Problem of Universality in the Logic(s) of Speech Acts

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Philosophical motivation

To investigate the relation between language and the mind.

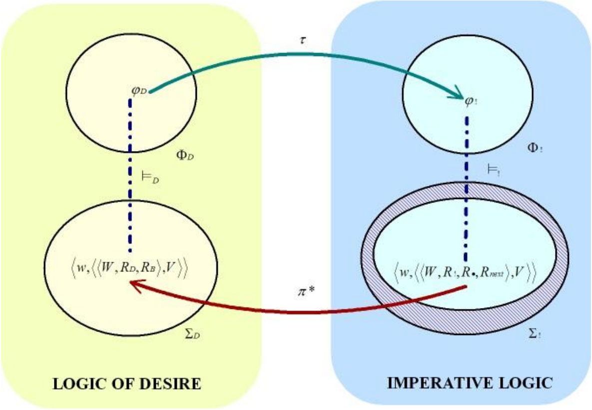
Tractatus logico-philosophicus

- 4.014
- The gramophone record, the musical thought, the score, the waves of sound, all stand to one another in that **pictorial internal relation**, which holds between language and the world.
- **To all of them the logical structure is common**.

- 4.0141
- In the fact that there is a general rule by which the musician is able to read the symphony out of the score, and that there is a rule by which one could reconstruct the symphony from the line on a gramophone record and from this again -- by means of the first rule -- construct the score, herein lies the internal similarity between these things which at first sight seem to be entirely different. And the rule is the **law of projection** which projects the symphony into the language of the musical score. It is the **rule of translation** of this language into the language of the gramophone record.

Modifying Tractatus

- **The gramophone record, the musical thought, the score, the waves of sound, all stand to one another in that pictorial internal relation, which holds between language and **the mind** [L.W.: the world]. To all of them the logical structure is common.**
- If there is a common logical structure, then there must be a “translation” and a “projection” between language and the mind.



Philosophical motivation

- The logical character of reason explanation.
  - Unresolved problem in philosophy (of action, of mind, of science etc.).
  - The crucial problem for foundation of “idiographic” (“hermeneutic”) science.
- The character of consequence relation..
  - Premises rationally require the conclusion (John Broome).
    - Two types of rationality:
      - Horizontal (relation between intentional states).
      - Vertical (relation between intentional states plus relation to the “real world”).
  - Premises make conclusion *prima facie* acceptable (Donald Davidson).

Some other philosophical inspiration and similar approach

- Measurement-theoretic approach to the semantics of "propositional attitude reports" (Davidson).
  - Just as in measuring weight we need a collection of entities which have structure in which we can reflect the relations between weighty objects, so in attributing states of belief (and other propositional attitudes) we need a collection of entities *related in the ways that will allow us to keep track of the relevant properties and relations* among the various psychological states.
    - D. Davidson. *Subjective, Intersubjective, Objective*. Oxford University Press, 2001.
- [Conjecture] Perhaps the "measurement space" required for the semantics of "propositional attitude reports" lies in the logic of speech acts.
  - If so, then logic of intentionality and logic of speech acts are connected.

Methodology

- Hypothesis to attack:
  - There is no *connection* between the **logic of intentional states** and **logic of speech acts**.
- Falsification attempt.
  - The hypothesis will be falsified if it can be proved that there is a connection between the logics of the two sorts.

Pretheoretical conception

Connection between logics

Terminological problem

- What it means for logics to be *connected*?
  - Proposal: *semantic coordination* between two logics shows that they are *connected*.
  - If a consequence (*sequitur*) and "nonconsequence" (*non sequitur*) relation of one logic (source logic) can be mimicked (preserved) by another (target logic), then they are connected.

Reasons to beleive there is connection

1. Successful logical theories.
2. Phenomenology.

Theoretical background

- Dynamic semantics gives a conceptual ground for the plausibility of connection between logics of intentional states and logics of speech acts.
  - **Meaning of a sentence may be understood in terms of change in Hearer's mental state and in terms of "social change" that the utterance of the sentence may bring about.**
    - Groenendijk, Stokhof, Veltman, Van Benthem and many others.
    - Metaphor: "natural language is the programming language of the human mind" (J.V. B.).

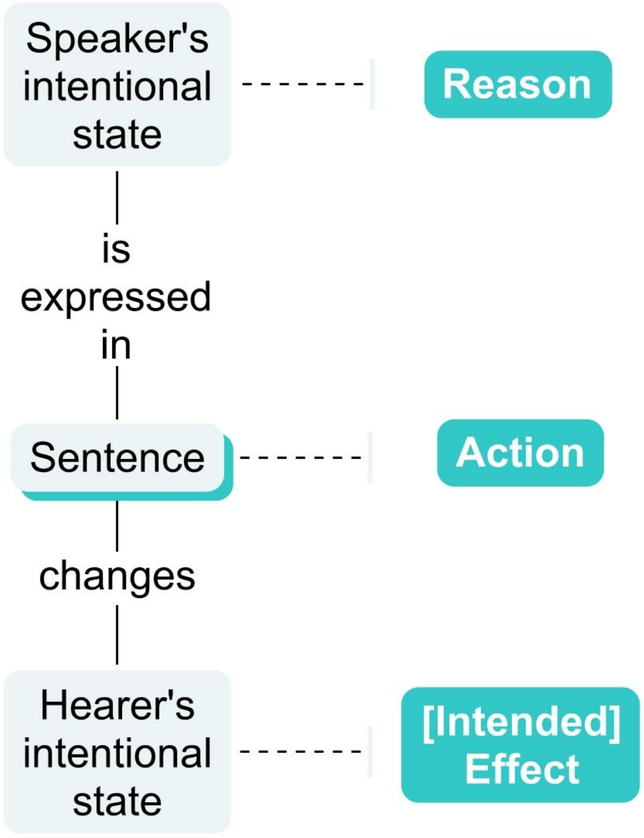
Several dynamic levels

- **(Intra)subjective level.**
- Meaning equals possible change in an agent's mind.
  - An ideal speech situation is assumed in the sense that each speech act is successful.
- Hearer changes (updates and upgrades) her cognitive-motivational state.
  - She updates her information or upgrades her preference ordering between epistemic and buletic possibilities.
    - Frank Veltman, Johan van Benthem, Fenrong Liu…
- Speaker's utterance expresses her cognitive state.
  - Groenedijk's modeling of questions as partitions on the set of epistemically possible situations.
  - Dynamics enters with respect to the change that "answer" brings about.

- **Intersubjective level**.
- Meaning equals change of social relations.
  - Changes of obligation pattern (Tomoyuki Yamada).
  - An example.
  - Speaker commands to Hearer that something be done. After the speech act: Hearer is obliged to see to it that theme of demand is fulfilled, while Speaker is not permitted to do the opposite.

The conceptual framework

- By uttering a sentence Speaker does several things.
  - She expresses her cognitive-motoviational state. [illocutionary act]
  - She changes the cognitive-motivational state of the interlocutor. [perlocutionary act]
  - She changes obligation pattern. [perlocutionary act]



Phenomenology of speech acts and intentional states

- Striking similarity.
  - Two component structure.
  - Two ways of relating to the world.
    - Noted by several authors (A. Kenny, J. Searle, …).
- 2 components:
  - Sentences.
    - 2 components: modal element (mood indicator) and sentence radical.
  - Speech acts (illocutionary acts).
    - 2 components: illocutionary force and propositional content.
  - Intentional states.
    - 2 components: attitude and propositional content.
- 2 directions of fit.
    - Word (mind) to world fit.
      - Indicatives; assertions; beliefs.
    - World to word (mind) fit.
      - Imperatives; requests; desires

Strategy of refutation of "no connection" hypothesis

Unwelcome hypothesis

- There is no connection between logic of speech acts and logic of intentional states.
- Attempting to falsify the special case.
  - There is no connection between imperative logic (logic of commands and requests) and logic of desire.

Counterexample: its virtue, its weakness, and its remedy

- If we succeed to show that logic of desire and imperative logic are connected, the hypothesis will be refuted, or, at least, it will be shown that probably it is not true.
- There is no well established logic of desire and there is no well established imperative logic.
- The logics will be semantically characterized and, hopefully, the plausibility of their respective semantics will give support to the falsification attempt.

Some preliminary definitions

Definition *A logic* L *is a triple* $L = \langle \Phi, \Sigma, \models \rangle$ *where* Φ *is a set of formulas,* Σ *is a set of structures (interpretations) and* $\models$ *is a satisfaction relation,* $\models \subseteq \Sigma \times \Phi$.

Definition $Mod(\Gamma) = \{\sigma \in \Sigma \mid \sigma \models \psi$ *for all* $\psi \in \Gamma\}$

Definition $\Gamma \models \varphi$ *iff* $Mod_L(\Gamma) \subseteq Mod_L(\{\varphi\})$.

Connected logics: explication

Definition *If there is a translation* $\tau : \Phi_1 \rightarrow \Phi_2$ *between logics* $L_1 = \langle \Phi_1, \Sigma_1, \models_1 \rangle$ *and* $L_2 = \langle \Phi_2, \Sigma_2, \models_2 \rangle$ *such that for any* $\Gamma_1 \cup \{\varphi_1\} \subseteq \Phi_1$ *it holds that*

$$\Gamma_1 \models_1 \varphi_1 \Leftrightarrow \tau(\Gamma_1) \models_2 \tau(\varphi_1),$$

then logics L_1 *and* L_2 *are connected.*

Notation $\tau(\Gamma)$ *stands for* $\{\tau(\varphi) \mid \varphi \in \Gamma\}$.

Connected logics

Proposition *If τ provides translation from logic L_1 to logic L_2, then it preserves consequence (**sequitur**) relation:*

$$Mod_{L_1}(\Gamma_1) \subseteq Mod_{L_1}(\{\varphi\}) \Rightarrow Mod_{L_2}(\tau(\Gamma)) \subseteq Mod_{L_2}(\{\tau(\varphi)\}),$$

*and it preserves nonconsequence (**non sequitur**) relation*

$$Mod_{L_1}(\Gamma_1) - Mod_{L_1}(\{\varphi\}) \neq \emptyset \Rightarrow Mod_{L_2}(\tau(\Gamma)) - Mod_{L_2}(\{\tau(\varphi)\}) \neq \emptyset.$$

Remark

- The definition of an abstract logic is taken from:
  - M. Garcìa-Matos and J. Väänänen. Abstract Model Theory as a Framework for Universal Logic. In: J.-Y. Beziau (Ed.), *Logica Universalis*, pp. 19--33, Birkhauser Verlag, Basel, 2005.
- "Connectedness" is usually called "sublogic relation".
  - All semantic relations between sets of sentences and a sentence obtaining in the "source" logic are covered in "target" logic.

$$\models \cup \not\models \; = \wp\Phi \times \Phi$$

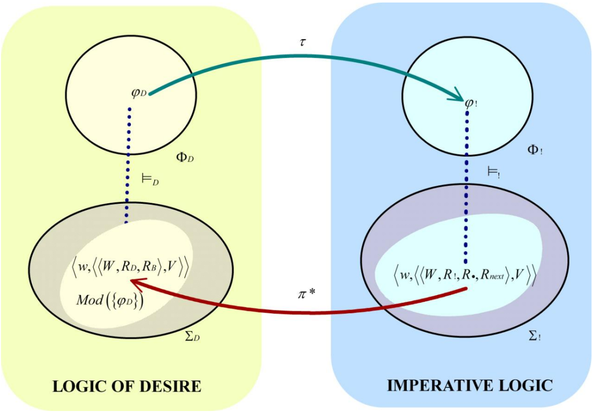
"Corridor"

Definition *Corridor* $\langle \tau, \pi \rangle$ *is a pair of functions: (i) sentence translation function* $\tau : \Phi_1 \rightarrow \Phi_2$, *(ii) "model reduction function":* $\pi : \Sigma_2 \rightarrow \Sigma_1$ *such that*

$$\sigma_2 \models_2 \tau(\varphi_1) \Leftrightarrow \pi(\sigma_2) \models_1 \varphi_1$$

for logics $L_1 = \langle \Phi_1, \Sigma_1, \models_1 \rangle$ *and* $L_2 = \langle \Phi_2, \Sigma_2, \models_2 \rangle$.

Proposition *If there is corridor with surjective "model reduction function" between logics, then* τ *is a translation that preserves semantic relations (sequitur and non sequitur).*



- T. Mossakowski, R. Diaconescu and A. Tarlecki. *What is a Logic Translation?* Unpublished. (accessible at: http://www.informatik.uni-bremen.de/~till/papers/mor.pdf), 2007.

GMV corridor

Definition (Garcia-Matos and Vaananen) *An abstract logic* $L = \langle S, F, \models \rangle$ *is a sublogic of another abstract logic* $L' = \langle S', F', \models' \rangle$*, in symbols*

$$L \leq L',$$

if there are: (i) a sentence $\theta \in F'$*, and functions (ii)* $\pi : S' \rightarrow S$ *and (iii)* $f : F \rightarrow F'$ *such that*

1. $\forall A[A \in S \rightarrow \exists A'(A' \in S' \wedge (\pi(A') = A \wedge A' \models' \theta))],$
2. $\forall \varphi \forall A'[(\varphi \in F \wedge A' \in S') \rightarrow (A' \models' \theta \rightarrow (A' \models' f(\varphi) \leftrightarrow \pi(A') \models \varphi))]$

- M. Garcìa-Matos and J. Väänänen. Abstract Model Theory as a Framework for Universal Logic. In: J.-Y. Beziau (Ed.), *Logica Universalis*, pp. 19--33, Birkhauser Verlag, Basel, 2005.
- GMV corridor preserves semantic relations.
- GMV corridor shows that projection function π needs not be total.
- It requires projection function to be surjective.
  - The fact that projection function does not have to be total will be used here.

Weakening the condition

- The surjection condition on projection function can be weakened for the logics with strong (classical) negation.

Definition *A logic* $L = \langle \Phi, \Sigma, \models \rangle$ *has a strong negation iff for any* $\varphi \in \Phi$ *there is a* $\psi \in \Phi$ *such that for any* $\sigma \in \Sigma$

$$\sigma \models \varphi \Leftrightarrow \sigma \not\models \psi.$$

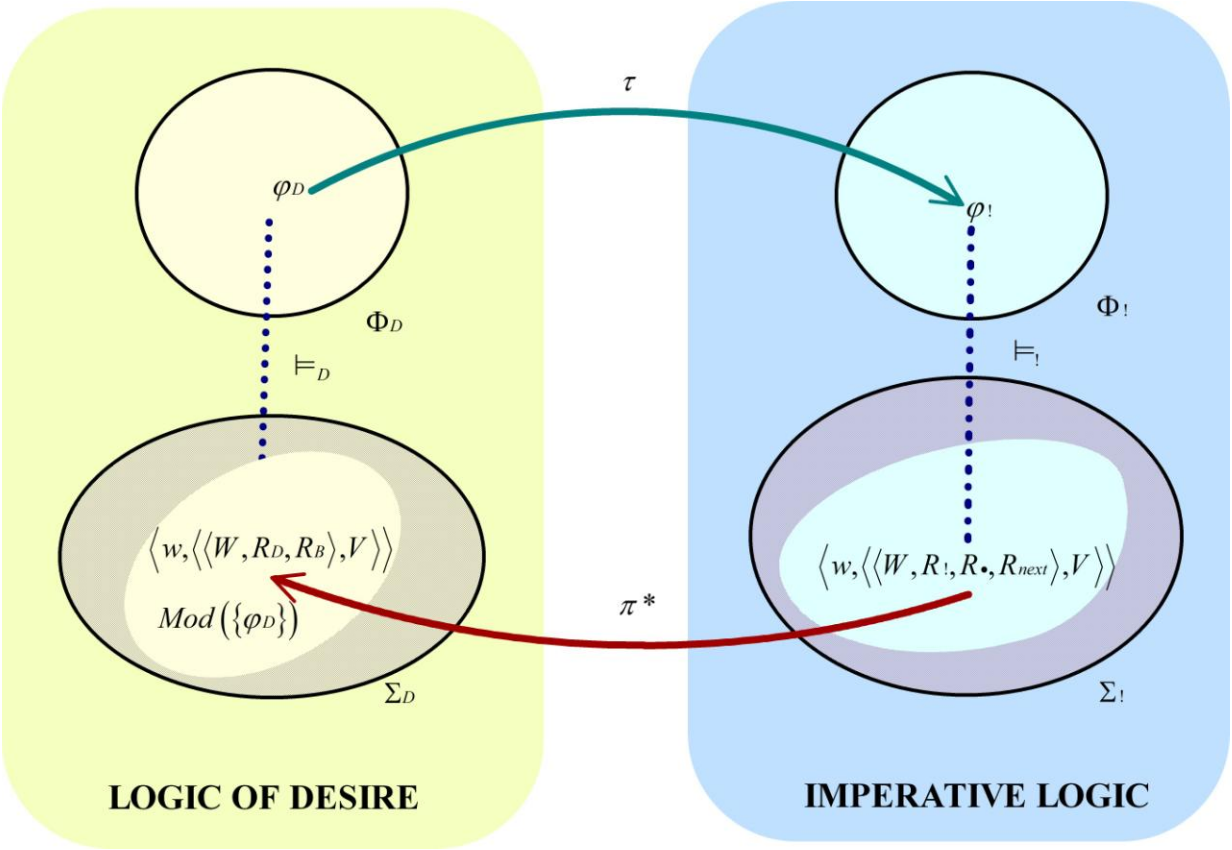
Parsimonious projection

- The weakened condition requires that for any set of models for a set of sentences in source logic there is at least one structure in target logic whose projection picks a model from the set.

Definition *For logics* $L_1 = \langle \Phi_1, \Sigma_1, \models_1 \rangle$ *and* $L_2 = \langle \Phi_2, \Sigma_2, \models_2 \rangle$ ***parsimonious projection*** π *is a projection* $\pi : \Sigma_2 \rightarrow \Sigma_1$ *such that for any satisfiable* $\Gamma_1 \subseteq \Phi_1$ *it holds that*

$$\exists \sigma_2 [\sigma_2 \in \Sigma_2 \wedge \pi(\sigma_2) \in Mod_{L_1}(\Gamma_1)]$$

Parsimonious projection



Weakened condition on corridors

Proposition *If there is corridor with parsimonious projection between logics* L_1 *and* L_2 *and* L_1 *is a logic with strong negation, then* τ *is a semantic relations preserving translation.*

Proof

- Interesting part, of course, lies in right-to left direction (*non sequitur* preservation) and it relays on parsimonious projection and strong negation.

Proof The proof that $\Gamma_1 \vDash_1 \varphi_1$ implies $\tau(\Gamma_1) \vDash_2 \tau(\varphi_1)$ is direct. For the other direction, i.e. that $\tau(\Gamma_1) \vDash_2 \tau(\varphi_1)$ implies $\Gamma_1 \vDash_1 \varphi_1$, after assuming (*) $\tau(\Gamma_1) \vDash_2 \tau(\varphi_1)$ we may use *reductio ad absurdum* and assume $\Gamma_1 \nvDash \varphi_1$. Due to the existence of classical negation ($\neg$) then there is $\sigma_1 \in \Sigma_1$ such that $\sigma_1 \vDash_1 \Gamma_1 \cup \{\neg\varphi\}$. Since π is a parsinoumus projection, then there is $\sigma_2 \in \Sigma_2$ such that $\pi(\sigma_2) = \sigma_1$ and $\pi(\sigma_2) \in Mod(\Gamma_1 \cup \{\neg\varphi_1\})$. Because of the existence of a corriodor, for such a model (interpretation, structure) σ_2 obviously it holds that $\sigma_2 \vDash_2 \tau(\Gamma_1)$ and $\sigma_2 \vDash_2 \tau(\neg\varphi_1)$. But the hypothesis (*) of this conditional proof guarantees $\sigma_2 \vDash_2 \tau(\varphi_1)$. Using corridor we get $\sigma_1 \vDash_1 \neg\varphi_1$ which is impossible for classical negation. Therefore we have arrived at the contradiction as we wanted to.

Slight modification for modal logics

- For the purpose of applying the approach in modal logic "model reduction", or, rather, "model projection" function must take a valuation point and a relational structure.
- In order to follow “room-corridor” metaphor we will call world-structure pair --- ‘evaluation corner’.

Definition *Evaluation corner is a pair* $\langle \mathfrak{M}, w \rangle$ *where* $\mathfrak{M}$ *is a (multi-)modal model,* $\mathfrak{M} = \langle \langle W, R_1, \ldots, R_n \rangle, V \rangle$.

Introducing the two logics

- *Caveat*!
- No well established logic of desire and no well established imperative logic.
- We will investigate:
  - **[Logic of desire] Charles B. Cross. The modal logic of discrepancy, *Journal of Philosophical Logic* 26: 143-168, 1997.**
  - **[Imperative logic] *Ad hoc* modal imperative logic in the tradition of E. Lemmon, G. H. von Wright, N. Belnap, K. Segerberg etc.**
    - Imperative is commanded action.

Semantic troubles left aside

The concept designated by the verb 'to want' is **extraordinarily elusive**. A statement of the form "A wants to X"-taken by itself, apart from a context that serves to amplify or to specify its meaning — conveys remarkably little information. Such a statement may be consistent, for example, with each of the following statements:

- (a) the prospect of doing X elicits no sensation or introspectible emotional response in A;
- (b) **A is unaware that he wants to X**;
- (c) **A believes that he does not want to X**;
- (d) **A wants to refrain from X-ing**;
- (e) A wants to Y and believes that it is impossible for him both to Y and to X;
- (f) **A does not "really" want to X**;
- (g) A would rather die than X; and so on.
  - Harry Frankfurt. Freedom of the will and the concept of a person. *Journal of Philosophy* **68**: 5–20, 1971.

Cross' logic of desire: syntax

- No iteration of modal operators allowed.
  - E.g. "second-order desire" is not expressible.

Syntax

Φ is a set of formulas classical propositional logic.

$P \in \Phi$

$\varphi ::= \bigstar P \mid \neg\varphi \mid \varphi \wedge \varphi$

$\bigstar ::= \Delta \mid \nabla \mid \oplus \mid \odot$

Cross logic of desire: semantics

$\mathfrak{M}_{Des} = \langle\langle W, R_D, R_B\rangle, V\rangle$

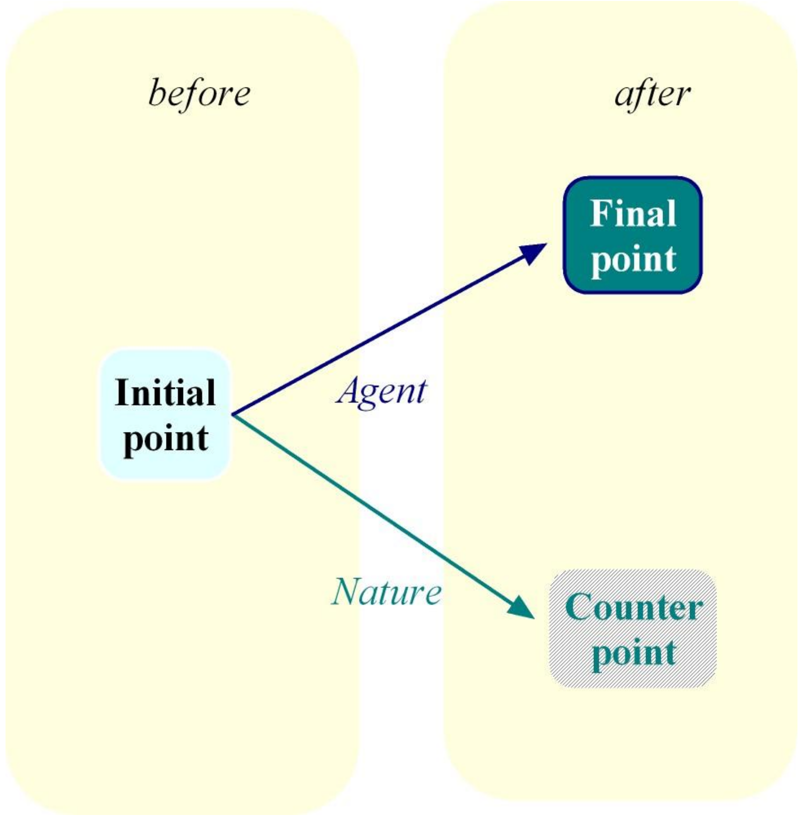
- $\mathfrak{M}_{Des}, w \models \Delta P$ iff
  - for all v: if $R_D(w,v)$, then $\mathfrak{M}_{Des}, v \models P$,
  - for all v: if $R_B(w,v)$, then **not** $\mathfrak{M}_{Des}, v \models P$.
- $\mathfrak{M}_{Des,w} \models \nabla P$ iff
  - for all v: if $R_D(w,v)$, then $\mathfrak{M}_{Des}, u \models P$,
  - there is v such that: $R_B(w,v)$ and $\mathfrak{M}_{Des}, v \models P$,
  - there is v such that: $R_B(w,v)$ and **not** $\mathfrak{M}_{Des}, v \models P$,
- $\mathfrak{M}_{Des}, w \models \oplus P$ iff
  - for any v: if $R_D(w,u)$, then $\mathfrak{M}_{Des}, u \models P$,
  - for any v: if $R_B(w,u)$, then $\mathfrak{M}_{Des}, u \models P$.
- $\mathfrak{M}_{Des}, w \models \odot P$ iff
  - there is v such that: $R_D(w,v)$ and $\mathfrak{M}_{Des}, v \models P$,
  - there is v such that: $R_D(w,v)$ and **not** $\mathfrak{M}_{Des}, v \models P$,
  - for all z such that $R_B(w,v)$: $\mathfrak{M}_{Des}, z \models P$.
- $\mathfrak{M}_{Des}, w \models \neg\varphi$ iff **not** $\mathfrak{M}_{Des}, w \models \neg\varphi$.

Cross' logic of desire: intended interpretation

- The agent **desires** (in the sense of goal belief discrepancy) that *P*.
  - Desire that *P* and belief that ¬*P*.
- The agent has a **reason to** (needs to) **make sure** that *P*.
  - Desire that *P* and uncertain belief (*might P* and *might* ¬*P*).
- The agent is **satisfied** that *P*.
  - Desire that *P* and belief that *P*.
- The agent **indifferently accepts** that *P*.
  - "Undecided" desire (*might should P* and *might should* ¬*P*) and belief that *P*.
    - Critique: lack of temporal dimension.

Three points action semantics

- G.H. von Wright
  - *The initial state* which the agent changes or which would have changed if the agent had not been active.
  - *The end-state* which results from the action.
  - *The counter-state* which would have resulted from agent's passivity.

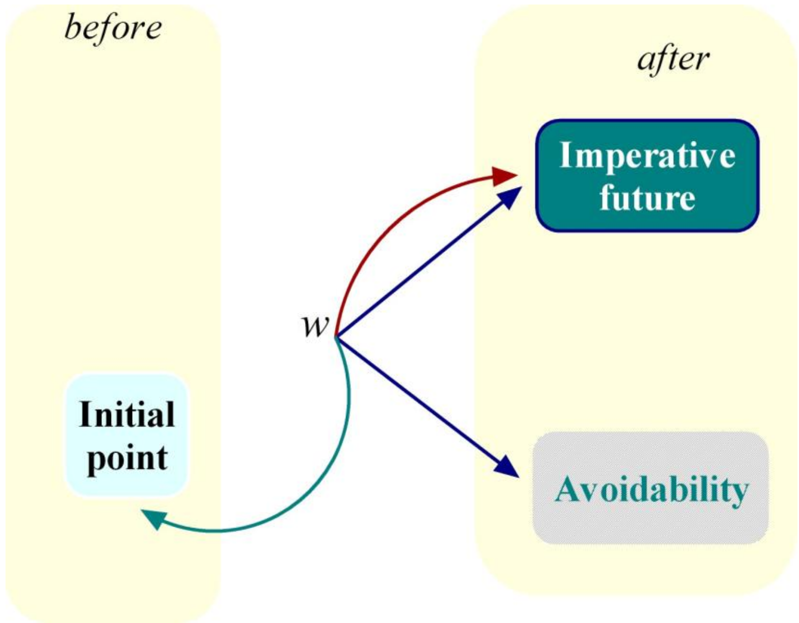


Classification of actions and classification of imperatives

- The actions that bring about a change:
  - Actions of **producing**,
  - Actions of **destroying** a state of affairs.
- The actions that prevent a change:
  - Actions of **sustaining**,
  - Actions of **suppressing** a state of affairs.
- Produce-destroy imperatives; complementary type:
  - $!(\neg A/A);!(A/\neg A)$
- Maintain-suppress imperatives; symmetric type:
  - $!(A/A);!(\neg A/\neg A)$
- “One-sided” imperatives (STIT imperatives):
  - $!(\top/A);!(\top/\neg A)$

3 point model

- What we need?
- In relational part:
  - Implicit temporality (branching time, moments and two instants).
  - "Historical" possibility.
    - $\mathbf{R_{next}}$
  - Preference for imperative future.
    - $\mathbf{R_{!}}$
  - Information on "initial point".
    - R.



An imperative logic: syntax

- No iteration of “mood indicators”.
  - Assertoric and imperative suggestions allowed.
    - It might be the case that …
    - It might be good to see to it that …
  - Only “one-sided” imperative allowed.
    - Other are expressible using conjunction of assertoric and imperative sentences.

$$P \in \Phi_{CPL}$$

$$\varphi ::= \bigstar P \mid \neg\varphi \mid \varphi \wedge \varphi$$

$$\bigstar ::= !^{STIT} \mid \bullet \mid \bullet_{might} \mid !_{might}$$

An imperative logic: semantics

- Three relations.
- Imperative relation is contained in historical relation.

Definition $\mathfrak{M}_! = \langle\langle W, R_!, R_., R_{next}\rangle, V\rangle$ where $R_! \subseteq R_{next}$

Definition $V(P) \subseteq W$ for P propositional letter. For compounds P and Q:

$$V'(\neg P) = W - V'(P)$$

$$V'(P \wedge Q) = V'(P) \cap V'(P)$$

An imperative logic: semantics

- Model shifts: refinement of a relation with respect to its second member and a proposition.

Definition *Refinement of relation* R_i *with respect to its second members and proposition* $P \in \Phi_{CPL}$ *is the relation* R_i^{*iP}*:*

$$R_i^{*iP} = \{\langle w, v \rangle \in R_i \mid mem_2(R_i) \in V'(P)\}$$

where $i \in \{!, \bullet, next\}$.

Definition *Eliminative model shifts for* $\mathfrak{M}_! = \langle\langle W, R_\bullet, R_\bullet, R_{After}\rangle, V\rangle$ *are models:*

$$\mathfrak{M}_!^{*!P} = \langle\langle W, R_!^{*!P}, R_\bullet, R_{next}\rangle, V\rangle$$

$$\mathfrak{M}_!^{*\bullet P} = \langle\langle W, R_!, R_\bullet^{*\bullet P}, R_{next}\rangle, V\rangle$$

Imperative logic: truth

$\mathfrak{M}_!, w \models !^{STIT}P$ iff

- for all v: if $R_!(w,v)$, then $\mathfrak{M}_!, v \models P$,
- there is v such that: $R_{After}(w,v)$ and $\mathfrak{M}_!, v \models P$,
- there is v such that: $R_{After}(w,v)$ and **not** $\mathfrak{M}_!, v \models P$.

$\mathfrak{M}_!, w \models \cdot P$ iff

- for all v: if $R_\cdot(w,v)$, then $\mathfrak{M}_!, v \models P$.

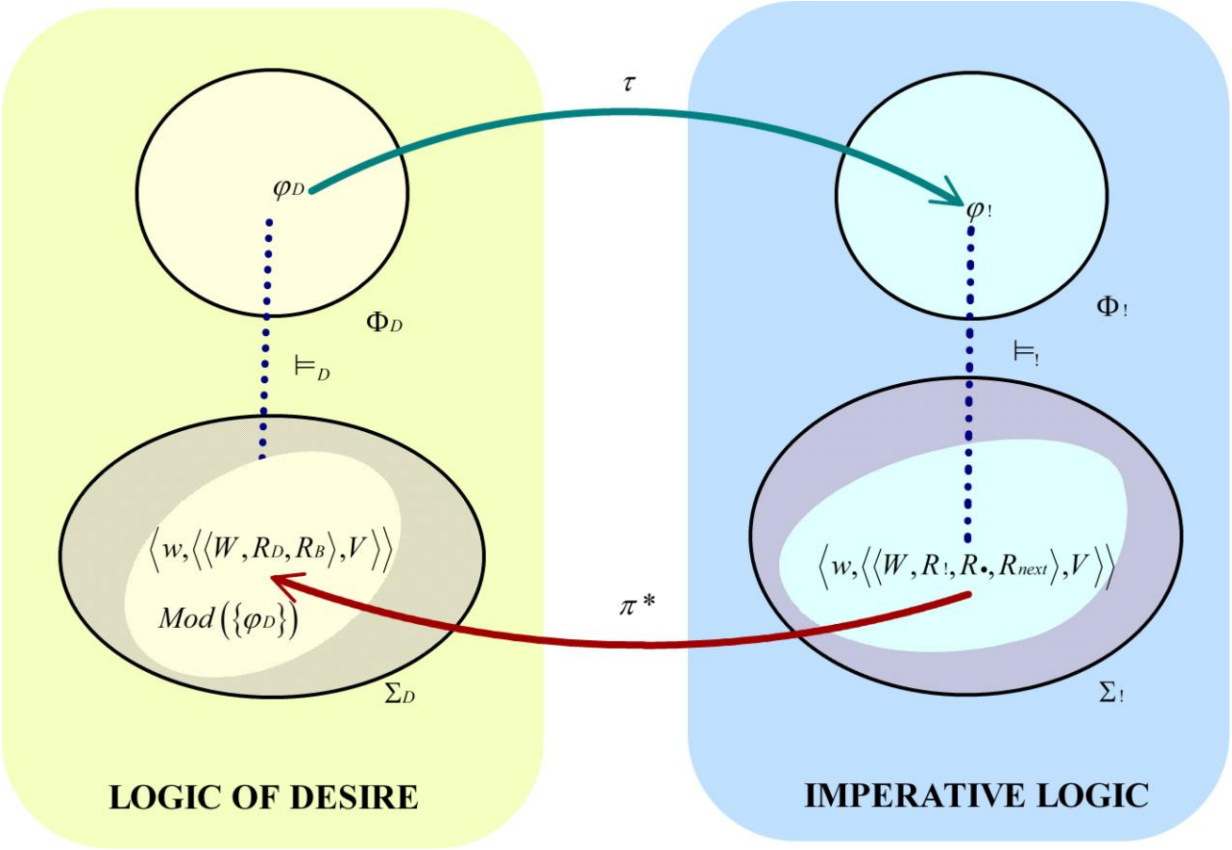
$\mathfrak{M}_!, w \models !_{might}P$ iff $\mathfrak{M}_!^{*!P}, w \models P$.

$\mathfrak{M}_!, w \models \cdot_{might} P$ iff $\mathfrak{M}_!^{*\cdot P}, w \models P$.

$\mathfrak{M}_!, w \models \neg\varphi$ iff **not** $\mathfrak{M}_!, w \models \neg\varphi$.

$\mathfrak{M}_!, w \models \varphi \wedge \psi$ iff $\mathfrak{M}_!, w \models \varphi$ and $\mathfrak{M}_!, w \models \psi$.

Corridor with parsimonious projection from restricted domain



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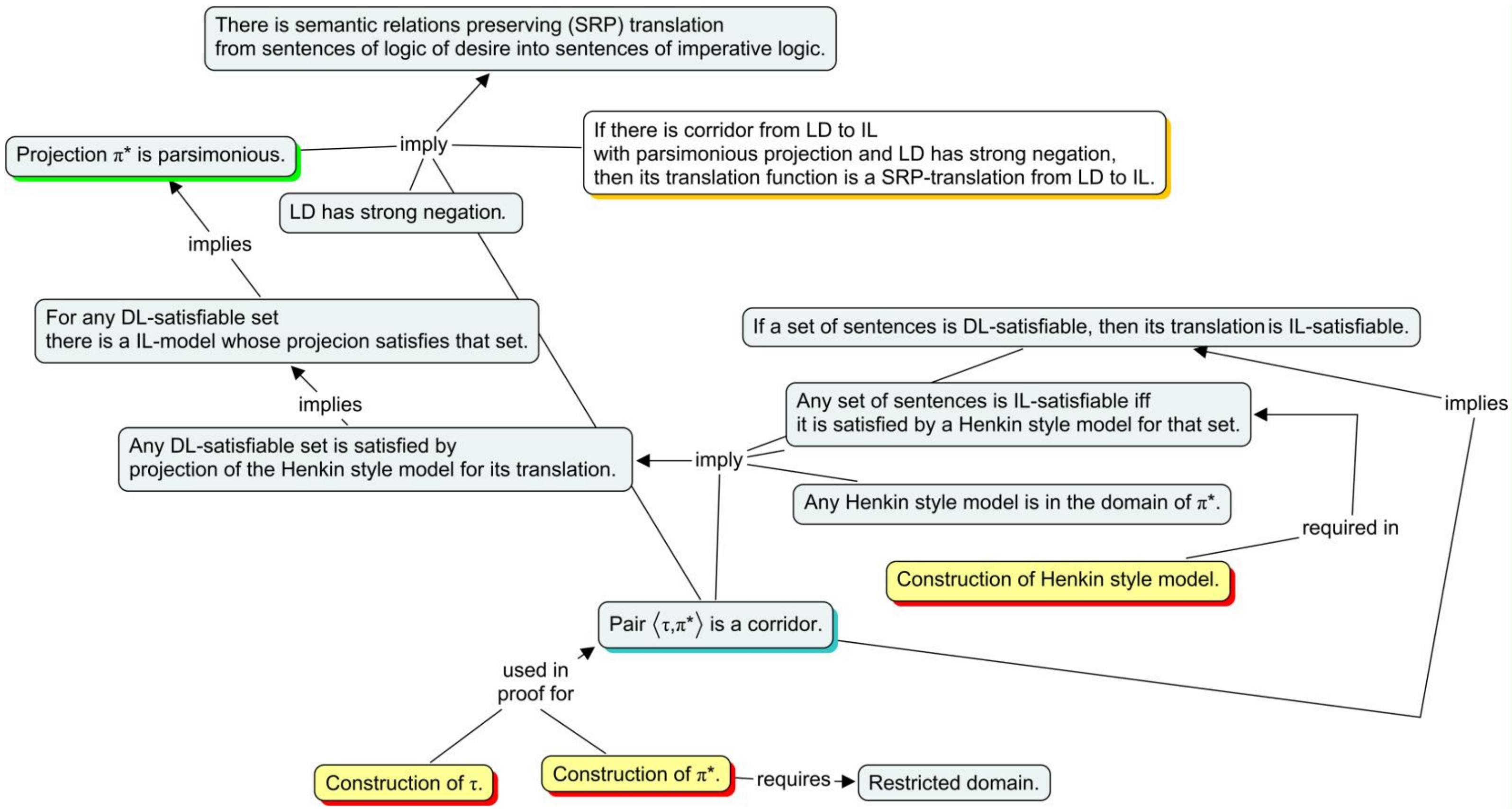
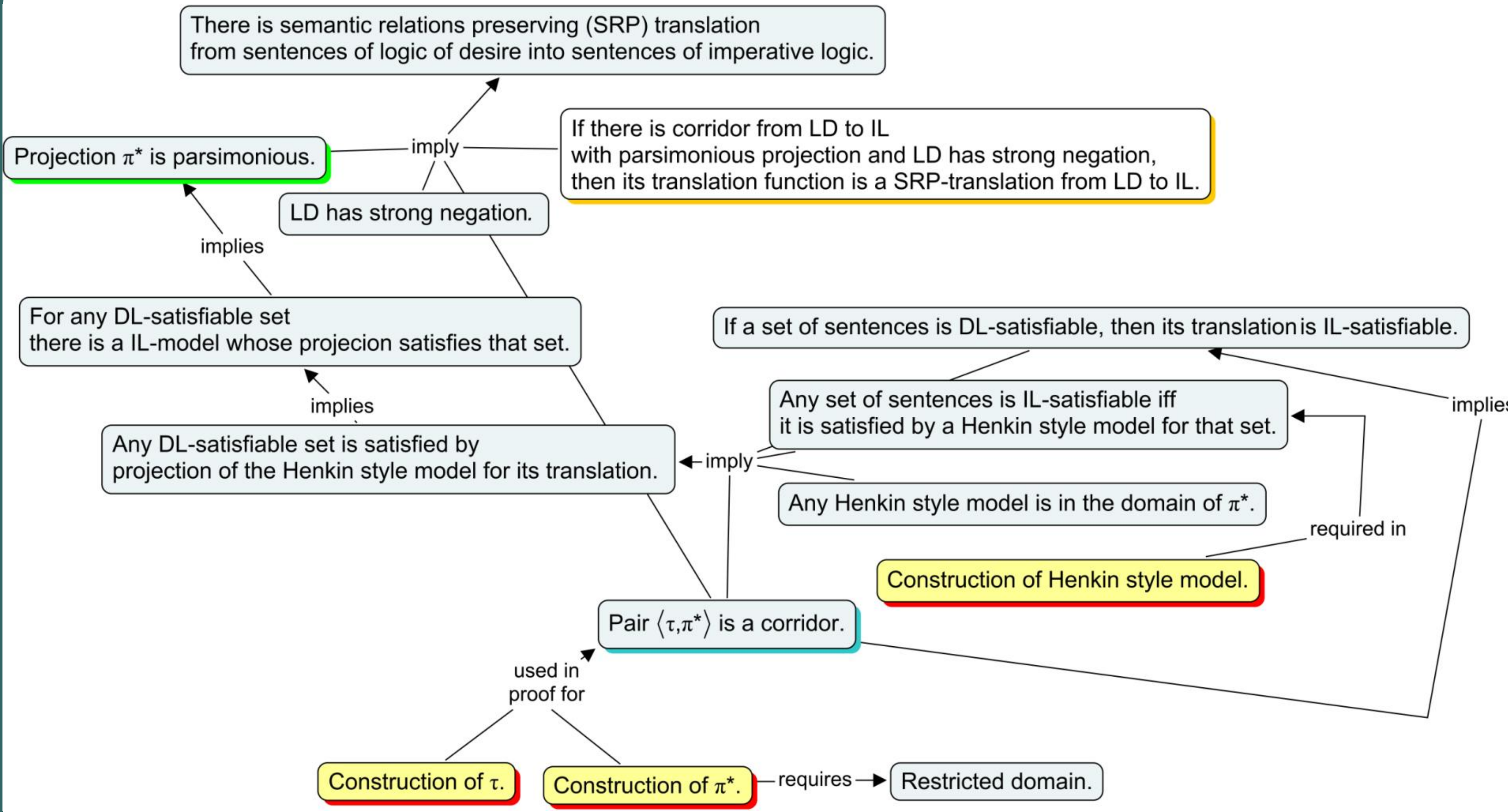
Outline of the proof




There is semantic relations preserving (SRP) translation
from sentences of logic of desire into sentences of imperative logic.
imply
Projection π* is parsimonious.
If there is corridor from LD to IL
with parsimonious projection and LD has strong negation,
then its translation function is a SRP-translation from LD to IL.
LD has strong negation.
implies
For any DL-satisfiable set
there is a IL-model whose projecion satisfies that set.
If a set of sentences is DL-satisfiable, then its translation is IL-satisfiable.
Any set of sentences is IL-satisfiable iff
it is satisfied by a Henkin style model for that set.
implies
implies
Any DL-satisfiable set is satisfied by
projection of the Henkin style model for its translation.
imply
Any Henkin style model is in the domain of π*.
required in
Construction of Henkin style model.
Pair ⟨τ,π*⟩ is a corridor.
used in
proof for
Construction of τ.
Construction of π*.
requires
Restricted domain.

Construction of translation

$$\tau(\Delta P) = \bullet\neg P \wedge !^{STIT} P$$

$$\tau(\nabla P) = \bullet_{might} P \wedge \bullet_{might} \neg P \wedge !^{STIT} P$$

$$\tau(\oplus P) = \bullet P \wedge !^{STIT} P$$

$$\tau(\odot P) = \bullet P \wedge !^{STIT}_{might} P \wedge !^{STIT}_{might} \neg P$$

$$\tau(\neg\varphi) = \neg\tau(\varphi)$$

$$\tau(\varphi \wedge \psi) = \tau(\varphi) \wedge \tau(\psi)$$

Projection with restricted domain

Definition *Model projection function* π^* *is a function from a subset of evaluation corners of* $L_!$ *to the set of evaluation corners of* L_D*:*

- *if* $\langle\langle\langle W, R_!, R_., R_{next}\rangle, V\rangle, w\rangle \vDash_! \,!_{might}A \vee \,!_{might}\neg A$ *for each propositional letter* A*, then* $$\pi^*\left(\left\langle \underbrace{\langle\langle W, R_!, R_., R_{next}\rangle, V\rangle}_{\mathfrak{M}_!}, w \right\rangle\right) = \left\langle \underbrace{\langle\langle W, R_D, R_B\rangle, V\rangle}_{\mathfrak{M}_D}, w \right\rangle$$ *where* $R_D = R_!$ *and* $R_B = R_.$*,*
- *otherwise undefined.*

Henkin style model ("evaluation corner"): preliminaries

Definition *The impact of sentences:*

- *On relation* $R_!$
  - $!P/R_! = \{\langle w,v\rangle \in R_! \mid v \in V'(P)\}$,
  - $\bullet P/R_! = \bullet_{might}\, P/R_! = !_{might}P/R_! = R_!$,
  - $\neg\varphi/R_! = R_! - \varphi/R_!$,
  - $(\varphi \wedge \psi)/R_! = \varphi/R_! \cap \psi/R_!$.
- *On relation* $R_\bullet$
  - $\bullet P/R_\bullet = \{\langle w,v\rangle \in R_\bullet \mid v \in V'(P)\}$,
  - $!P/R_\bullet = \bullet_{might}\, P/R_\bullet = !_{might}P/R_\bullet = R_\bullet$,
  - $\neg\varphi/R_\bullet = R_\bullet - \varphi/R_\bullet$,
  - $(\varphi \wedge \psi)/R_\bullet = \varphi/R_\bullet \cap \psi/R_\bullet$.
- *On relation* R_{next}
  - $!P/R_{next} = \bullet P/R_{next} = \bullet_{might}\, P/R_{next} = !_{might}P/R_{next}$,
  - $\neg\varphi/R_{next} = R_{next}$,
  - $(\varphi \wedge \psi)/R_{next} = R_{next}$.

Henkin style model: construction

Definition *Henkin evaluation corner* $\langle \sigma^{\#}, w \rangle = \langle\langle\langle W^{\#}, R^{\#}_{!}, R^{\#}_{?}, R^{\#}_{next} \rangle, V^{\#} \rangle, w^{\#} \rangle$ *for a set of sentences* $\Gamma \in \Phi_{L_D}$ *is a point-structure pair built as follows:*

- $W^{\#} = \wp(atom(\Gamma))$, where $atom(\Gamma)$ is the set of propositional letters appearing in Γ.
- $V(A) = \{w \mid A \in w\}$ for propositional letters $A \in atom(\Gamma)$.
- $R^{\#}_{!} = \bigcap_{i \in |\Gamma|} R^{i}_{!}$, where $R^{0}_{!} = W^{\#} \times W^{\#}$ and $R^{i}_{!} = \varphi_i / R^{0}_{!}$,
- $R^{\#}_{?} = \bigcap_{i \in |\Gamma|} R^{i}_{?}$, where $R^{0}_{?} = W^{\#} \times W^{\#}$ and $R^{i}_{?} = \varphi_i / R^{0}_{?}$,
- $R^{\#}_{next} = W^{\#} \times W^{\#}$,
- $w \in mem_1(R^{\#}_{!})$ (or $w \in mem_1(R^{\#}_{?})$).

Some repercussions

- It seems that investigation into relations between logics of speech acts and logics of intentional states has important philosophical and methodological implications.
  - It may contribute to the evolution of the popular metaphor of “picture relation between the language and the world” with “the world” substituted with “the mind(s)” and inverted direction (language is the “painter”).
  - It may provide the foundational work required for the logic modeling that uses the framework of dynamic logic (“logic of action in its primitive form,” K. Segerberg), with programs as speech acts and their post conditions as intentional states (of an agents or of group of agents).
  - Universal logic should encompass both “theoretical Logic” and “practical Logic.” The conceptual approach of dynamic semantics and the perspective opened by logic translations may enlight the “underdeveloped” area of practical logic.