Discourse Structure in Dialogue

Lecture 3: The Logical Form of Narratives

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The need for defeasibility

– New information can change the interpretation of a dialogue at any time.

(1) α : May fell.
β : John kicked him.
$\rightsquigarrow \pi_0$: *Explanation*(α, β)

(2) α : May fell.
β : John kicked him.
γ : But this is not why he fell.
δ : John kicked him after he fell.
$\rightsquigarrow \pi_0$: *Narration*(α, π_1)
π_1 : *Contrast*$(\beta, \gamma) \wedge$ *Elaboration*(β, δ)

We’re going on a Tangent!

- We want to formalise the notion “typically” or “normally”.
- This is so we can say “typically, a discourse with such and such linguistic form has such and such narrative form” (construction of SDRSs)
- We also want to say something like “speaker A thinks that normally salmon and cheese are a great dinner”
- We do this in default logics, logics that license statements like “X entails Y unless it doesn’t”
- Because this is weird, I’m showing you one such logic.

Commonsense Entailment

Brief Excursion: Generics

- Prototypes:

(3) Birds (can) fly.

(4) Mammals give live birth.

- Habituals:

(5) John smokes.

(6) Lisa rides her bike to work.

- Mixed:

(7) Actors smoke.

Why We Care

– They Tolerate Exceptions

(8) Birds fly. (unless they are penguins)

(9) Mammals give live birth. (unless they are platypus)

(10) John smokes. (except when he's trying to quit)

(11) Lisa rides her bike to work (unless it rains).

(12) Actors smoke. (not all; not always)

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(12) Actors smoke. (not all; not always)

- The exceptions do not seem to impeach on our intuitions that the statements are, somehow, true.

Reasoning with Exceptions

- We feel entitled to use these sentences in inference.

(13) Birds fly.
Tux is a bird.
———————
Tux flies.

(14) Julian uses the whiteboard to teach.
Julian is teaching.
———————————————
Julian is using the whiteboard.

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Julian is using the whiteboard.

– We feel that such inferences blocked without contradiction.

(15) Birds fly.
Tux is a bird.
Tux doesn't fly (he's a penguin!).
―――――――
~~Contradiction.~~

They are *intensional*, too!

(16) Mail from Antarctica goes to Helena.
(we've never gotten any mail from Antarctica)

(17) This button makes decaf coffee.
(nobody ever pressed that button).

(18) Around here, we help each other out in emergencies.
(there has never been an emergency)

- The generic statement need not occur even once.

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- The generic statement need not occur even once.

$\Rightarrow$ Extensional analysis is generally incorrect.

- (e.g. frequency, proportion, similarity to a prototype)

The Epistemic Argument (Pelletier & Asher 1997)

- Exception-tolerant statements form a large part of our knowledge.
  - → And that knowledge is true, inferentially tractable, *good*.
  - → "intellectually satisfying and practically useful" (P&A 97)

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- Commonsense Knowledge.
- $\approx$ the knowledge of regularity while being simultaneously aware that regularities can be broken.

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- Commonsense Knowledge.
- $\approx$ the knowledge of regularity while being simultaneously aware that regularities can be broken.
- That is, we want:

(a) Truth-conditional semantics *for* commonsense knowledge.

(b) Inference *on* commonsense knowledge.

Default Logic

- Default Logics are logics of nonmonotonic inference.
  - → Monotonicity: If $\Gamma \vdash \psi$ then $\Gamma, \varphi \vdash \psi$.
- The idea is that added information can cancel inferences.
  - → "A entails B ($A \vdash B$) unless it happens to be the case that $\neg B$. Then A doesn't entail B ($A, \neg B \nvdash B$)
  - → "A entails B unless we are in a state where it A came to be through **abnormal circumstances**, in which A doesn't entail B."

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  - → "A entails B unless we are in a state where it A came to be through **abnormal circumstances**, in which A doesn't entail B."
- Goal: define an ceteris paribus-conditional $>$ and with a default entailment relation $\mid\!\sim$ (default inference).
- Defeasible Modus Ponens:
  $A, A > B \mid\!\sim B$.
  $A, A > B, \neg B \mid\!\not\sim B$.

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- $\textit{generic}(P)x.Q(x) \;=\; \forall x.Px > Qx$. (P&A 1997)

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- $generic(P)x.Q(x) \;=\; \forall x.Px > Qx$. (P&A 1997)
- This means that "birds fly" expands to "if I have an *x* that is a bird, then I have an *x* that flies, unless *x* happens to be a bird that doesn't fly"
- Write this as "if I have an *x* that is a bird, then I have an *x* that flies, unless *x* **happens to be an abnormal bird**"

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- For simplicity, let's not worry about quantifiers and zoom in on the propositional logic semantics of >.

Simple Transformations

(19) Birds fly.

Airplanes fly.

Things that are Birds or Airplanes fly.

- $b > f, a > f \mid\!\sim (b \vee a) > f$.
  (Disjunction of the Antecedent).

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Fliers must have wings.

Birds have wings.

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  (Closure in the Consequent).

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(21) Birds fly.

Birds fly or swim.

- $b > f \mid\!\sim b > (f \vee s)$. (Consequent Weakening).

The Nixon Diamond

(22) Richard Nixon is a Quaker.
Richard Nixon is a Republican.
Republicans are warmongers.
Quakers are pacifists.

~~Nixon is a warmonger~~.
~~Nixon is a pacifist~~.

- When in doubt, conclude neither.

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- When in doubt, conclude neither.
- $q, r, r > w, q > p, \neg(w \wedge p) \not\vdash p$
- $q, r, r > w, q > p, \neg(w \wedge p) \not\vdash w$

The Penguin Principle

(23) Birds fly.

Penguins don't fly.

Penguins are birds (by definition).

Tux is a penguin.

~~Tux flies.~~

Tux doesn't fly.

- The more specific inference wins.

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Penguins are birds (by definition).

Tux is a penguin.

~~Tux flies.~~

Tux doesn’t fly.

- The more specific inference wins.

(24) Birds fly.

Penguins don’t fly.

All Penguins are Birds.

Penguins with jetpacks fly.

Tux is a *jetpack* penguin

~~Tux doesn’t fly.~~

Tux flies.

Antecedent Strengthening?

(25) Birds fly.
$\overline{\hspace{6em}}$
Red Birds fly.

(26) Birds fly.
$\overline{\hspace{7em}}$
??Dead Birds fly.

- It is possible to phrase a cautious version of this.
- $p > q \mid\!\sim (p \wedge r) > q$, but not
- $p > q, (p \wedge r) > \neg q \mid\!\sim (p \wedge r) > q$.

Truth–Conditions for $>$

- The idea is that $p > q$ is true if in all circumstances where p holds and these are normal circumstances for p, then q holds.

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- The idea is that $p > q$ is true if in all circumstances where p holds and these are normal circumstances for p, then q holds.
- We express this with the following modal semantics.

Commonsense Entailment Frames

A commonsense entailment frame is a tuple $\langle W, *\rangle$ where W is a set of worlds (propositional models) and $* : W \times \mathcal{P}(W) \rightarrow \mathcal{P}(W)$ is a function such that:

- for all $w \in W$, $*(w, X) \subseteq X$,
- If $*(w, X) \subseteq Y$ and $*(w, Y) \subseteq X$, then $*(w, X) = *(w, Y)$.
- for all w, X, Y: $*(w, X \cup Y) \subseteq *(w, X) \cup *(w, Y)$ ("Dudley Doorite").

The Logic of Commonsense Entailment (cont.)

Truth

A commonsense entailment model is a structure $\langle W, *, V \rangle$ such that $\langle W, * \rangle$ is a CE frame and $V : W \to \mathcal{P}(\mathrm{At})$ is a valuation.

- $M, w \Vdash p$ iff $p \in V(w)$ for atoms p.
- $M, w \Vdash \neg A$ iff $M, w \nVdash A$.
- $M, w \Vdash A \wedge B$ iff $M, w \Vdash A$ and $M, w \Vdash B$.
- $M, w \Vdash \Box A$ iff for all v, $M, v \Vdash A$.
- $M, w \Vdash A > B$ iff $*(w, [\![A]\!]) \subseteq [\![B]\!]$
  where: $[\![\varphi]\!] = \{w' \in W \mid M, w' \Vdash \varphi\}$.

- A proposition A roughly corresponds to a set of worlds $[\![A]\!]$.
- We interpret $*$ to select all the worlds where A is normal.
- So the truth–conditions of $A > B$ are circumscribed as "everywhere where A is normally true, B is true."

Monotonic Commonsense Entailment

Validity

$\Gamma \models A$ iff on all models M and for all $w \in W^M$:
if $M, w \Vdash \Gamma$ then $M, w \Vdash A$.

- Standard arguments (finite model property) show that this is decidable for finite Γ.

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Lemma: Disjunction of the Antecedent

$\models ((p > r) \wedge (q > r)) \rightarrow ((p \vee q) > r)$.

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Lemma: Disjunction of the Antecedent

$\models ((p > r) \wedge (q > r)) \rightarrow ((p \vee q) > r))$.
Proof: Suppose $M, w \Vdash (p > r) \wedge (q > r)$. Then:
$*(w, [\![p \vee q]\!]) = *(w, [\![p]\!] \cup [\![q]\!]) \subseteq *(w, [\![p]\!]) \cup *(w, [\![q]\!]) \subseteq [\![r]\!]$. $\square$

Closure in the Consequent

- $\models \big(\Box(B \rightarrow C) \wedge (A > B)\big) \rightarrow (A > C)$.

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- $\models \big(\Box(B \to C) \land (A > B)\big) \to (A > C)$.
- Proof:
  - Fix a model M and a world w.
  - Assume $M, w \Vdash \Box(B \to C) \land (A > B)$.
  - By the first conjunct, $[\![B]\!] \subseteq [\![C]\!]$.
  - By the second conjunct, $*(w, [\![A]\!]) \subseteq [\![B]\!]$.
  - Hence $*(w, [\![A]\!]) \subseteq [\![C]\!]$.

Towards Defeasible Modus Ponens

- We now have a truth definition and a monotonic entailment relation that tells us from facts about generic statements further true generic statements.
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- But we want to know what to infer from $A, A > B$.
- So we know that if "Birds fly" and "Fliers have wings" that "Birds have wings", but we do not know that "Birds fly, Tux is a bird" (nonmonotonically) entails that "Tux flies."

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- We need a definition of $\mid\!\sim$ that valildates $A, A > B \mid\!\sim B$ and $A, A > B, \neg B \not\mid\!\sim B$.
- We are inclined to just take all normal worlds and check what is going on there.
  - → However, $>$ embeds and thus this needs to be recursed. This is bonkers complicated.

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- Let Γ be a finite set of formulae. Define:

$$\mathrm{Ant}(\Gamma) = \{A \mid \Gamma \models A > B \text{ for some } B\}.$$

For any $A \in \mathrm{Ant}(\Gamma)$ define:

$$\Gamma^A = \{(A > B) \to (A \to B) \mid \Gamma \models A > B\}.$$

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- An extension of Γ is an immediate extension of Γ or an immediate extension of an extension of Γ.

Commonsense Entailment (finally)

Propositional Commonsense Entailment

$\Gamma \mathrel{|\!\!\sim} A$ iff $\Gamma^{\rightarrow} \models A$ for all maximally satisfiable extensions $\Gamma^{\rightarrow}$ of Γ.

- Recall that $\models$ is decidable; thus $\Gamma \mathrel{|\!\!\sim} A$ is decidable.

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- Recall that $\models$ is decidable; thus $\Gamma \mathrel{|\!\sim} A$ is decidable.
- It is easy to see that Defeasible Modus Ponens holds:
  - → $A, A > B \mathrel{|\!\sim} B$ and $A, A > B, \neg B \mathrel{|\!\not\sim} B$.
  - → But $A, A > B, C \mathrel{|\!\sim} B$ if C is not a defeater for B.
  - → Because without a defeater, $(A > B) \rightarrow (A \rightarrow B)$ is in every consistent extension.

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- It is easy to see that Defeasible Modus Ponens holds:
  - $\rightarrow$ $A, A > B \mathrel{|\!\sim} B$ and $A, A > B, \neg B \mathrel{|\!\not\sim} B$.
  - $\rightarrow$ But $A, A > B, C \mathrel{|\!\sim} B$ if C is not a defeater for B.
  - $\rightarrow$ Because without a defeater, $(A > B) \rightarrow (A \rightarrow B)$ is in every consistent extension.
- Nixon Diamond:
  - $\rightarrow$ $A > B, C > \neg B, C, A \mathrel{|\!\not\sim} B$.
  - $\rightarrow$ $A > B, C > \neg B, C, A \mathrel{|\!\not\sim} \neg B$.
  - $\rightarrow$ Because there are consistent extensions with B and with $\neg B$.

Specificity (kudos to Michael Morreau)

- We need one more lemma for the penguin principle:
- $\models \big(\Box(P \to B) \wedge (B > F) \wedge (P > \neg F)\big) \to (B > \neg P)$.
  (Penguins are birds, birds fly, penguins do not fly.
  Thus, normal birds are not penguins.)

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- $\models \big(\Box(P \to B) \wedge (B > F) \wedge (P > \neg F)\big) \to (B > \neg P)$.
  (Penguins are birds, birds fly, penguins do not fly.
  Thus, normal birds are not penguins.)
- Proof:
  - Fix a model M and a world w. Assume the antecedent of the conditional.
  - Then $[\![P]\!] \subseteq [\![B]\!]$, i.e. $[\![B]\!] = ([\![B]\!] \setminus [\![P]\!]) \cup [\![P]\!]$.
  - Then $*(w, [\![B]\!]) \subseteq *(w, [\![B]\!] \setminus [\![P]\!]) \cup *(w, [\![P]\!])$ by DD.
  - Also $*(w, [\![P]\!]) \subseteq [\![\neg F]\!]$ and $*(w, [\![B]\!]) \subseteq [\![F]\!]$.
  - So $*(w, [\![P]\!])$ and $*(w, [\![B]\!])$ are disjoint.
  - Thus $*(w, [\![B]\!]) \subseteq *(w, [\![B]\!] \setminus [\![P]\!])$.
  - Hence $*(w, [\![B]\!]) \subseteq [\![B]\!] \setminus [\![P]\!] \subseteq [\![\neg P]\!]$. $\square$

The Penguin Principle

- To show: $\Box(P \rightarrow B), B > F, P > \neg F, P \mid\!\sim \neg F$.

  (Penguins are Birds; Birds fly; Penguins don't fly; we have a penguin $\mid\!\sim$ it doesn't fly)

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  (Penguins are Birds; Birds fly; Penguins don't fly; we have a penguin $\mathrel{|\!\sim}$ it doesn't fly)

- Proof.
  - Let $\Gamma = \{\Box(P \to B), B > F, P > \neg F, P\}$.
    Then, $\mathrm{Ant}(\Gamma) = \{A \mid \Gamma \models A > X \text{ for some } X\} = \{P, B\}$.
  - We know: $\models \big(\Box(P \to B) \wedge (B > F) \wedge (P > \neg F)\big) \to (B > \neg P)$.
  - So $\Gamma \models B > \neg P$.
  - So it is inconsistent to extend Γ with the antecedent *B*:
    $\Gamma \cup \{(B > \varphi) \to (B \to \varphi) \mid \Gamma \models B > \varphi\} \models P \wedge \neg P$.
  - Thus *B* as an antecedent is defeated. All maximally consistent extensions of Γ contain $P \to \neg F$.
  - So we get $\Gamma \mathrel{|\!\sim} \neg F$. $\Box$

Commonsense Entailment

Context Update

Commonsense Entailment

Context Update

Modifications to DRT

- DRT hat the connectives $\neg$, $\vee$ and $\Rightarrow$.
- We want to regiment $\vee$ and $\Rightarrow$ in the narrative structure, so we remove them from the microstructure.
  - $\rightarrow$ But we keep how DRT does quantification!
- But we want to include “might” ($\Diamond$) and “typically” ($>$), so add these to DRT.
- The SDRS microstructure is DRT with $\neg$, $\Diamond$, $>$ and $\Rightarrow$ as connectives.

Modifications to Commonsense Truth

Quantifier-free Commonsense Entailment Models

A **qf** commonsense entailment model is a structure $\langle W, *, D, I \rangle$ such that $\langle W, * \rangle$ is a CE frame, **D is a set of referents, I is an interpretation that assigns a set of tuples to each predicate**. Then, for a variable assignment f:

- $M, w, f \Vdash R(x_1, ..., x_n)$ **iff** $(f(x_1), ..., f(x_n)) \in I(R)$**.**
- $M, w, f \Vdash \neg A$ iff $M, w, f \nVdash A$.
- $M, w, f \Vdash \Box A$ iff for all v, $M, v, f \Vdash A$.
- $M, w, f \Vdash A > B$ iff $*(w, [\![A]\!]) \subseteq [\![B]\!]$
  where: $[\![\varphi]\!] = \{w' \in W \mid M, w', f \Vdash \varphi\}$.

Microstructure Vocabulary

Variables ($x, y, \ldots, e_1, e_2, \ldots$); Name symbols (John, Max, ...); Predicate symbols (`eat`, `overlap`, ...); logical connectives ($=, >, \Rightarrow, \neg, \Diamond$).

Microstructure Formulas (DRSs)

A DRS is a tuple $\langle U, Cond \rangle$ where U is a set of variables, and $Cond$ is a set of conditions.

- For a name N and a variable x, $N(x)$ is a condition.
- For a predicate P and variables $x_1, \ldots, x_n$, $P(x_1, \ldots, x_n)$ is a condition.
- For variables x and y, $x = y$ is a condition.
- If C_1 and C_2 are DRSs, $C_1 > C_2$, $C_1 \Rightarrow C_2$, $\neg C_1$ and $\Diamond C_1$ are conditions.

(add more as needed!)

Microstructure Evaluation (now with worlds!)

Microstructure Semantics

Let $M = (W, *, I)$ be a qf commonsense entailment model. Define by simultaneous recursion for any $w \in W$:

1. $f[\![\langle U, Cons\rangle]\!]_{M,w}g$ iff $f[\langle U, Cons\rangle]_{M,w}g$ and $M, w, g \models_{micro} C$ for all $C \in Cons$.
2. $M, w, f \models_{micro} R(x_1, \cdots, x_n)$ iff $M, w, f \models R(f(x_1), \cdots, f(x_n))$.
3. $M, w, f \models_{micro} \neg K$ iff there is no g with $f[\![K]\!]_{M,w}g$.
4. $M, w, f \models_{micro} \Diamond K$ iff there is a $v \in W$ and a g with $f[\![K]\!]_{M,v}g$
5. $M, w, f \models_{micro} K_1 \Rightarrow K_2$ iff for every g with $f[\![K_1]\!]_{M,w}g$ there is a h with $g[\![K_2]\!]_{M,w}h$.

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2. $M, w, f \models_{micro} R(x_1, \cdots, x_n)$ iff $M, w, f \models R(f(x_1), \cdots, f(x_n))$.
3. $M, w, f \models_{micro} \neg K$ iff there is no g with $f[\![K]\!]_{M,w}g$.
4. $M, w, f \models_{micro} \Diamond K$ iff there is a $v \in W$ and a g with $f[\![K]\!]_{M,v}g$
5. $M, w, f \models_{micro} K_1 \Rightarrow K_2$ iff for every g with $f[\![K_1]\!]_{M,w}g$ there is a h with $g[\![K_2]\!]_{M,w}h$.
6. For M, g let $N^{M,g}(K)$ be the set of all worlds v such that there is a h with $g[\![K]\!]_{M,v}h$. Then: $M, w, f \models_{micro} K_1 > K_2$ iff:
   for any $v \in *(w, N^{M,f}(K_1))$ and g such that $f[\![K]\!]_{M,v}g$, there is a h such that $g[\![K_2]\!]_{M,v}h$

Sidenote: The trick about "might"

- The interesting thing about the clause for $\Diamond$ is that $\Diamond K$ doesn't effect a context update:
- If $f[\![\Diamond K]\!]_{M,w}g$ then $f = g$.
- But if $f[\![K]\!]g$ then (generally) $f \neq g$.

Sidenote: The trick about "might"

- The interesting thing about the clause for $\Diamond$ is that $\Diamond K$ doesn't effect a context update:
- If $f[\![\Diamond K]\!]_{M,w}g$ then $f = g$.
- But if $f[\![K]\!]g$ then (generally) $f \neq g$.
- (this is in general not quite right because of modal subordination)

(27) A wolf might come in. It would eat Julian first.

- But it's good enough for present purposes.

One more thing...

- Note that "microstructure" is just about clauses.
- Recall that we associated events with verb phrases.
- Let's call the event associated with the main verb phrase of a clause its semantic index.
- Let's refer to the semantic index of a microstructure K e_K.
- Or, if K is labelled by π, also e_π.

Reminder: Outscoping

Outscoping

- Note that $\mathcal{F}$ induces an order on Π.
- Say that $\alpha < \beta$ iff α occurs in $\mathcal{F}(\beta)$.
- Let $\prec$ denote the reflexive transitive closure of $<$.
- Call this relation “outscoping”.

Interpretable SDRS

- A SDRS (Π$, \mathcal{F},$ *L*) is well formed if:
- There is a unique outscoping-maximal label in Π (“root”).
- $\prec$ is anti-symmetric (in particular, then, it has no circles)

- To define evaluation/truth we need a more expressive language than the one we write SDRSs in.

Macrostructure Vocabulary

DRSs; discourse relation symbols (Elaboration, Narration, ...); label variables (π, λ, ...); logical connectives ($\neg$, $>$, $\Rightarrow$, $\wedge$, $\Diamond$).

Macrostructure Formulas

- Any DRS *K* is a macrostructure formula.
  (DRSs are like the atoms of the macrostructure)
- For a discourse relation *R* and label variables α, β, $R(\alpha, \beta)$ is a macrostructure formula.
- If *P* and *Q* are macrostructure formulae, then so are $P \wedge Q$, $\neg P$, $\Diamond P$, $P > Q$, $P \Rightarrow Q$.

Truth and Update

- Let P be a macrostructure formula, w be world worlds, f, g be variable assignments, M be a model, and $S = (\Pi, \mathcal{F}, L)$ be an SDRS such that all labels that appear in P are members of Π.
- We wish to define what it means that $f[\![P]\!]^S_{M,w} g$.
- So if you start with a *set* of possible worlds W and an assignment f, and you want to *narrow* this set down to the worlds that support the information in an SDRS $S = (\Pi, \mathcal{F}, L)$, you compute which world-assignment pairs are not ruled out by the content of S's root label π_0:

$$\{(v, g) \mid \text{there is a } w \in W \text{ such that } f[\![\mathcal{F}(\pi_0)]\!]^S_{M,w} g)\}$$

Macrostructure Evaluation (the idea)

- We recursively translate a macrostructure formula P into a *microstructure* K such that update with K represents the information in P (not as hard as it sounds!).

- A bit of notation:

- For two DRSs $K_1 = \langle U_1, C_1 \rangle$, $K_2 = \langle U_2, C_2 \rangle$, define $K_1 + K_2 = \langle U_1 \cup U_2, C_1 \cup C_2 \rangle$.

Macrostructure-to-Microstructure

Given an SDRS $S = (\Pi, \mathcal{F}, L)$, translate a macro formula P to a DRS $[\![P]\!]^S$ (say, *P interpreted in the narrative structure S*).

1. If $P = K$ for a DRS K, then $[\![P]\!]^S = K$.

2a. If $P = Q_1 \wedge Q_2$, then $[\![P]\!]^S = [\![Q_1]\!]^S + [\![Q_2]\!]^S$.

2b. If $P = \neg Q$, then $[\![P]\!]^S = \boxed{\begin{array}{c} \\ \hline \neg [\![Q]\!]^S \end{array}}$

2c. If $P = \Diamond Q$, then $[\![P]\!]^S = \boxed{\begin{array}{c} \\ \hline \Diamond [\![Q]\!]^S \end{array}}$

2d. If $P = Q_1 > Q_2$, then $[\![P]\!]^S = \boxed{\begin{array}{c} \\ \hline [\![Q_1]\!]^S > [\![Q_2]\!]^S \end{array}}$.

2e. If $P = Q_1 \Rightarrow Q_2$, then $[\![P]\!]^S = \boxed{\begin{array}{c} \\ \hline [\![Q_1]\!]^S \Rightarrow [\![Q_2]\!]^S \end{array}}$.

3. If $P = R(\alpha, \beta)$ for a veridical discourse relation R, then $[\![P]\!]^S = [\![\mathcal{F}(\alpha) \wedge \mathcal{F}(\beta) \wedge Info_R(\mathcal{F}(\alpha), \mathcal{F}(\beta))]\!]^S$

   where $Info_R$ is the specific semantic contribution provided by the relation R (a meaning postulate).

- For example, Narration is veridical and adds the information that events are reported in order:

$$\mathit{Info}_{\text{Narration}}(\mathcal{F}(\alpha), \mathcal{F}(\beta)) = e_\alpha \prec e_\beta \wedge \mathit{end}(e_\alpha) \approx \mathit{start}(e_\beta)$$

- Elaboration is veridical and adds that the second content defeasibly entails the first, but not vice versa, and that the evens overlap:

$$\mathit{Info}_{\text{Elab}}(\mathcal{F}(\alpha), \mathcal{F}(\beta)) = (K_\beta > K_\alpha) \wedge \neg(K_\alpha > K_\beta) \wedge \mathit{part\text{-}of}(e_\beta, e_\alpha)$$

- Explanation is veridical and adds that the second event caused the first.

$$\mathit{Info}_{\text{Expl}}(\mathcal{F}(\alpha), \mathcal{F}(\beta)) = \mathit{cause}(e_\beta, e_\alpha) \wedge \neg(e_\alpha \prec e_\beta)$$

CDUs

– Wait, Julian, what about CDUs that are parts of further discourse relations?

CDUs

- Wait, Julian, what about CDUs that are parts of further discourse relations?

- I'm glad you ask: we also need to assign non-microstructure events a semantic index. So, technically:

$$\textit{Info}_{\text{Narration}}(\mathcal{F}(\alpha), \mathcal{F}(\beta)) = \boxed{\begin{array}{l} e \\ \hline \textit{part-of}(e_\alpha, e) \\ \textit{part-of}(e_\beta, e) \\ e_\alpha \prec e_\beta \end{array}}$$

While we are being technical...

- Actually, if we are being *super* precise, we need to keep track of which label in the SDRS we are evaluating gave rise to this $\mathit{Info}_{\text{Narration}}$ so that we can assign e to that label.

- So we *should* write:

3. If $\mathcal{F}(\pi) = R(\alpha, \beta)$ for a veridical discourse relation R, then $f[\![\mathcal{F}(\pi)]\!]^S_{M,w}g$ iff $f[\![\mathcal{F}(\alpha) \wedge \mathcal{F}(\beta) \wedge \mathit{Info}_R(\pi, \mathcal{F}(\alpha), \mathcal{F}(\beta))]\!]^S_{M,w}g$ where Info_R is the specific semantic contribution provided by the relation R.

$$\mathit{Info}_{\text{Narration}}(\pi, \mathcal{F}(\alpha), \mathcal{F}(\beta)) = \boxed{\begin{array}{l} e_\pi \\ \hline \mathit{part\text{-}of}(e_\alpha, e_\pi) \\ \mathit{part\text{-}of}(e_\beta, e_\pi) \\ e_\alpha \prec e_\beta \end{array}}$$

Evaluating SDRSs

- When we evaluate an entire SDRS $(\Pi, \mathcal{F}, L)$, we find its root label π_0 and compute $[\![\mathcal{F}(\pi_0)]\!]$.
- By design, this runs through the entire SDRS.
- In some SDRSs we might hit the same label multiple times; this is harmless since this just repeats information we already know.

(28) π_1 : John had a great day.

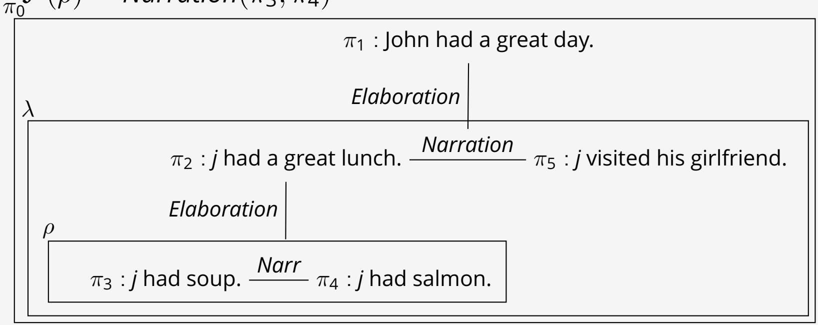
π_2 : He had a great lunch .

π_3 : He had soup.

π_4 : Then he had salmon.

π_5 : Afterwards, he visited his girlfriend.

- $\Pi = \{\pi_0, \pi_1, \pi_2, \pi_3, \pi_4, \pi_5, \lambda, \rho\}$, $L = \pi_5$.
- $\mathcal{F}(\pi_0) =$ *Elaboration*(π_1, λ)
- $\mathcal{F}(\lambda) =$ *Elaboration*$(\pi_2, \rho) \wedge$ *Narration*(π_2, π_5)
- $\mathcal{F}(\rho) =$ *Narration*(π_3, π_4)



A non-veridical relation

- For non-veridical relations we need to give special evaluation clauses. Correction is quite interesting. Somewhat simplified, its semantics are:

4. If $\mathcal{F}(\pi) = \text{Correction}(\alpha, \beta)$, then $f[\![\mathcal{F}(\pi)]\!]^{S}_{M,w}g$ iff there is a h such that $f[\mathcal{F}(\alpha)]h$ (note the single brackets) and $h[\![\mathcal{F}(\beta) \wedge \mathit{Info}_{\mathit{Correction}}(\pi, \mathcal{F}(\alpha), \mathcal{F}(\beta))]\!]^{S}_{M,w}g$

$$\mathit{Info}_{\text{Corr}}(\pi, \mathcal{F}(\alpha), \mathcal{F}(\beta)) = \neg(\mathcal{F}(\alpha) \wedge \mathcal{F}(\beta))$$

A non-veridical relation

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$$\mathit{Info}_{\mathrm{Corr}}(\pi, \mathcal{F}(\alpha), \mathcal{F}(\beta)) = \neg(\mathcal{F}(\alpha) \wedge \mathcal{F}(\beta))$$

- The role of the single brackets:

(29) a. There is a cat outside.
b. No it's a dog.
$\Big]$ Correction

What do these semantics do?

(30) a. Frank doesn't have classic cars.
b. He has two 1967 spiders.

$\Big]$ Correction

- You learn that 1967 spiders are classic cars, because the "surviving worlds" in this update are *only* worlds where it is false that (Frank no classic cars & Frank has two 1967 spiders).
- These are exactly the worlds where this conditional is true: *Frank has two 1967 spiders* → *Frank has classic cars*
- Much the same can be said about the updates effected by Elaboration or Explanation (and many other relations).

- For more relations please refer to the glossary.
- Note however that the micro- and macrostructure is a good deal more expressive in the glossary (and in the book it’s from).
- But this additional expressivity is not *conceptually* different—if you get all this here, it is easy to extend the language with whatever you need.