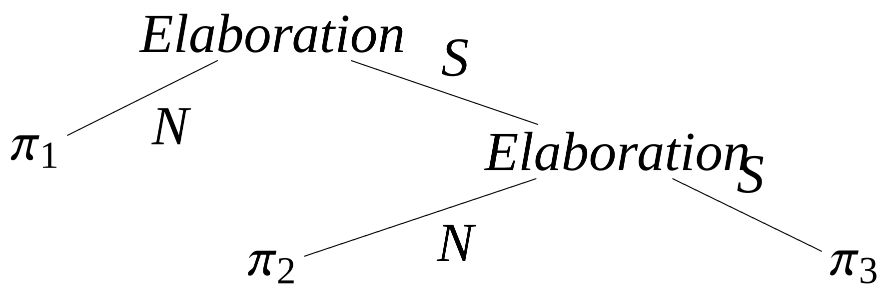
RST

Discourse structure is a tree, where nodes are either discourse relation names or basic units (the leaves). Two kinds of arcs in the structure: a relation may have either a nucleus or a satellite (Marcu 2000). These are important for interpreting the trees and finding the arguments of the relations.

An example

(2) a. John quit school (π_1)
    b. He was having academic troubles. (π_2)
    c. He was failing all his classes (π_3)

RST's tree structure requires the discourse tree to be interpreted according to the Nuclearity Principle such that π_2 is the second argument of the topmost Elaboration.



A discourse structure or SDRS is a triple $\langle A, \mathcal{F}, Last \rangle$, where:

- A is a set of labels.
- $Last$ is a label in A (intuitively, this is the label of the content of the last clause that was added to the logical form); and
- $\mathcal{F}$ is a function which assigns each member of A a member of a formula of the SDRS language, which includes formulas of some version of dynamic semantics (DRT, DPL, Update Semantics, MLTT, etc.)

From Logic to Graphs

- Each constituent is a node
- Each subordinating relation creates a downward edge
- Each coordinating relation creates a horizontal edge.

Constraints:

- No two nodes can be connected by both a subordinating and coordinating relation
- Several edges (of the same type) possible between 2 constituents
- Many SDRSs can be represented as trees but some cannot.
- Anaphora resolution and SDRS update dependent on graph structure. Right Frontier

Building SDRSs

- Use compositional and lexical semantics and syntax to build an underspecified logical form for clauses
- Clause logical forms to be linked by glue logic axioms that exploit presence of discourse connectors, compositional and lexical semantics and simplified information about discourse participants' cognitive states. Asher and Lascarides (2003) explore the limits of using such purely linguistic resources.
- Sometimes inference to discourse relations is easy (discourse connectors), sometimes not so easy (reasoning by default)
- Incremental update of discourse logical form with new information and glue logic results. Attachment only on the right frontier.

1. *Constructing* logical form must be computable. So it doesn't involve full access to the logic for *interpreting* logical form.

   (3) a. There are unsolvable problems in number theory.

   b. Any even number greater than two is equal to the sum of two primes, for instance.

2. In fact, constructing logical form has only limited access to:

   - Lexical semantics, domain knowledge, cognitive states etc.

   for similar reasons.

A simple example

(4) π_1 John had a great evening last night.

π_2 He had a great meal.

π_3 He ate salmon.

π_4 He devoured lots of cheese.

π_5 He then won a dancing competition.

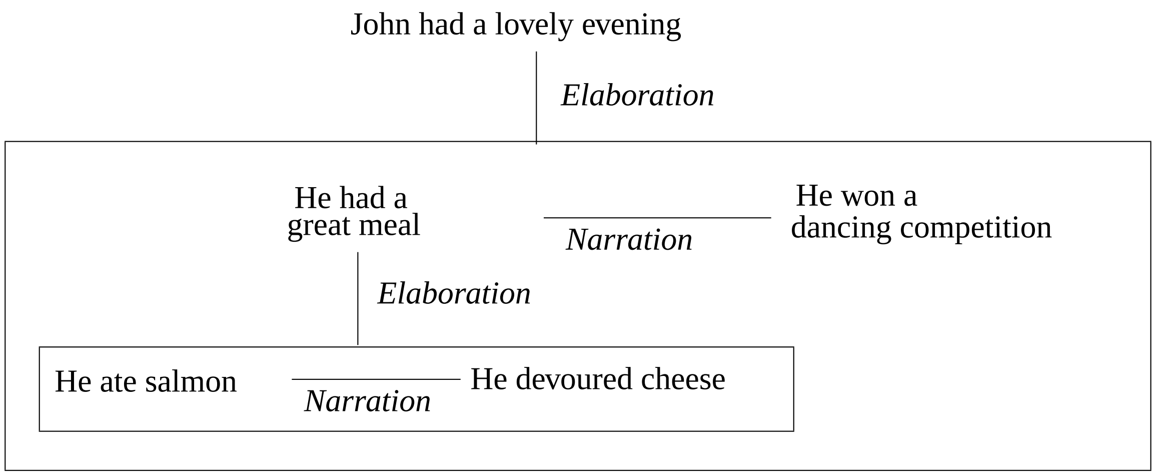
π_6 # It (# the salmon) was a beautiful pink.

The discourse structure for (4)

$\langle A, \mathcal{F}, Last \rangle$, where:

- $A = \{\pi_0, \pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \pi_6, \pi_7\}$
- $\mathcal{F}(\pi_1) = K_{\pi_1}, \mathcal{F}(\pi_2) = K_{\pi_2}, \mathcal{F}(\pi_3) = K_{\pi_3}, \mathcal{F}(\pi_4) = K_{\pi_4}, \mathcal{F}(\pi_5) = K_{\pi_5}$,
  $\mathcal{F}(\pi_0) = Elaboration(\pi_1, \pi_6)$
  $\mathcal{F}(\pi_6) = Narration(\pi_2, \pi_5) \wedge Elaboration(\pi_2, \pi_7)$
  $\mathcal{F}(\pi_7) = Narration(\pi_3, \pi_4)$
- $Last = \pi_5$

Graph for (4)



John had a lovely evening
Elaboration
He had a great meal
Narration
He won a dancing competition
Elaboration
He ate salmon
Narration
He devoured cheese

Example from MUC6 corpus.

(5) a. Wall Street traders said
    b. Piedmont shares fell
    c. partly because of market uncertainty about federal regulatory approval for a merger with USAir.

(5b,c) should together form the constituent that is the argument to the Source (or Attribution) relation whose first argument is (5a)

The SDRS for (5)

- $A = \{\pi_0, \pi_1, \pi_2, \pi_3, \pi\}$
- $\mathcal{F}(\pi_1)$ = Wall street traders said p
  $\mathcal{F}(\pi_2)$ = Piedmt shares fell
  $\mathcal{F}(\pi_3)$ = market uncertainty about fed..
  $\mathcal{F}(\pi_0) = Source(\pi, \pi_1)$
  $\mathcal{F}(\pi) = Explanation(\pi_2, \pi_3)$
- $Last = \pi_3$

SDRS graph for (5)

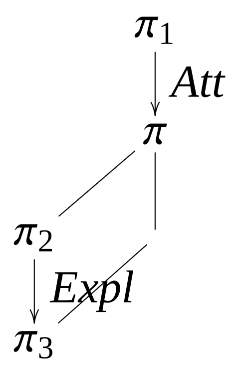
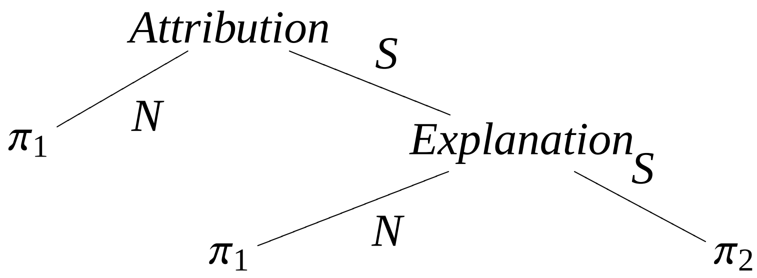


Figure 1: SDRT graph for (5)

RST structure for (5)



Rhetorical relations are an essential component of discourse semantics and affect semantics

- tense (Lascarides and Asher 1993):

(6) John fell. Max helped him up.

(7) John fell but Mary didn't.

(8) John fell. Max pushed him.

(9) John fell. Max pushed him and John rolled off the edge of the cliff.

(10) a. One plaintiff was passed over for promotion three times.
b. Another didn't get a raise for five years.
c. A third plaintiff was given a lower wage compared to males who were doing the same work.
d. But the jury didn't believe this.

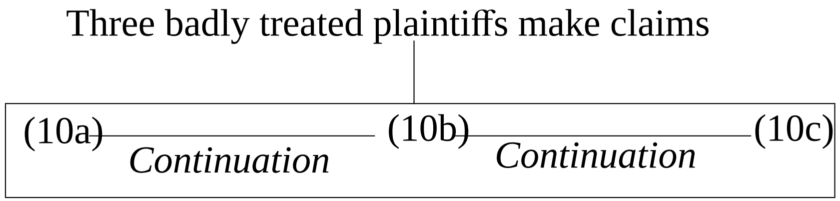
What does *this* pick up?

- The proposition expressed by the first three sentences.
- The proposition expressed by the last sentence.

Dynamic accessibility overgenerates the possibilities.

A Discourse Structure and Right Frontier

(10′)



Two Questions About Updating:

1. Where do you attach new information?
2. how does this affect context update (e.g. resolution of anaphors)?

Possible Answers:

1. The Right Frontier Constraint:
   The last attached discourse constituents and constituents that dominate the last are available for attachment.
2. Antecedents to an anaphoric condition in a constituent β must either be accessible to it within β or accessible to all the bits of a constituent α that β is rhetorically connected to (so availability subsumes dynamic accessibility).

Now change text (10) by inserting between (10c) and (10d) a clause which expresses the topic of the segment (10a–c):

(10) a. One plaintiff was passed over for promotion three times.

b. Another didn't get a raise for five years.

c. A third plaintiff was given a lower wage compared to males who were doing the same work.

c′ These people were really badly treated.

d But the jury didn't believe this.

The Effect of this Insertion

The addition to the text was implicated by the original, but this addition has dramatic effects on what *this* can refer to:

- *not* (10c) anymore, and only with difficulty the group of all three claims.
- preferred antecedent:
  the proposition that the plaintiffs were badly treated.

Right Frontier to the Rescue!

- (10c′) is the previous clause and nothing dominates it (see (10′)). So only (10c′) is on the right frontier.

The available nodes in a discourse structure for attachment:

1. The label $\alpha = \mathit{Last}$;
2. Any label $\gamma \geq_D^* \alpha$ where $\geq_D^*$ is defined recursively:
   (a) $R(\gamma, \alpha)$ is a conjunct in $\mathcal{F}(l)$ for some label l, where R is a subordinating discourse relation (like *Elaboration*, *Explanation* or $\Downarrow$);
   (b) $R(\gamma, \delta)$ is a conjunct in $\mathcal{F}(l)$ for some label l, where R is a subordinating discourse relation and $\mathcal{F}(\delta)$ contains as a conjunct $R'(\delta', \alpha)$ or $R'(\alpha, \delta')$, for some R' and δ'; or
   (c) $R(\gamma, \delta)$ is a conjunct in $\mathcal{F}(l)$ for some label l, where R is a subordinating discourse relation and $\delta \geq_D^* \alpha$.

Situation:

- $\beta : K_\beta$;
- K_β contains anaphoric condition φ.

Available antecedents are:

1. in K_β and DRS-accessible to φ
2. in K_α, DRS-accessible to any condition in K_α, and there is a condition $R(\alpha, \gamma)$ in the SDRS such that $\gamma = \beta$ or $\gamma \geq^*_D \beta$) (where R isn't structural).

Antecedent must be DRS-*accessible on the right frontier, unless we attach with Parallel or Contrast*

- Anaphoric availability in SDRT is not a strictly structural constraint, depends on the semantics of the relations attaching the constituents.
- Matching condition for Parallel/Contrast consists of constructing a maximal partial isomorphism between the two related constituents.
- Anaphors within a complex constituent α linked to β by Parallel/Contrast may find an antecedent in $\beta' <^*_D \beta$ using the matching condition (Asher 1993), even though β' not on the right frontier.

Anaphora, ellipsis (Asher 1993, Asher, Hardt, Busquets 2001)

(11) a. Every doctor saw at least one patient, and every nurse saw at least one patient too.

b. Every doctor saw at least one patient, and every nurse did too. (Quantificational Structure)

c. When John goes to school, he normally brings his books. But when Samantha goes to school, she normally doesn't. (Conditional structure)

d. Kim is happy because her friend is in town, but Sam isn't because hers isn't.

More effects of discourse structure

Presupposition (Asher and Lascarides 1998, 2003)

(12) We went to a Thai restaurant and then had drinks at a hotel in Midtown. The waitress was from Bankok.

One might say that these are just pragmatic implicatures and don't interfere with the grammar. However, let's consider the phenomenon of sluicing.

(13) a. John ate, but I never figured out what ∅ [John ate].

b. John ate. Sam ate. But I never figured out what ∅ [John ate and Sam ate].

c. John ate. But I don't know what.

d. Mary kissed somebody. You'll never guess who.

Sluicing across separate sentences, so traditional syntactic theories can't impose constraints on such anaphoric phenomena. (data from Romero and Hardt 2004)

(14) a. John left and then Mary kissed someone. You’ll never guess who.
b. Mary kissed someone and then John arrived. #You’ll never guess who.
c. Mary kissed someone and then John arrived. You’ll never guess from where.
d. John arrived and then Mary kissed someone. #You’ll never guess from where.

(14) a. John left and then Mary kissed someone. You'll never guess who.
b. Mary kissed someone and then John arrived. #You'll never guess who.
c. Mary kissed someone and then John arrived. You'll never guess from where.
d. John arrived and then Mary kissed someone. #You'll never guess from where.

- *and then* implies a Narratiion relation between clauses of first sentences in (14).
- So right frontier contains just the second clause of the first sentence.
- Only material in that clause is available for reconstructing the ellipsis.

(15) a. Mary kissed someone because John left for some other party. You'll never guess who.
b. ??Because Mary kissed someone, John left early. You'll never guess who.
c. Mary kissed someone, He's a student here. You'll never guess who.
d. Mary kissed someone. You know him. But you'll never guess who.

SDRT predicts (15a,c,d) to be OK. Subordinating discourse relations between the first two clauses, allows for accessibility to either constituent. (15b) predicted to be bad, violation of Rt frontier.

SDRS-formulae are constructed from a vocabulary that includes that of first order logic together with:

- a modal connective $>$, ($\phi > \psi$ can be glossed as *If* ϕ *then normally* ψ),
- the modal operator δ that turns formulae into action terms ($\delta\phi$ can be glossed as the action of bringing it about that ϕ),
- and the operators '?' and λ-terms for representing questions as $?\lambda x_1 \ldots \lambda x_n \phi$, each x_i corresponding to a *wh*-element.
- labels: π, π_1, π_2, etc.
- a set of relation symbols for discourse relations: R, R_1, R_2, etc.

The set $\mathcal{L}$ of well-formed SDRS-formulae:

1. Let $\mathcal{L}_{basic}$ be the set of well-formed formulae that are derived using the usual syntax rules for first order modal languages with action terms. Then $\mathcal{L}_{basic} \subseteq \mathcal{L}$.
2. If R is an n-ary discourse relation symbol and $\pi_1, \ldots, \pi_n$ are labels, then $R(\pi_1, \cdots, \pi_n) \in \mathcal{L}$.
3. For $\phi, \phi' \in \mathcal{L}, (\phi \wedge \phi'), \neg\phi \in \mathcal{L}$, where $\wedge$ is understood dynamically.

Definition 1 An SDRS

Let $\mathcal{L}$ be the set of SDRS-formulae. Then an SDRS is a triple $\langle \Pi, F, Last \rangle$, where:

- Π is a set of labels.
- *Last* is a label in Π (intuitively, this is the label of the content of the last clause in the discourse); and
- F is a function which assigns each member of Π a member of $\mathcal{L}$.
- The relation $\succ$ that is the transitive closure of the *immediately outscopes* relation on labels Π as defined by F (i.e., π immediately outscopes π' iff $F(\pi)$ contains as a literal either $R(\pi'', \pi')$ or $R(\pi', \pi'')$ for some relation R and label π'') (a) forms a well-founded partial order, (b) has a unique root (that is, there is a unique label π_0 such that $\forall \pi \in \Pi$, $\pi_0 \succeq \pi$).

When there is no confusion, we may write $\langle \Pi, F \rangle$ instead of $\langle \Pi, F, Last \rangle$.

A remark on labels

Suppose that discourse relations take abstract entity denoting terms as arguments, but not labels which technically give us instances of such abstract entities in a particular discourse context, or speech act discourse referents.

(16) John slipped π_1. Max pushed him π_2.

(17) John slipped π_3. Max pushed him π_4. And then John rolled off the cliff.

Narration(π_3, π_4) is compatible with Explanation(π_1, π_2). BUT:
Narration(a, b) $\wedge$ Explanation(a, b) $\rightarrow \perp$

Let $M = \langle \Delta, W, *, R_{\Box_i}, I \rangle$ be a model, where:

- Δ is a set of individuals;
- W is a set of possible worlds;
- $R_{\Box_i}$ is a binary relation on W for the interpretation of a modality $\Box_i$.
- I is a function which assigns an n-ary predicate P_n at a world w a set of n-tuples of Δ (which we refer to as $I(P_n)(w)$).

1. $(w, f)[\![R(x_1, \cdots, x_n)]\!]^M_\delta(w', g)$ iff $(w, f) = (w', g)$ and $\langle f(x_1), \cdots, f(x_n)\rangle \in I(R)(w)$
2. $(w, f)[\![\exists x]\!]^M_\delta(w', g)$ iff $w = w'$, $dom(g) = dom(f) \cup \{x\}$, and $f \subseteq g$ (that is, $\forall y \in dom(f), f(y) = g(y)$).
3. $(w, f)[\![\phi \wedge \psi]\!]^M_\delta(w', g)$ iff $(w, f)[\![\phi]\!]^M_\delta \circ [\![\psi]\!]^M_\delta(w', g)$.
4. $(w, f)[\![\neg\phi]\!]^M_\delta(w', g)$ iff $(w, f) = (w', g)$ and there is no (w'', h) such that $(w, f)[\![\phi]\!]^M_\delta(w'', h)$.

The semantics is conservative with respect to DRT or dynamic semantics.

Intentional Approaches (Grice, Searle, BDI)

- provide a theory of speech acts: *force* and *propositional content*;
- link communication to rationality—communication is based on planning and interactions between beliefs, intentions and desires.
- make special cognitive hypothesis about dialogue participants (sincerity);
- do not stipulate a fixed structure for dialogue

Conventional Approaches (Traum, Hamblin, Dialogue Game tradition)

- provide a typology of linguistic actions— dialogue moves
- link communication to observable state of the interaction
- do not require any special cognitive hypotheses;
- fix the structure of dialogue a priori (rules for dialogue);
- represent the conventions governing linguistic interaction

- Within AI a well developed tradition of thinking of dialogues in terms of games: MacKenzie 1979, Walton & Krabbe, 1995, McBurney and Parsons 2002, Amgoud 2003, Maudet and Parsons 2000, Wooldridge 2000...
- many different sorts of moves and motivations in dialogue besides those seen so far in eg SDRT.

Examples of dialogue games (Walton and Krabbe)

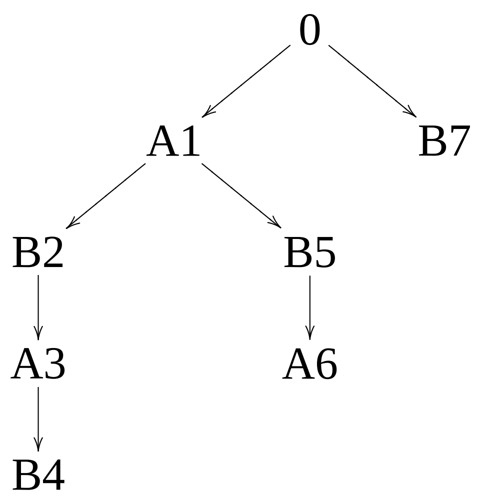
- persuasion games (goal is to persuade other participants of some proposition)
- information seeking games (one agent answers questions of another who knows the answers)
- inquiry games (the participants collaborate to answer some question whose answer is not known to them)
- negotiation games (participants bargain over the division of a scarce resource)
- deliberational games (the participants collaborate to decide group actions)
- eristic dialogues (the goal is to vent perceived greviances)

But...

- Little use made (as far as I know) of solution concepts from game theory.
- Little formal analysis about how to detect such moves in real dialogue. Little to no interaction between formal semantics, pragmatics and the game level description in this work.
- Most DG people (see McBurney and Parsons 2002 for a survey) think that most dialogues do not fall neatly into any one of these categories but are a combination of such games or ”moves”.
- Following Conversational Analysis we can add other moves: empathy moves, put-down moves, etc.

(18) A1 Who won the game?
B2 Which game ?
A3 England vs South Africa
B4 Oh, OK.
B5 South Africa.
A6 Thank goodness.
B7 OK.

A picture of (18)



(19) a. A: John went to jail.
b. A: He was found stealing the pension funds.
c. B: No! John was found stealing the pension funds, <u>but</u> he went to jail <u>because</u> he was convicted of tax evasion.

In general many new relations involving not only indicative forms but also interrogatives and imperatives.

(20) a. A: Did John fail his exams?

b. B: He got 60%.

(21) a. A: How does one make onion soup?

b. B: Chop onions and saute them in olive oil or butter until soft, add stock until the onions are well covered, and simmer for two hours at low heat.

- The *content* of the (complex) imperative (21b) is sufficient for *A* to compute a direct answer to his question.

SDRT brings the two strands of research together

- links speech acts to rhetorical relations. By making a contribution to discourse that plays a certain rhetorical role, one performs a relational speech act—e.g. answering a question.
- distinguishes what is communicated in the dialogue from what is (privately) believed by each of the participants
- has a logic for constructing discourse structure (glue logic) that is distinct and does not appeal directly to special cognitive hypotheses
- grounds certain axioms of the glue logic in a logic of cognitive modeling.

Propositional Commitment (Hamblin 1970)

A speaker is committed to what he has said.

- ”A language-user’s beliefs or other mental attitudes are often not well-defined at all. [...] The concept of belief is an idealization of indicative commitment.”
- ”And it is the same for intentions and imperative commitment.” [Hamblin, 1987] : p240-241)
- ”Indicative commitments are not beliefs. [...] The utterer of a lie is as commited by it as if it were not one.[...]” idem p240

A full theory of dialogue needs both.

- Commitments must be distinguished from private attitudes (lies)
- Reasoning about what dialogue moves to perform or why certain were performed requires reasoning about a speaker's private mental attitudes.
- Explicitly represent the commitments of each speaker (Maudet, Muller, Prévot 2006) to model grounding correctly and to preserve monotonic construction even with Corrections (Asher and Lascarides, in preparation)

An example

(22) a. A: Can we meet next weekend?
b. B: How about Saturday afternoon?
c. A: I'm busy then.
d. ??How about 3pm? availability and goals at work

Cognitive States and Availability are Both Needed!

- Constraints on antecedents from DRT and SDRT restrict the antecedents to *3pm* to a subset of the linguistic expressions:
  - *then* in (22c) (Saturday afternoon);
  - *Saturday* and *Saturday afternoon* in (22b); and
  - *next weekend* in (22a).
- *Next weekend* ruled out by uniqueness constraints on bridging.
- Linguistic constraints predict *3pm* on Saturday and block it from being on Sunday.
- But the goals explain why *3pm can't* be 3pm on Saturday: why is he asking to meet then when (22c) implies he doesn't want to meet then?

- Grosz and Sidner (1986) *inter alia* also model goals and plans. But GS's model of discourse structure is quite different from SDRT's—it contains elements that *aren't* linguistically explicit.
- When interpreting (22c), their linguistic structure includes the current discourse segment purpose (DSP) as a prominent element, to find a time to meet which falls on Saturday morning or Sunday.
- Possible overgeneration of the interpretations of *3pm* in (22d).

Grounding

- what the participants are jointly committed to (often glossed as what is mutually believed for the purposes of the conversation)

A *conversational information state* (or CIS) for each participant:

(23)

$G, DU1, DU2, DU3, UDU, CDU$
$G = \ldots$ $DU1 = \ldots$ $DU2 = \ldots$ $DU3 = \ldots$ $UDU = \langle DU1, DU3 \rangle$ $CDU = first(UDU) = DU1$

G : "ground"), *DU* : "discourse unit" are DRSs. Currently pending discourse units *UDU*; top element *UDU* = current discourse unit (*CDU*).

Update effects and preconditions of performing an assertion.

(24) ASSERT: If $\textbf{Assert}(B, A, K)$ then:
add to G: : $\textbf{Try}(B, \textbf{Bel}(A, K))$
If $\textbf{Accept}(A, \textbf{Assert}(B, A, K)$ then: $\textbf{SCCOE}(A, B, K)$

In GAM ϕ is grounded in a conversation with agents A and B, iff $G \vdash \textbf{SCCOE}(A, B, \phi) \wedge \textbf{SCCOE}(B, A, \phi)$

(25) a. A: The room went dark.
b. A: John turned out the lights.
c. B: and Max drew the blinds.

- in GAM: cannot conclude that *B* accepts *A*'s assertions and so cannot conclude *B* is socially committed to (25a), (25b) or Explanation (25a, 25b).
- So GAM does not predict anything is grounded.

Treatment in SDRT of (Asher and Lascarides 2003)

- Asher and Lascarides 2003) construct one SDRS, one, common discourse structure for the dialogue.

(25’)

π_1, π
π_1 : dark
π : [π_2, π_3 | Narration(π_2, π_3) π_2 : lights, π_3 : blinds]

What’s grounded in standard SDRT

- Asher and Lascarides (2003): lack of dissent = assent
- So in Common ground: (25a), (25b), (25c); Explanation (25a, [25b,25c]); Narration(25b,25c).
- Intuitively, (25a) and (25b) are grounded and (25b) is at least a *partial* cause of (25a)
- GAM and standard SDRT get this example wrong.
- implicatures can be grounded; (25b) is at least part of the cause of (**??**a) is grounded.
- grounding can be implicated. (25a) and (25b) grounded as a byproduct of B’s speech act.

Partial successes

What was right about GAM

- marking individual commitments.

What was right about SDRT

- commitments made without explicit acknowledgements
- commitments persist until they are disavowed.

Representing individual commitments separately in SDRT

- Represent public commitments of each participant separately in 2 graphs 2 SDRSs that share labels and structure.
- Represent *all* the commitments at a given turn.
- interpretation of a dialogue will be the product of SDRS interpretations (one for each dialogue participant).
- Model grounded statements as those that are entailed by the commitments of each dialogue participant.

Revised commitments of participants in (25)

- A: (25a), (25b), Explanation(25a,25b);
- B: (25a), (25b), (25c), Explanation(25a, [25b,25c]), Narration(25b,25c).
- Common entailments of A's and B's public commitments: (25a), (25b) and that (25b) is part of the explanation of why (25a) happened.

(26) π_1 A: John entered the room.

π_2 B: He sat down.

π_3 A: He lit a cigarette.

π_4 B: He read the paper.

(27) $\pi : \mathit{Narration}(\pi_1, \pi_2) \wedge \mathit{Narration}(\pi_2, \pi_3)$

(28) $\pi'' : \mathit{Narration}(\pi_1, \pi_2) \wedge \mathit{Narration}(\pi_2, \pi_3) \wedge \mathit{Narration}(\pi_3, \pi_4)$

What's grounded: $\mathit{Narration}(\pi_1, \pi_2) \wedge \mathit{Narration}(\pi_2, \pi_3)$

A generalization

- `The Persistence Principle:`
  The undenied commitments of a constituent β in turn n persist to turn $n + 1$.

- `Undenied Commitments for simple left veridical relations:`
  If A commits to a type of speech act which entails the truth of B's utterance π_j —in other words A is committed to $R(\pi_j, pi_i)$ where R is simple left veridical, then for any R' and any π_k , as long as it's consistent to do so, the undenied commitments of π_j include $R'(\pi_k, \pi_j)$.

Persistence and Undenied Commitments hold trivially for monologue.

Turn	A's SDRS	B's SDRS
1	π_1	$\emptyset$
2	π_1	$\pi_{2B} : Narration(\pi_1, \pi_2)$
3	$\pi_{3A} : Narration(\pi_1, \pi_2) \wedge Narration(\pi_2, \pi_3)$	$\pi_{2B} : Narration(\pi_1, \pi_2)$
4	$\pi_{3A} : Narration(\pi_1, \pi_2) \wedge Narration(\pi_2, \pi_3)$	$\pi_{4B} : Narration(\pi_1, \pi_2) \wedge Narration(\pi_2, \pi_3) \wedge Narration(\pi_3, \pi_4)$

The troublesome example revisited

Turn	A's SDRS	B's SDRS
1	$\pi_{1A} : Explanation(\pi_1, \pi_2)$	$\emptyset$
2	$\pi_{1A} : Explanation(\pi_1, \pi_2)$	$\pi_{2B} : Explanation(\pi_1, \pi)$ $\pi : Narration(\pi_2, \pi_3)$

Another application of Persistence and Undenied Commitments

(29) π_1 A: Can I meet with you sometime in the next two weeks?

π_2 A: What days are good for you?

π_3 B: Well, I have some free time on almost every day except Fridays.

π_4 B: Fridays are bad.

π_5 B: So any day besides Friday we can probably work out a time.

π_6 A: Well next week I am out of town Tuesday, Wednesday and Thursday.

π_7 A: So perhaps Monday afternoon?

Turn	A's SDRS	B's SDRS
1	$\pi_{1A} : \textit{Q-Elab}(\pi_1, \pi_2)$	$\emptyset$
2	$\pi_{1A} : \textit{Q-Elab}(\pi_1, \pi_2)$	$\pi_{2B} : \textit{Q-Elab}(\pi_1, \pi_2) \wedge \textit{IQAP}(\pi_2, \pi)$ $\pi : \textit{Result} * (\pi', \pi_5)$ $\pi' : \textit{Explanation}(\pi_3, \pi_4)$
3	$\pi_{3A} : \textit{Q-Elab}(\pi_1, \pi_2) \wedge \textit{IQAP}(\pi_2, \pi) \wedge$ $\textit{Plan-Elab}(\pi, \pi_6) \wedge \textit{Q-Elab}(\pi_6, \pi_7)$ $\textit{Result*}(\pi_6, \pi_7)$	$\pi_{2B} : \textit{Q-Elab}(\pi_1, \pi_2) \wedge \textit{IQAP}(\pi_2, \pi)$ $\pi : \textit{Result} * (\pi', \pi_5)$ $\pi' : \textit{Explanation}(\pi_3, \pi_4)$

(30) π_1 B: John is not a good speaker

π_2 B: because he's hard to understand.

π_3 A: I agree that he's hard to understand.

The undenied commitments for acknowledgements correspond to the contents associated with their first arguments.

(31) π_1 A: John embezzled the funds.

π_2 B: No, BILL embezzled the funds.

π_3 A: OK

B's utterance commits him to *Correction*(π_1, π_2), and hence to the negation of K_{π_1}. But *B* has not denied every aspect of K_{π_1}, only what is in focus.

What *B* has not denied is of importance in computing what is acknowledged when a correction is acknowledged (π_3).

Strategies

Could revise structures to maintain consistency as in Asher and Lascarides (2003), but there are reasons for trying to avoid revision.

- clear preservation results for monotonic construction of SDRSs (which are like first order structures)
- avoid loss of information, incremental logical form construction and interpretation

As we do not represent grounding explicitly in logical form. This makes the monotonic construction of logical form feasible, even when corrections or ungrounding occurs.

In order to ensure that *A* remains committed to the undenied content when he acknowledges a correction, place this undenied content in a veridical part of *A*'s SDRS— it must be connected to the root label via a sequence of zero or more veridical relations.

- `Undenied Commitments for Acknowledgements of Corrections (AC):`
  If A acknowledges (explicitly or implicitly) π_j, where B's SDRS contains $Correction(\pi_i, \pi_j)$ and A was committed to π_i in the prior turn, then the undenied commitments of p_j include the undenied content of π_i, as long as it's consistent to do so.

(a) the undenied content of π_i computed recursively by replacing corrected labels that are outscoped by π_i with their undenied parts and veridical rhetorical relations that involved these labels with V, while preserving all other aspects of the content of π_i;

(b) the resulting representation of the undenied content of π_i is assigned a label that ensures it is in the same scopal position to the new root label as this content was to the root label for the prior turn;

(c) A *Background* relation is added between the last label in this undenied content and the label of the correcting segment (in dialogue (32), this introduces *Background*(π_2^b, π_{2B})), and assign this *Background* relation the same label as the undenied content of π_i.

Turn	A's SDRS	B's SDRS
1	π_1	$\emptyset$
2	π_1	$\pi_{2B} : Correction(\pi_1, \pi_2)$
3	$\pi_{3A} : \; Background(\pi_2^b, \pi_{2B}) \wedge$ $Acknowledgement(\pi_2, \pi_3)$	$\pi_{2B} : Correction(\pi_1, \pi_2)$

A more complex example

(32) π_1 A: John went to jail.

π_2 A: He embezzled the pension funds.

π_3 B: Bill embezzled the pension funds.

π_4 A: OK.

Turn	A's SDRS	B's SDRS
1	$\pi_{1A} : Explanation(\pi_1, \pi_2)$	$\emptyset$
2	$\pi_{1A} : Explanation(\pi_1, \pi_2)$	$\pi_{2B} : Correction(\pi_{1A}, \pi_3) \wedge Correction(\pi_2, \pi_3)$
3	$\pi_{3A} : V(\pi_1, \pi_2^b) \wedge Background(\pi_2^b, \pi_{2B}) \wedge Acknowledgement(\pi_3, \pi_4)$ $\pi_2^b : \exists x embezzle(e', x, funds)$	$\pi_{2B} : Correction(\pi_{1A}, \pi_3) \wedge Correction(\pi_2, \pi_3)$

Let D be a set of dialogue participants. Then a DSDRS (Dialogue SDRS) is a tuple $\langle n, T, \Pi, F, Last \rangle$, where:

- $n \in \mathcal{N}$ is a natural number (intuitively, $m \leq n$ is the m^{th} turn in the dialogue);
- Π is a set of labels;
- F is a function from Π into the SDRS-formulae $\mathcal{L}$;
- T is a mapping from $[1, n]$ to a function from D into SDRSs, such that each SDRS is drawn from Π and F. That is, if $T(m)(d_i) = \langle \Pi_m^{d_i}, F_m^{d_i}, Last_m^{d_i} \rangle$ for some $m \in [1, n]$ and some $d_i \in D$, then $\Pi_m^{d_i} \subseteq \Pi$ and $F_m^{d_i} =_{def} F \restriction \Pi_m^{d_i}$ (that is, $F_m^{d_i}$ is F restricted to $\Pi_m^{d_i}$), and $Last_m^{d_i} \in \Pi_m^{d_i}$.
- $Last =_{def} Last_n^d$, where d is the (unique) speaker of the last turn n

we will refer to the SDRS that T maps turn m and dialogue participant d_i to as $T^{d_i}(m)$. That is, $T(m)(d_i)$ may be written as $T^{d_i}(m)$.

Intuitively, T will map each turn and dialogue participant to an SDRS that represents everything he is publicly committed to up to that point. Note that F must be defined so that for each $F_m^{d_i}$ where $m \in [1, n]$ and $d_i \in D$, the relation $\succ$ on the nodes $\Pi_m^{d_i}$ meets the constraints specified in Definition 1.

- $\mathfrak{A} \times \mathfrak{B} \models \phi$ iff $\mathfrak{A} \models \phi$ and $\mathfrak{B} \models \phi$

This definition readily transfers to our dynamic setting Let $\mathcal{T} = \langle n, T, \Pi, F, Last \rangle$ be a DSDRS for dialogue participants D, and let $j \in [1, n]$ and $d_i \in D$. Let $\models_{m,}$ be the dynamic semantic entailment relationship afforded by $[\![.]\!]_m$ (semantics for monologue)

Definition 2 Grounding

- $\mathcal{T} \models_d \phi$ iff for all $d_i \in D$, $T^{d_i}(n) \models_m \phi$, where n is the last turn in the conversation.

(33) π_1 A: John embezzled a pension fund,

π_2 A: and he was convicted of tax evasion.

π_3 B: BILL embezzled the funds.

π_3' B: I agree he embezzled a pension fund.

- *A*'s commitments– π_{1A} : $Narration(\pi_1, \pi_2)$.
- π_3 must attach with *Correction* to π_{1A} (by denying that John embezzled the pension funds, he also denies that the narrative is true.)
- *B* is also committed to $Correction(\pi_1, \pi_3)$. π_1 should be available for attachment.
- Normal analyses of right frontier preclude $Correction(\pi_1, \pi_3)$.

(34) π_1 A: John embezzled a pension fund,

π_2 A: and he was convicted of tax evasion.

π_3 B: It wasn't a PENSION fund.

π_3' B: It was indeed a large pension fund.

(35) π_1 A: John came in, with a coat over his arm.

π_2 A: He sat down.

π_3 A: He drank a beer.

π_4 B: He didn't drink ANYTHING.

π_5 A: OK.

π_6 A: It was made of tweed.

Although *A* is committed to the proposition that John came in with a coat over his arm, the coordinating relation *Narration* makes π_1 unavailable for subsequent rhetorical connections

Given *Correction*(π_3, π_4), we have also *Correction*(π_{1A}, π_4)

Given *A*'s ackn of *B*'s correction π_4. AC says we must add a representation of undenied parts of π_3 and π_{1A} to *A*'s SDRS as well. The background part π_3^b of π_3 is $\top$,

So the undenied content of $\pi_{1A} = Narration(\pi_1, \pi_2)$. So π_2 is its last label, and so by AC part (c) it is connected to π_{2B} with *Background*. Finally, by part (b) of AC, we must label *Narration*(π_1, π_2) and *Background*(π_2, π_{2B}) so that their scopal position in the new SDRS is the same as the scopal position of *Narration*(π_1, π_2) in the prior SDRS. So it's assigned the root label.

Definition 3 Definition of Availability for DSDRSs

Let D be a set of discourse participants, and let $\langle n, T, \Pi, F, Last\rangle$ be a DSDRS for D. Furthermore, where $d_i \in D$ and $j \in [1, n]$, let $A_j^{d_i} \subseteq \Pi_j^{d_i}$ be the set of the available labels for the SDRS $T^{d_i}(j)$, as defined in Definition **??**. Then the set $A \subseteq \Pi$ of available labels for the DSDRS is defined as:

$$A = \bigcup_{d_i \in D} A_n^{d_i}$$

In other words, A is the union of all available labels from all the SDRSs for the last turn n.

What are commitments? Hamblin says commitments are distinct from beliefs—the standard view is to identify belief and commitment.

Gaudou, Longin and Herzig (2006):

(36) a. (In a private conversation) A to B: C is stupid.
b. (Later in the presence of B) A to C: You are not stupid.

A intuitively is lying in one of these dialogue situations.
His public commitments in the two discourses are not consistent, but his beliefs are not thereby inconsistent. B will be aware of this but not C.

Public commitments to what?

- Not just to contents of assertions
- but asking questions,
- making requests,
- making various relational speech acts (e.g., Explanations, Elaborations, Contrasts, Corrections)

(37) π_1 A: Can I meet with you sometime in the next two weeks?
π_2 A: What days are good for you?
π_3 B: Well, I have some free time on almost every day except Fridays.
π_4 B: Fridays are bad.
π_5 B: So any day besides Friday we can probably work out a time.
π_6 A: Well next week I am out of town Tuesday, Wednesday and Thursday.
π_7 A: So perhaps Monday afternoon?

(38) a. A: What did the committee decide?
b. B: That question is irrelevant.

A problem with SDRT's simple semantics

Questions and other speech acts can give rise to problems

(39) And if we were to get more serious, should I give him my name?

- In (Asher and Lascarides 2003), questions have as output a set of propositions. Could not be embedded (Asher 2007).
- and no clean model theoretic interpretation of rhetorical relations involving questions
- Groenendijk (2003) questions partition the information state.
- Asher (2007) lifts the distributive dynamic semantics to partitions or equivalence classes of the information state.

Let $M = \langle D, W, *, R_\Box, I\rangle$ be a model as defined in Definition **??**. And let $C, C', \ldots \subseteq (W \times F)^2$.

Then the CCP $[\![]\!]_m$ of $\mathcal{L}_{basic}$ is defined as follows:

1. $C[\![R(x_1, \ldots, x_n)]\!]^M_s C'$ iff

$$C' = \{\langle (w, f), (w', g)\rangle \in C : \begin{array}{l}(w, f)[\![R(x_1, \ldots x_n)]\!]^M_\delta (w, f) \text{ and} \\ (w', g)[\![R(x_1, \ldots, x_n)]\!]^M_\delta (w', g)\}\end{array}$$

2. $C[\![\exists x]\!]^M_m C'$ iff

$$C' = \{\langle (w, f'), (w', g')\rangle : \begin{array}{l}\langle (w, f), (w', g)\rangle \in C, \\ (w, f)[\![\exists x]\!]^M_\delta (w, f') \text{ and} \\ (w', g)[\![\exists x]\!]^M_\delta (w, g')\}\end{array}$$

3. $C[\![\phi \wedge \psi]\!]^M_m C'$ iff $C[\![\phi]\!]^M_m \circ [\![\psi]\!]^M_m C'$.

4. $C[\![\neg\phi]\!]^M_m C'$ iff
$C' = \{\langle(w, f), (w', g)\rangle \in C' : (w, f)[\![\neg\phi]\!]^M_\delta(w, f) \text{ and } (w', g)[\![\neg\phi]\!]^M_\delta(w', g)\}$

5. $C[\![\phi > \psi]\!]^M_m C'$ iff
$C' = \{\langle(w, f), (w', g)\rangle \in C : (w, f)[\![\phi > \psi]\!]^M_\delta(w, f) \text{ and } (w', g)[\![\phi > \psi]\!]^M_\delta(w', g)\}$

6. $C[\![?\lambda x_1 \ldots x_n\phi]\!]^M_m C'$ iff
C' refines the input partition by differentiating the world-assignment pairs that verify distinct complete answers answers to the question.

$C' = \{\langle (w, f), (w', g) \in C$:

- for each f' such that $dom(f') = dom(f) \cup \{x_1, \ldots, x_n\}$ and $f \subseteq f'$,
  there is a g' such that $dom(g') = dom(g) \cup \{x_1, \ldots x_n\}$ and $g \subseteq g'$, *and*
  $f'(x_i) = g'(x_i)$ for $1 \leq i \leq n$ and
  $\exists (w'', k), (w''', l)(w, f')[\![\phi]\!]^M_\delta (w'', k) \leftrightarrow (w', g')[\![\phi]\!]^M_\delta (w''', l)$ and
- conversely, for each g' such that $dom(g') = dom(g) \cup \{x_1, \ldots x_n\}$ and $g \subseteq g'$, there is a
  f' such that $dom(f') = dom(f) \cup \{x_1, \ldots, x_n\}$ and $f \subseteq f'$,
  $f'(x_i) = g'(x_i)$ for $1 \leq i \leq n$ and
  $\exists (w'', k), (w''', l)((w, f')[\![\phi]\!]^M_\delta (w'', k) \leftrightarrow (w', g')[\![\phi]\!]^M_\delta (w''', l)\}$

Various axioms on relations —e.g. the veridical schema— apply directly. $[\![]\!]_m$:

- `Veridical Schema:`
  $C[\![R(\pi_1, \pi_2)]\!]_m C'$ iff $C[\![K_{\pi_1} \wedge K_{\pi_2} \wedge \varphi_{R(\pi_1,\pi_2)}]\!]_m C'$

One relation of Narration for assertions, commands and questions:

(40) π_1 A: Who went to work yesterday?
π_2 A: Who did you see protesting?

Answers to the second question must form a Narrative sequence–i.e. answers to the second question must be people who went to work yesterday.

Other relations homogenized

(41) π_1 A: John arrived at the party at 8pm last night.

π_2 B: Who did he dance with? (narration)

(42) π_1 A: Max ate a lovely meal.

π_2 B: What did he eat? (elaboration)

(43) π_1 A: You should submit your paper.

π_2 B: Why? (explanation)

(44) a. A: Who kissed John?

b. B: Mary.

(44b) is an answer even if not exhaustive (contra Groenendijk and Stokhof).

Answer(p,q) is a test on the input context C: were C to be partitioned by the question q, then updating that context with p would remove all elements of the partition save those that specify a *de re* value for a wh-question or specify that there are no such elements.

- Semantics of QAP:
  $C[\![QAP(\alpha,\beta)]\!]_m C'$ iff $C[\![K_\alpha]\!]_m \circ [\![Answer(K_\alpha, K_\beta)]\!]_m \circ [\![K_\beta]\!]_m C'$

- Unlike most other formal theories of discourse structure, SDRT has a composition logic (Glue Logic or GL) for inferring discourse structures. GL tells you how to integrate the logical form for a new discourse unit with the representation of the antecedent discourse context using lexical and compositional semantics, prosody and syntax.
- The dynamic semantics for SDRT projects a complex context forward with multiple constaints.
- But GL is static. GL is a description logic. Its models are sets of DSDRSske a composition logic for clauses (λ calculus) it does not allow us to reason about continuations, what would happen if...
- Similarly for the cognitive modelling logic CL.

- This lack of attention to continuations seems wrong. Some discourse moves's content only affects future discourse (e.g. conversation exit moves, entrance moves, coordination moves).
- More generally, we want to reason about possible discourse moves and their cognitive effects. Representing agent's choices of discourse move and understanding why they make the moves they do. Such choice is, we assume, rationally based. Using reasoning based on preferences and beliefs.
- Explore the hypothesis that GL and CL can be extended for computing next moves, or continuations more generally.

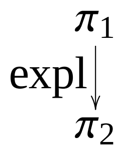
Review of semantics of standard GL

- $\mathcal{M}, s \models \phi$ iff $s \in V(\phi)$ for atomic ϕ
- $\mathcal{M}, s \models \phi \wedge \psi$ iff $\mathcal{M}, s \models \phi$ and $\mathcal{M}, s \models \psi$
- $\mathcal{M}, s \models \neg\phi$ iff $\mathcal{M}, s \not\models \phi$
- $\mathcal{M}, s \models \phi > \psi$ iff $*^{\mathcal{M}}(s, ||\phi||) \subseteq ||\psi||$, where $||\phi|| = \{s' \; : \; M, s' \models \phi\}$

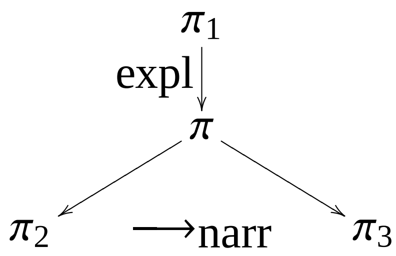
- Given an input SDRS (or family of SDRSs), find the available attachment sites.
- Compute the most plausible discourse relations for attaching the new information to a choice of site(s).
- Add the new information together with its relations to the antecedent discourse structure.

An example: B's turn in (25)

π_{1A} :



Updating with B's contribution:



Plausiblle reasoning in GL

Defeasible Modus Ponens: $\phi, \phi > \psi \mathrel{|\!\sim} \psi$

Penguin Principle: If $\phi \vdash \psi$ then $\phi, \phi > \chi, \psi > \neg\chi \mathrel{|\!\sim} \chi$

Nixon Diamond: If $\phi \nvdash \psi$ and $\psi \nvdash \phi$ then

$\phi, \psi, \phi > \chi, \psi > \neg\chi \mathrel{|\!\not\sim} \chi$
$\phi, \psi, \phi > \chi, \psi > \neg\chi \mathrel{|\!\not\sim} \neg\chi$

GL dynamized

- $\mathcal{M}, s \models [!\phi]\psi$ iff $\mathcal{M}^{\phi}, s \models \psi$ ($\phi >$ free)
- $\mathcal{M}, s \models [!\phi]^{cp}\psi$ iff $\mathcal{M}^{ct(\phi)}, s \models \psi$
- $\mathcal{M}^{\phi} = \langle S^{\phi} *^{\mathcal{M}} | S^{\phi}, V \rangle$, where
  - $S^{\phi} = S^{\mathcal{M}} \cap ||\phi||$
- $\mathcal{M}^{cp(\phi)} = \langle S^{cp(\phi)}, *^{\mathcal{M}} | S^{cp(\phi)}, V \rangle$, where
  - $S^{cp(\phi)} = \{s' \in S \ : \ Th(\mathcal{M}), \phi {\mid\!\sim} \psi \rightarrow M, s' \models \psi\}$

- $\sigma + \phi \vdash \psi$ iff $Th(\sigma) \models [!\phi]^{cp}\psi$
- Let $\Sigma_1, \ldots \Sigma_n$ be all the jointly compossible attachment sites of β in the set of all possible attachment sites for each DSDRS in $\mathcal{M}$ of new information about a new constituent β, ϕ_β and let $1 \ldots k_i$ be an enumeration of those compossible attachment sites in Σ_i. Then
- Update($\mathcal{M}, \phi_\beta$) has as consequence ψ iff $\forall s \in S^{\mathcal{M}}, \mathcal{M}, s \models [Last = \beta]\{[\lambda^1_1 :?(\alpha^1_1, \beta) \wedge T(d, m, \lambda^1_1) \wedge \ldots \wedge \lambda^1_{k_n} :?(\alpha^1_{k_1}, \beta) \wedge T(d, m, \lambda^1_{k_1}]^{cp}\psi \vee [\lambda^2_1 :?(\alpha^2_1, \beta) \wedge T(d, m, \lambda^2_1) \wedge \ldots \wedge \lambda^2_{k_2} :?(\alpha^2_{k_2}, \beta) \wedge T(d, m, \lambda^2_{k_2}]^{cp}\psi \vee \ldots \vee [\lambda^n_1 :?(\alpha^n_1, \beta) \wedge T(d, m, \lambda^n_1) \wedge \ldots \wedge \lambda^n_{k_n} :?(\alpha^n_{k_n}, \beta) \wedge T(d, m, \lambda^n_{k_n}]^{cp}\psi\}$

- **Reduction Axioms and Rules**
- $[\phi]p \leftrightarrow (\phi \rightarrow p)$
- $[\phi](\psi \wedge \chi) \leftrightarrow ([\phi]\psi \wedge [\phi]\chi)$
- $[\phi]\neg\psi \leftrightarrow \neg[\phi]\psi$
- $[\phi](\psi > \chi) \leftrightarrow ([\phi]\psi > [\phi]\chi)$
- $$\frac{\Gamma \vdash [\phi]^{cp}\psi}{\Gamma, \phi \mid\!\sim \psi}$$

Note that Since $\mid\!\sim$ is decidable, the reduction axioms rules show that our extension here is decidable as well.

- SDRT (Asher and Lascarides 2003) also contains a simple cogntivie modelling logic (CL) for inferring interactions between goals, beliefs and intentions and speech acts.
- Useful for deriving certain rules for discourse attachment, QAP, Q-elab.
- Couldn't model strategic conversation, where cooperativity isn't always operative (even as a default).
- Asher and Lascarides (2003) didn't specify contributions as commitments
- a non dynamic logic. Couldn't reason about updates.
- But following our proceedure for GL, we can dynamicize CL as well, opening the way to modifying agents's models of other participants' cognitive states, which in turn opens the way to an integration of strategic reasoning (real game theory) within a modelling of conversation.

What is left to be done– a lot

- study iterated games to simulate sequences of dialogue moves.
- study preferences change in iterations of dialogue moves.
- study best continuations discourse moves, given what has been revealed about preferences so far in more complex games.
- study whether to add qualitative probability. Is it possible to have a qualitative version of maximization of utility?
- in any case a rich area for research...