Permission in Deontic Logic: From Sanskrit Philosophy to AI

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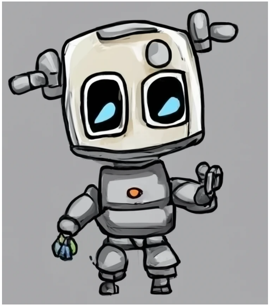
Autonomous Agent



Actions are constrained by **norms**

- Obligations?
- Prohibitions?
- Permissions?

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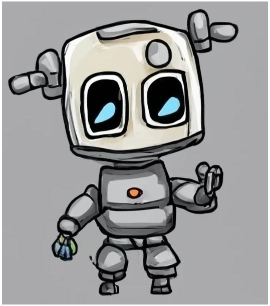

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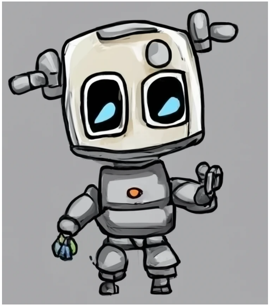

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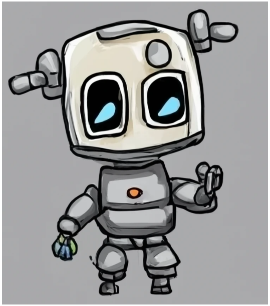

Actions are constrained by **norms**

- Obligations! - Actions you have to do
- Prohibitions! - Actions you are not allowed to do
- Permissions? - Unclear

Outline

1. Permission in Deontic Logic
2. Mīmāṃsā Deontic
3. Mīmāṃsā Permission
4. Incorperating Preferences

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1 Permission in Deontic Logic

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Permission in Standard Deontic Logic (SDL)

Deontic Logic: reasoning about norms (obligations, prohibitions, permissions)

- Introduced by Von Wright, 1951:

$$\varphi ::= p \mid \neg\varphi \mid (\varphi \vee \varphi) \mid (\varphi \rightarrow \varphi) \mid \mathcal{P}\,\varphi$$

- φ is **permitted**: $\mathcal{P}\,\varphi$
- φ is **forbidden**: $\mathcal{F}\,\varphi := \neg\,\mathcal{P}\,\varphi$
- φ is **obligatory**: $\mathcal{O}\,\varphi := \neg\,\mathcal{P}\,\neg\varphi$

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- **Obligation** implies **permission**: $\mathcal{O}\,\varphi \rightarrow \mathcal{P}\,\varphi$
- Kripke Semantics

Paradoxes

- Free choice inference
- Ross' paradox

Paradoxes

- Free choice inference
  1. You may have coffee or tea
  2. Therefore, you may have coffee
  3. **and**, therefore, you may have tea

  $\mathcal{P}(\phi \vee \psi) \rightarrow \mathcal{P}(\phi) \wedge \mathcal{P}(\psi)$

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  You may read the letter. $\mathcal{P}(\phi)$

  BUT by monotonicity of permission (since $\phi \rightarrow \phi \vee \psi$):

  You may read the letter or burn it. $\mathcal{P}(\phi \vee \psi)$

Types of permission

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- Bilateral permission: ‘a permission to have tea implies a permission to not have tea’
- Right: ‘the right to vote’
- Exception: ‘It is permitted to smoke, only in that area’

What do we have?

- An ambiguous concept
- A faulty formalization

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The Mīmāṃsā school

Mīmāṃsā is one of the most important schools of Hindu philosophy

- ca 2500 years of deontic investigations
- Focus on the interpretation of the prescriptive portions of the *Vedas*, a book of commands such as: do not kill living beings
- Some of these commands seem contradictory
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- Some of these rules can be translated to Hilbert axioms!

Methodology

Goal: extract logical properties from Mīmāṃsā texts

Original texts

↓

Nyāyas

natural language

Methodology

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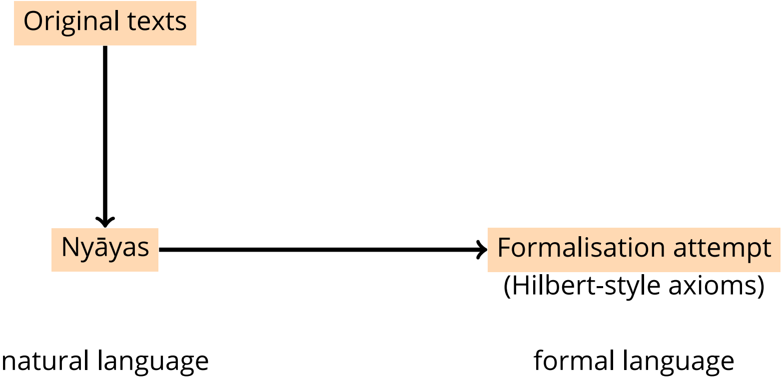

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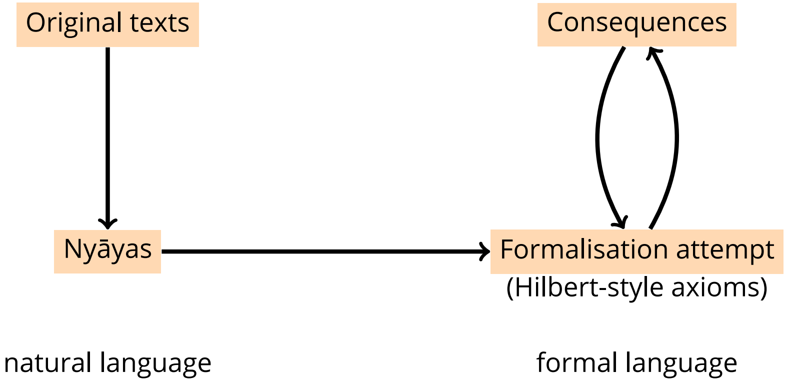

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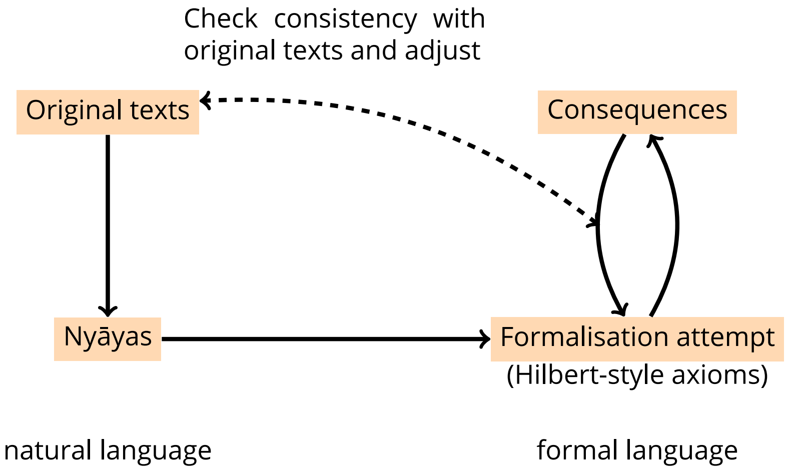

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- All operators are **dyadic**, e.g. $\mathcal{O}(\phi/\psi)$,
  Each command is uttered with regard to a specific eligible/responsible person (*adhikārin*) or to a specific situation.

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  Each command is uttered with regard to a specific eligible/responsible person (*adhikārin*) or to a specific situation.
- **Not interdefinable**: fulfilling an obligation leads to a reward (or desired result), while trangressing a prohibition to a punishment. E.g. "It is forbidden to lie" $\neq$ "It is obligatory not to lie".

Resulting Logic

$$\phi ::= p \mid \phi \vee \phi \mid \neg\phi \mid \mathcal{O}(\phi/\psi) \mid \mathcal{F}(\phi/\psi) \mid \boxed{U}\phi$$

Ax1. $(\boxed{U}(\phi \to \psi) \wedge \mathcal{O}(\phi/\theta) \wedge \neg\boxed{U}\psi) \to \mathcal{O}(\psi/\theta)$

Ax2. $(\boxed{U}(\phi \to \psi) \wedge \mathcal{F}(\psi/\theta) \wedge \Diamond_U\phi) \to \mathcal{F}(\phi/\theta)$

Ax3. $\neg(X(\phi/\theta) \wedge X(\neg\phi/\theta))$ for $X \in \{\mathcal{O}, \mathcal{F}\}$

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Ax5. $(\boxed{U}(\psi \leftrightarrow \theta) \wedge X(\phi/\psi)) \to X(\phi/\theta)$ for $X \in \{\mathcal{O}, \mathcal{F}\}$

Ax6. $(\Diamond_U(\phi \wedge \theta) \wedge \mathcal{O}(\phi/\top) \wedge \mathcal{O}(\theta/\top)) \to \mathcal{O}(\phi \wedge \theta/\top)$

S5 axioms for the global modality: $\boxed{U}$

Modelled with: Neighborhood Semantics $\langle W, N_{\mathcal{O}}, N_{\mathcal{F}}, V\rangle$.

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van Berkel, K., A. Ciabattoni, E. Freschi, F. Gulisano, and M. Olszewski. 2022. *Deontic Paradoxes in Mīmāṃsā Logics: There and Back Again.* JOLLI 2021.

What do we have?

1. A thought-out source of deontic investigations
2. Hilbert style formalization of obligation and prohibition
3. Without paradoxes!

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  - $(\mathcal{P}(\phi/\psi) \wedge (\mathcal{F}(\phi/\theta) \vee \mathcal{O}(\neg\phi/\theta))) \rightarrow \boxed{\text{U}}(\psi \rightarrow \theta)$

  e.g.: The permission to eat after buying Soma implies the prohibition to eat (or the obligation not to eat) before it (*Tantravārttika* on 1.3.4).

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  - $(\mathcal{P}(\phi/\psi) \wedge (\mathcal{F}(\phi/\theta) \vee \mathcal{O}(\neg\phi/\theta))) \rightarrow \boxed{\cup}(\psi \rightarrow \theta)$
- Commands entail possibility
  - $(\mathcal{O}(\phi/\psi) \vee \mathcal{F}(\phi/\psi)) \rightarrow \Diamond_{\cup}(\phi \wedge \psi) \wedge \neg\boxed{\cup}(\phi \wedge \psi)$
    The seeming prohibition “The fire is not to be kindled on the earth, nor in the sky, nor in heaven” cannot be taken as a prohibition, because fire cannot be kindled in the sky nor in heaven (see ŚBh on 1.2.5 and 1.2.18).

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- Permissions are better-not permissions
  e.g: If one still refrains from eating meat, even though eating it is permitted, this is a meritorious act which leads one to the accumulation of good *karman*. (TV ad ŚBh 1.3.4)

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- ✗ Interdefinability: $\phi ::= p \mid \neg\phi \mid \phi \vee \phi \mid \mathcal{O}(\phi/\phi) \mid \mathcal{F}(\phi/\phi) \mid \mathcal{P}(\phi/\phi) \mid \boxed{\cup}\phi$

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- ✗ Obligation implies permission
  a) $\neg(\mathcal{P}(\phi/\psi) \wedge \mathcal{F}(\phi/\psi))$
  b) $\neg(\mathcal{P}(\phi/\psi) \wedge \mathcal{O}(\phi/\psi))$
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  $\boxed{\cup}(\phi \rightarrow \psi)$, $\mathcal{P}(\phi/\theta)$ implies $\mathcal{P}(\psi/\theta)$

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- ✗ Monotonicity of permission
  $\boxed{\text{U}}(\phi \rightarrow \psi)$, $\mathcal{P}(\phi/\theta)$ implies $\mathcal{P}(\psi/\theta)$
  $\Rightarrow \mathcal{F}(\psi/\top) \vee \mathcal{O}(\neg\psi/\top)$

Resulting logic

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Earlier axioms for $\mathcal{O}$ and $\mathcal{F}$, the S5 axioms for $\boxed{U}$

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P2. (a) $\neg(\mathcal{P}(\phi/\psi) \wedge \mathcal{F}(\phi/\psi))$

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P3. $(\mathcal{O}(\phi/\psi) \vee \mathcal{F}(\phi/\psi)) \rightarrow \Diamond_U(\phi \wedge \psi) \wedge \neg\boxed{U}\phi$

P4. (a) $(\boxed{U}(\psi \leftrightarrow \theta) \wedge \mathcal{P}(\phi/\psi)) \rightarrow \mathcal{P}(\phi/\theta)$

(b) $(\boxed{U}(\phi \leftrightarrow \psi) \wedge \mathcal{P}(\phi/\theta)) \rightarrow \mathcal{P}(\psi/\theta)$

P5. $(\mathcal{P}(\phi/\psi) \wedge (\mathcal{F}(\phi/\theta) \vee \mathcal{O}(\neg\phi/\theta))) \rightarrow \boxed{U}(\psi \rightarrow \theta)$

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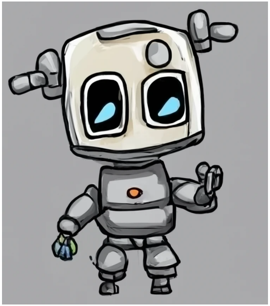
- Agata Ciabattoni, Josephine Dik, and Elisa Freschi. *Disambiguating Permissions: A Contribution from Mīmāṃsā.* DEON 2023.

BUT



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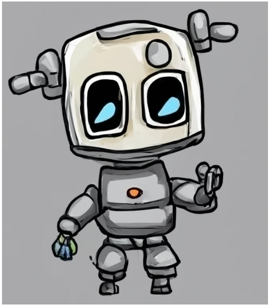

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Better-not permission?

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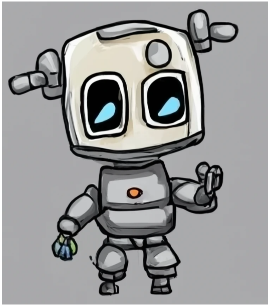

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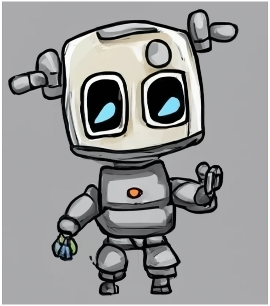

Humanoid robot working in a household setting

- Cleaning
- Assisting with entertainment
- Handle sharp objects

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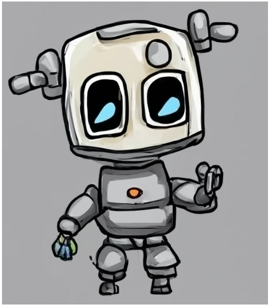

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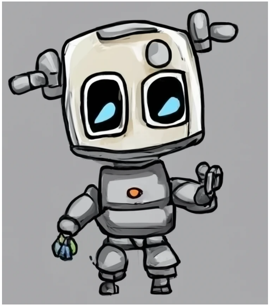

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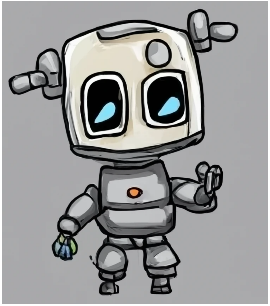

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- $\neg$ Handle sharp objects $\geq$ Handle sharp objects

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Goal: give a formal definition

Operator $\boxed{\preceq}$

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- $\boxed{\preceq}\phi$:= in all better scenarios, ϕ holds
  - $\boxed{\preceq}(\phi \to \psi) \to (\boxed{\preceq}\phi \to \boxed{\preceq}\psi)$
  - $\boxed{\preceq}\phi \to \boxed{\preceq}\boxed{\preceq}\phi$
  - $\boxed{\preceq}\phi \to \phi$
- $M = \langle W, N_\chi, \leq, V\rangle$ (for $\chi \in \{\mathcal{O}, \mathcal{P}, \mathcal{F}\}$)
  - where $\leq$ is transitive and reflexive
- $M, w \models \boxed{\preceq}\phi$ iff $\forall v\ w \leq v\ M, v \models \phi$

Operator $\boxed{\preceq}$

- $\boxed{\preceq}\phi$:= in all better scenarios, ϕ holds
  - $\boxed{\preceq}(\phi \rightarrow \psi) \rightarrow (\boxed{\preceq}\phi \rightarrow \boxed{\preceq}\psi)$
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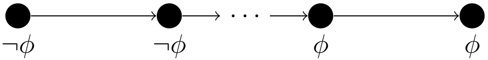

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$\Rightarrow$ Ceteris paribus preferences!
$\Rightarrow$ Thus we say ϕ is preferred over ψ, assuming a set of conditions Γ is agreed on.

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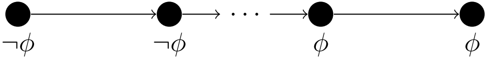
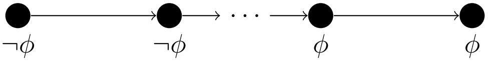


Operator $\boxed{\preceq}^{\Gamma}$

- $\boxed{\preceq}^{\Gamma}\phi$:= in all better scenarios that agree on Γ, ϕ holds
  - $\boxed{\preceq}^{\Gamma}(\phi \to \psi) \to (\boxed{\preceq}^{\Gamma}\phi \to \boxed{\preceq}^{\Gamma}\psi)$
  - $\boxed{\preceq}^{\Gamma}\phi \to \boxed{\preceq}^{\Gamma}\boxed{\preceq}^{\Gamma}\phi$
  - $\boxed{\preceq}^{\Gamma}\phi \to \phi$
- $w \equiv_{\Gamma} v$ iff for all $\gamma \in \Gamma$ ($M, w \vDash \gamma$ iff $M, v \vDash \gamma$)
- $M = \langle W, N_{\chi}, \leq, V \rangle$, (for $\chi \in \{\mathcal{O}, \mathcal{P}, \mathcal{F}\}$),
  - where $\leq$ is transitive and reflexive
- $M, w \vDash \boxed{\preceq}^{\Gamma}\phi$ iff $\forall v$ $w \leq v$ and $w \equiv_{\Gamma} v$, $M, v \vDash \phi$
- 'ϕ is preferred over $\neg\phi$' is translated to $\boxed{U}(\psi \to (\phi \to \boxed{\preceq}^{\Gamma}(\psi \to \phi)))$



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$\Gamma := f(\phi) = \mathcal{L}_{deon} \cup Atm \setminus Atm(\phi)$

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$$\mathcal{P}^{-}(\phi/\psi) ::= \mathcal{P}(\phi/\psi) \wedge \boxed{\cup}(\psi \rightarrow (\neg\phi \rightarrow \boxed{\preceq}^{\ulcorner}(\psi \rightarrow \neg\phi)))$$

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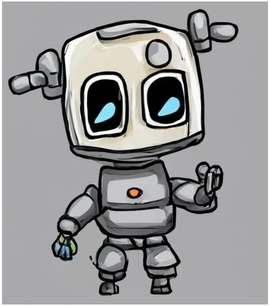
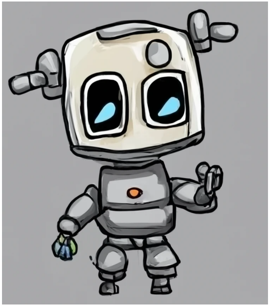
Household Robot



Humanoid robot working in a household setting.

- Cleaning $\geq \neg$ Cleaning
- Assisting in entertainment $\sim \neg$ Assisting in entertainment
- $\neg$ Handle sharp objects $\geq$ Handle sharp objects

Household Robot



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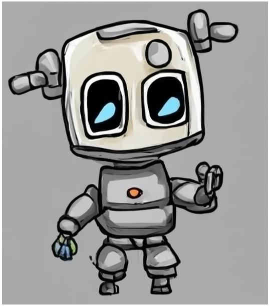

Humanoid robot working in a household setting.

- $cln \geq \neg cln$ - $\mathcal{P}^{+}(cln/req)$
- $ent \sim \neg ent$ - $\mathcal{P}^{0}(ent/req)$
- $\neg sharp \geq sharp$ - $\mathcal{P}^{-}(sharp/req)$

Model

$M \models \mathcal{P}^{-}(sharp/req)$

Model

$M \vDash \mathcal{P}^{-}(sharp/req)$

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- $W = \{a, b\}$
- $N_{\mathcal{P}}(w) = \{(\|sharp\|, \|req\|)\}$ for all $w \in W$.

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- $V(req) = \{a, b\}$, $V(sharp) = \{a\}$
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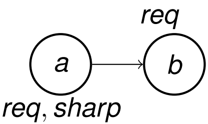

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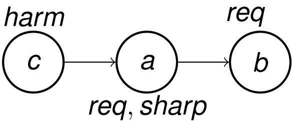
$M = \langle W, N_{\chi}, \leq, V \rangle$ (for $\chi \in \{\mathcal{O}, \mathcal{P}, \mathcal{F}\}$, where

- $W = \{a, b, c\}$
- $N_{\mathcal{P}}(w) = \{(\|sharp\|, \|req\|)\}$ for all $w \in W$.
- $V(req) = \{a, b\}$, $V(sharp) = \{a\}$, $V(harm) = \{c\}$
- Atm:= $\{sharp, req, harm\}$
- $f(sharp) = \mathcal{L}_{deon} \cup \{req, harm\}$



Model

$M \models \mathcal{P}^{-}(sharp/req) \wedge \mathcal{P}^{+}(cln/req) \wedge \mathcal{P}^{0}(ent/req)$

$M = \langle W, N_\chi, \leq, V \rangle$ (for $\chi \in \{\mathcal{O}, \mathcal{P}, \mathcal{F}\}$, where

- $W = \{a, b, c, d, e, f\}$
- $N_{\mathcal{P}}(w) = \{(\|sharp\|, \|req\|), (\|cln\|, \|req\|), (\|ent\|, \|req\|)\}$ for all $w \in W$.
- $V(req) = \{a, b, d, e, f\}$, $V(sharp) = \{a\}$, $V(harm) = \{c\}$,$V(ent) = \{d\}$, $V(cln) = \{f\}$
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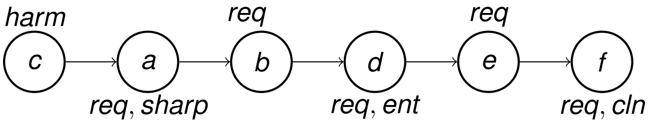

Concluding remarks

Conclusion:

- 2500 years of deontic investigation led to very thought-out and inspiring definitions
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Future work:

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Long-term future work:

- Take inspiration from Mīmāṃsā deontic and apply to AI