

Ignorance is not Bliss:

Deontic Risk and the Asking of Questions

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Motivation

We model *evocation* of questions bearing on *normative issues*, when reasoning under *uncertainty*.

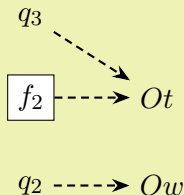
- ▶ are conditional norms triggered? → “normative questions”
- ▶ are defeaters available? → “dialectical questions”



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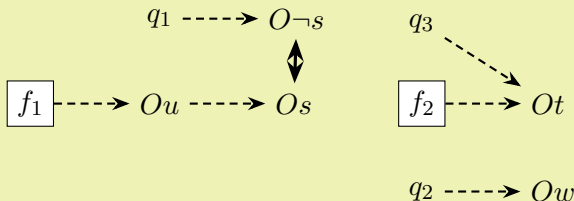
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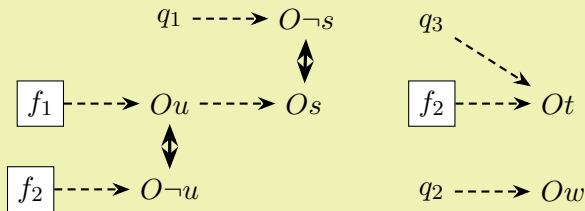
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Evoked Questions Norm

EQN: Rationality requires that you have an *Inquiring Attitude* toward a *Question* only if

- (1) Your knowledge entails that the *Question* has a true, direct answer, and
- (2) Your knowledge does not entail any direct answer to the *Question*.

- We focus on (2); (1) would require a richer logical language to adequately capture (for modeling unknowability, category mistakes, etc.).

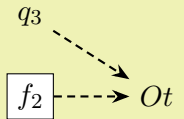
Willard-Kyle, C., Millson, J., & Whitcomb, D. (2024). *Evoked questions and inquiring attitudes*. The Philosophical Quarterly. pp. 384–406



Our Four Rationality Postulates (1/2)

Affirmative openness. Don't ask what you already know.

Trigger relevance. Ask only if the answer could change what you ought to do.



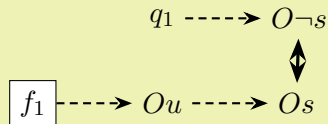
$$q_2 \dashrightarrow Ow$$



Our Four Rationality Postulates (2/2)

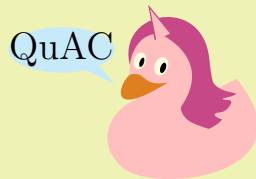
Defeat relevance. Inquire potential defeaters before acting.

Cost Minimality. Here: Ask the least specific question that resolves the issue. (See paper)



- *Minimality:* you don't know p or q but have $p \rightsquigarrow k$, $q \rightsquigarrow k$; asking $p \vee q$ suffices, so asking p alone is overly specific.





The

Calculus

Argumentation Calculi

$$\text{AX} \frac{\vdash_{\mathbf{C}} \Gamma \Rightarrow \Delta}{\Gamma^{\times} \Rightarrow \Delta^{\times}}$$

$$\text{DDet} \frac{\phi^f, \Gamma \Rightarrow \Delta}{\phi^o, \Gamma \Rightarrow \Delta}$$

$$\text{Cut} \frac{\Gamma \Rightarrow \phi \quad \phi, \Gamma' \Rightarrow \Delta}{\Gamma, \Gamma' \Rightarrow \Delta}$$

$$\text{FDet} \frac{}{\phi^f, (\phi, \psi)^n \Rightarrow \psi^o}$$

$$\text{Def} \frac{\Gamma, (\phi, \psi)^n \Rightarrow}{\Gamma \Rightarrow \neg(\phi, \psi)^n}$$

$$\text{OR} \frac{\phi_1^f, \Gamma_1 \Rightarrow \psi^o \quad \phi_2^f, \Gamma_2 \Rightarrow \psi^o}{(\phi_1 \vee \phi_2)^f, \Gamma_1, \Gamma_2 \Rightarrow \psi^o}$$

- ▶ $\mathcal{L}^{DAC}$ is a labeled language ($\times \in \{f, o, n\}$)
- ▶ builds on a base sequent calculus $\mathbf{C}$, here $\mathbf{C} = LK$

van Berkel, K., & Straßer, C. (2022). Reasoning with and about norms in logical argumentation. In: F. Toni, S. Polberg, R. Booth, M. Caminada, & H. Kido (Eds.), Computational models of argument. pp. 332–343.

* For cut-free version see Andrea's talk!



Example. A clinical decision system needs to decide whether to prescribe a pain killer. If the patient is in pain, the system should prescribe the drug (p, k) , but if the patient also has a fever $(p \wedge f, \neg k)$ the system should not prescribe the drug. Assume that the patient is in pain and has a fever: p^f, f^f .

$$\mathbb{K} = \langle \mathcal{F}, \mathcal{N} \rangle, \text{ for } \mathcal{F} = \{p^f, f^f\} \text{ and } \mathcal{N} = \{(p, k)^n, (p \wedge f, \neg k)^n\}.$$



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$$\text{Cut} \frac{\text{Cut} \frac{\vdots}{p^f, f^f, (p \wedge f, \neg k)^n \Rightarrow \neg k^o} \quad \text{Cut} \frac{\text{FDet} \frac{}{p^f, (p, k)^n \Rightarrow k^o} \quad \text{AX} \frac{\vdash_{\mathbf{C}} k, \neg k \Rightarrow}{k^o, \neg k^o \Rightarrow}}{p^f, (p, k)^n, \neg k^o \Rightarrow}}{\text{Def} \frac{p^f, f^f, (p, k)^n, (p \wedge f, \neg k)^n \Rightarrow}{p^f, f^f, (p \wedge f, \neg k)^n \Rightarrow \neg (p, k)^n}}$$



Question Evocation Rule 1 (Qnor)

$\phi_{\text{nor}}^?$

stands for the normative question:

does ϕ , which entails further obligations, hold?



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$$\text{Qnor} \frac{\Gamma^f, \Delta^n \Rightarrow \phi^o}{\sim(\wedge \Gamma')^f, \sim\phi^o, (\Gamma \setminus \Gamma')^f, \Delta^n \Rightarrow \wedge \Gamma'_{\text{nor}}^?}$$

known fact, obligation, unknown

*for $\emptyset \neq \Gamma' \subseteq \Gamma$

- **defeasible!!** – can be defeated if
 - (a) agent is not ignorant about $\psi \in \Gamma'$ or ϕ^o
 - (b) the norms in Δ are unreliable
 - (c) (a more minimal question suffices)



Derivation with Qnor

Example. Our clinical decision system recommends monitoring the patient's blood pressure if they take painkillers and have a heart condition $(k \wedge h, b)^n$.

$$\mathcal{F} = \{p^f\} \text{ and } \mathcal{N} = \{(p, k)^n, (p \wedge f, \neg k)^n, (k \wedge h, b)^n\}$$

$$\begin{array}{c} \text{FDet} \frac{}{p^f, (p, k)^n \Rightarrow k^o} \quad \text{DDet} \frac{\vdots}{k^o, h^f, (k \wedge h, b)^n \Rightarrow b^o} \\ \text{Cut} \frac{}{p^f, h^f, (p, k)^n, (k \wedge h, b)^n \Rightarrow b^o} \\ \text{Qnor} \frac{}{\mathbf{a} : \sim h^f, \sim b^o, p^f, (p, k)^n, (k \wedge h, b)^n \Rightarrow h_{\text{nor}}^?} \end{array}$$



Question Evocation Rule 2 (Qdia)

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stands for the dialectic question:

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*for $\Gamma' \in \wp(\Gamma_1) \setminus \{\emptyset\}$



Question Evocation Rule 2 (Qdia)

$\phi_{\text{dia}}^?$ stands for the dialectic question:

does ϕ , which entails the defeat of a committed norm, hold?

$$\text{Qdia} \frac{\Gamma_1^f, \Delta_1^n \Rightarrow \neg(\phi, \psi)^n \quad \Gamma_2^f, \Delta_2^n, (\phi, \psi)^n \Rightarrow \psi^o}{\sim(\wedge \Gamma'), \sim \neg(\phi, \psi)^n, (\Gamma_1 \setminus \Gamma')^f, \Gamma_2^f, (\Delta_1 \cup \Delta_2)^n \Rightarrow (\wedge \Gamma')_{\text{dia}}^?}$$

*for $\Gamma' \in \wp(\Gamma_1) \setminus \{\emptyset\}$

- **relates to deontic risk** – acting on ψ^o without checking whether Γ' could lead to a norm violation

$$\frac{\vdots}{\frac{p^f, f^f, (p \wedge f, \neg k)^n \Rightarrow \neg(p, k)^n \quad p^f, (p, k)^n \Rightarrow k^o}{\sim f^f, \sim \neg(p, k)^n, p^f, (p \wedge f, \neg k)^n \Rightarrow f_{\text{dia}}^?}} \begin{array}{l} \text{FDet} \\ \text{Qdia} \end{array}$$



Ignorance Rules (1/2)

If you can derive ϕ^x , you are not ignorant about ϕ^x !

$$\text{nF1} \frac{\Gamma^f \Rightarrow \phi^f}{\Gamma^f \Rightarrow \neg \sim \phi^f}$$

$$\text{nF2} \frac{\Gamma^f \Rightarrow (\neg \phi)^f}{\Gamma^f \Rightarrow \neg \sim \phi^f}$$

$$\text{nN} \frac{\Gamma^f \Rightarrow \neg(\phi, \psi)^n}{\Gamma^f \Rightarrow \neg \sim \neg(\phi, \psi)^n}$$

$$\text{nO1} \frac{\Gamma^f, \Delta^n \Rightarrow \phi^o}{\Gamma^f, \Delta^n \Rightarrow \neg \sim \phi^o}$$

$$\text{nO2} \frac{\Gamma^f, \Delta^n \Rightarrow (\neg \phi)^o}{\Gamma^f, \Delta^n \Rightarrow \neg \sim \phi^o}$$

► blocking “doh questions” –

► all rules block questions about things following from $\mathbb{K}$



Ignorance Rules (2/2)

$$\begin{array}{c}
 \text{FDet} \frac{}{p^f, (p, k)^n \Rightarrow k^o} \\
 \hline
 \sim p^f, \sim k^o, (p, k)^n \Rightarrow p_{\text{nor}}^?
 \end{array}
 \quad
 \text{vs.}
 \quad
 \begin{array}{c}
 \frac{p^f \Rightarrow p^f}{p^f \Rightarrow \neg \sim p^f} \text{ nF1}
 \end{array}$$

and

$$\begin{array}{c}
 \frac{}{q^f, (f, k)^n \Rightarrow k^o} \text{ FDet} \\
 \hline
 q^f, (f, k)^n \Rightarrow \neg \sim k^o \text{ nO1}
 \end{array}$$



Argumentation



Dung Semantics

Let $AF = \langle \text{Arg}, \text{Att} \rangle$ be an AF and let $\mathcal{E} \subseteq \text{Arg}$.

- ▶ $\mathcal{E}$ is **conflict-free** if there are no $a, b \in \mathcal{E}$ with $(a, b) \in \text{Att}$.
 - ▶ $\mathcal{E}$ is **stable** if it is conflict-free and attacks every argument not in $\mathcal{E}$.
-

Given a knowledge base $\mathbb{K}$, a QuAC-induced AF is the pair $\langle \text{Arg}(\mathbb{K}), \text{Att}(\mathbb{K}) \rangle$, where

- ▶ $\text{Arg}(\mathbb{K})$ is all $\mathbb{K}$ -based QuAC derivable arguments
 - ▶ $\text{Att}(\mathbb{K})$ are ...
-

Dung, P. M. (1995). On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games. Artificial Intelligence. 77, pp. 321–357.



Attacks in Detail

- **Norm attacks.** $\Gamma \Rightarrow \neg(\phi, \psi)^n$ attacks

$$\begin{cases} \Delta, (\phi, \psi)^n \Rightarrow \Theta & \text{Is the norm reliable} \\ \Delta, \sim\neg(\phi, \psi)^n \Rightarrow \Theta & \text{Is there really no attack on the norm?} \end{cases}$$

$$p^f, f^f, (p \wedge f, \neg k)^n \Rightarrow \neg(p, k)^n$$

$$\sim f^f, \sim\neg(p, k)^n, p^f, (p \wedge f, \neg k)^n \Rightarrow f_{\text{dia}}^?$$



Attacks in Detail

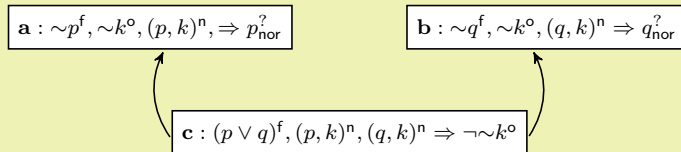
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$$\boxed{p^f, f^f, (p \wedge f, \neg k)^n \Rightarrow \neg(p, k)^n} \longrightarrow \boxed{\sim f^f, \sim\neg(p, k)^n, p^f, (p \wedge f, \neg k)^n \Rightarrow f_{\text{dia}}^?}$$

- **$\sim f/o$ -attacks.** $\Gamma \Rightarrow \neg\sim\gamma^{f/o}$ attacks

$$\begin{cases} \Delta, \sim\gamma^f \Rightarrow \Theta & \text{Are we really ignorant about the fact } \gamma^f \\ \Delta, \sim\gamma^o \Rightarrow \Theta & \text{Are we really ignorant about the obligation } \gamma^o \end{cases}$$



Attacks in Detail

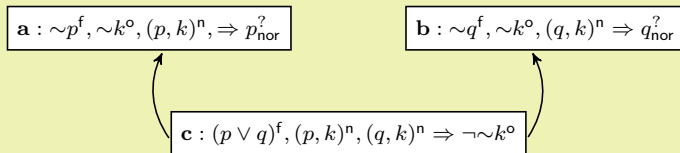
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- **Minimality attacks.** see paper.

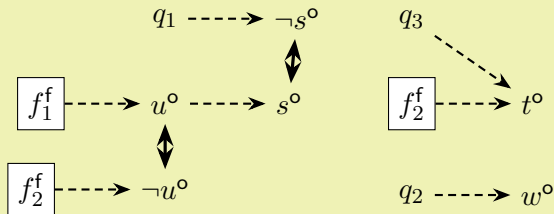


An Example (1/2)

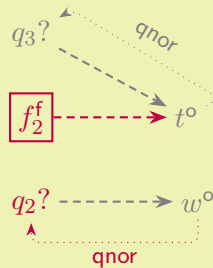
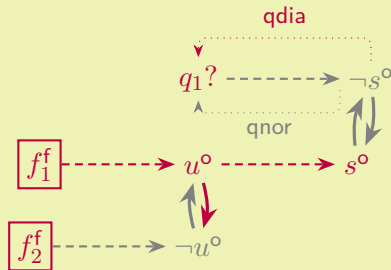
$\mathcal{F} = \{f_1^f, f_2^f\}$, and

$$\mathcal{N} = \{(f_1, u)^n, (u, s)^n, (f_2, \neg u)^n, (f_2, t)^n, (q_1, \neg s)^n, (q_2, w)^n, (q_3, t)^n\}.$$

Schematic:



Stable set $\mathcal{E}_2$



- Obligations: $\mathcal{E}_2 \models u^o$ and $\mathcal{E}_2 \models s^o$
- Questions: $\mathcal{E}_2 \models q_{1_{dia}}^?$ and $\mathcal{E}_2 \models q_{2_{nor}}^?$
- Suspended obligations: $\mathcal{E}_2 \models^? s^o$
- All-things-considered obligations: $\mathcal{E}_2 \models^! t^o$



Suspension in QuAC-induced AFs

For a stable set $\mathcal{E}$, we introduce the following notations:

- ▶ $\mathcal{N}^+(\mathcal{E}) = \{(\sigma_1, \sigma_2)^n \in \mathcal{N} \mid \exists \Gamma \Rightarrow \neg(\sigma_1, \sigma_2)^n \in \mathcal{E}\}$
- ▶ $\mathbb{K}_{\mathcal{E}}^{\phi} = \langle \mathcal{F} \cup \{\phi^f\}, \mathcal{N} \setminus \mathcal{N}^+(\mathcal{E}) \rangle$

Let $\mathcal{E}$ be a stable extension of $\text{AF}(\mathbb{K})$. We let:

- ▶ **(simple validity)** $\boxed{\mathcal{E} \models \phi}$ if there is an argument $\mathbf{a} \in \mathcal{E}$ with $\text{Con}(\mathbf{a}) = \phi$.
- ▶ **(suspended obligation, local)** $\boxed{\mathcal{E} \models^? \phi^o}$ iff $\mathcal{E} \models \phi^o$ but $\forall \mathbf{a} \in \mathcal{E}$, if $\text{Con}(\mathbf{a}) = \phi^o$ then $\exists \sigma$ with $\mathcal{E} \models \sigma_{\text{dia}}^?$ and $\exists \mathbf{b} \in \text{Arg}(\mathbb{K}_{\mathcal{E}}^{\sigma}) \setminus \mathcal{E}$ that norm-attacks $\mathbf{a}$.
- ▶ **(all-things-considered obligation, local)** $\boxed{\mathcal{E} \models^! \phi^o}$ iff $\mathcal{E} \models \phi^o$ but $\mathcal{E} \not\models^? \phi^o$.



(Graded) Nonmonotonic Inference

We define three skeptical consequence relations:

- ▶ **(shared conclusions)** $\boxed{\mathbb{K} \sim \varphi}$ iff $\mathcal{E} \models \varphi$ in every stable set $\mathcal{E}$.
- ▶ **(all-things-considered obligations, global)** $\boxed{\mathbb{K} \sim^! \varphi^\circ}$ iff $\mathcal{E} \models^! \varphi^\circ$ in every stable set $\mathcal{E}$.
- ▶ **(suspended obligations, global)** $\boxed{\mathbb{K} \sim^? \varphi^\circ}$ iff $\mathcal{E} \models \varphi^\circ$ in every stable set $\mathcal{E}$, but $\mathcal{E} \models^? \varphi^\circ$ in some stable set.



Meta-Theory



Theorem 1

Let $\langle \text{Arg}(\mathbb{K}), \text{Att}(\mathbb{K}) \rangle$ be a DACQ-induced AF and let $\mathcal{E} \subseteq \text{Arg}(\mathbb{K})$. Let $\mathcal{E}$ be a stable extension in $\text{AF}(\mathbb{K})$. We have: $\mathcal{E} \models \phi_{\text{nor}}^?$ iff

- ▶ **(factual ignorance)** $\mathcal{E} \not\models \phi^f$ and $\mathcal{E} \not\models (\neg\phi)^f$, and
- ▶ **(normative relevance)** there is a ψ for which $\mathcal{E} \not\models \psi^o$ and $\mathcal{E} \not\models (\neg\psi)^o$ while there is an argument $\mathbf{b} \in \text{Arg}(\mathbb{K}_{\mathcal{E}}^{\phi}) \setminus \text{Arg}(\mathbb{K})$ with $\text{Con}(\mathbf{b}) = \psi^o$; and for this ψ :
- ▶ **(minimality)** there are no ξ and $\mathbf{b} \in \text{Arg}(\mathbb{K}_{\mathcal{E}}^{\xi})$ with $\text{Con}(\mathbf{b}) = \psi^o$ and $\phi > \xi$.



Theorem 2

Let $\langle \text{Arg}(\mathbb{K}), \text{Att}(\mathbb{K}) \rangle$ be a DACQ-induced AF and let $\mathcal{E} \subseteq \text{Arg}(\mathbb{K})$. Let $\mathcal{E}$ be a stable extension in $\text{AF}(\mathbb{K})$ and let $\mathbb{K}' = \mathbb{K}_{\mathcal{E}}^{\phi}$. We have $\mathcal{E} \models \phi_{\text{dia}}^?$ iff

- ▶ **(factual ignorance)** $\mathcal{E} \not\models \phi^f$ and $\mathcal{E} \not\models (\neg\phi)^f$, and
- ▶ **(dialectic relevance)** there are $(\sigma, \psi)^n \in \mathcal{N}$ and arguments $\mathbf{a} \in \mathcal{E}$ with $\text{Con}(\mathbf{a}) = \psi^o$ and $\mathbf{b} \in \text{Arg}(\mathbb{K}') \setminus \mathcal{E}$, such that $\mathbf{b}$ attacks $\mathbf{a}$ in $(\sigma, \psi)^n$; and for this $(\sigma, \psi)^n$:
- ▶ **(minimality)** there are no ξ and $\mathbf{b} \in \text{Arg}(\mathbb{K}_{\mathcal{E}}^{\xi})$ with $\text{Con}(\mathbf{b}) = \neg(\sigma, \psi)^n$ and $\phi > \xi$.



Overview

Our goal: to provide a **model of normative reasoning with questions due to uncertainty**.

- 1^{st} Conceptual background: when are questions rational? extension to normative domain $\Rightarrow$ when do conditional norms recommend inquiry?
- 2^{nd} Logical tools: capturing the desiderata from 1. in the sequent calculus **QuAC**;
- 3^{rd} Argumentation: investigating nonmonotonic inference to questions and obligations & their interaction; suspension due to dialectical questions.



Related & Future Work

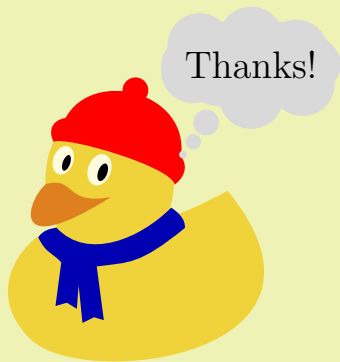
- ▶ Connections to Erotetic/Inquisitive Logics
- ▶ Connections to Abduction
- ▶ Planning (see [2])
- ▶ Nuance with Norm Conflicts:
 - ▶ c.f. [1]; handling specificity, CTDs, etc.
- ▶ thinking beyond deontic logic:

$$\text{RatMon} \frac{\Gamma \vdash C \quad \Gamma \not\vdash \neg B}{\Gamma, B \vdash C} \Leftrightarrow \text{RatMon} \frac{\Gamma \vdash C \quad \Gamma, B \not\vdash C}{\Gamma \vdash \neg B}$$
$$\text{RatMonQ} \frac{\Gamma \vdash C \quad \Gamma, B \not\vdash C}{\Gamma \vdash B_{\text{dia}}^?}$$

[1] – van Berkel, K., & Straßer, C. (2025). Reasoning with and about normative conflicts. In K. van Berkel, A. Ciabattini, & J. F. Horty (Eds.), Deontic Logic and Normative Systems - 17th International Conference, DEON 2025, Vienna, Austria, July 1-3, 2025 pp. 21–40. College Publications.

[2] – Pardo, P., & Straßer, C. (2024). The goal after tomorrow: Offline goal reasoning with norms. Journal of Artificial Intelligence Research, 80, pp. 1703–1759





Appendix

Minimality Rules

If multiple inquiries are directed at the same normative issue, we should prefer the most general question that still resolves the issue.

$$\text{MinQnor} \frac{\sim \omega_1^f, \sim \phi^o, \Gamma_1^f, \Delta_1^n \Rightarrow \omega_1^?_{\text{nor}} \quad \sim \omega_2^f, \sim \phi^o, \Gamma_2^f, \Delta_2^n \Rightarrow \omega_2^?_{\text{nor}} \quad \omega_1 > \omega_2}{\sim \omega_2^f, \sim \phi^o, \Gamma_2^f, \Delta_2^n \Rightarrow \neg(\sim \omega_1^f \wedge \sim \phi^o)}$$

$$\text{MinQdia} \frac{\sim \omega_1^f, \sim \neg(\phi, \psi)^n, \Gamma_1^f, \Delta_1^n \Rightarrow \omega_1^?_{\text{dia}} \quad \sim \omega_2^f, \sim \neg(\phi, \psi)^n, \Gamma_2^f, \Delta_2^n \Rightarrow \omega_2^?_{\text{dia}} \quad \omega_1 > \omega_2}{\sim \omega_2^f, \sim \neg(\phi, \psi), \Gamma_2^f, \Delta_2^n \Rightarrow \neg((\phi, \psi)^n \wedge \sim \omega_1^f)}$$

* $\omega_1 > \omega_2$ abbreviates $\omega_1 \Rightarrow \omega_2, \omega_2 \not\Rightarrow \omega_1$, i.e. ω_1 is more specific than ω_2



Derivation with MinQnor

Example. Consider a clinical decision system where if the patient is in pain it should prescribe the painkiller and if the patient is queasy it should also prescribe it. This time there is no info about the patient.

$$\mathcal{F} = \{ \} \text{ and } \mathcal{N} = \{(p, k)^n, (q, k)^n\}$$

$$\begin{array}{c}
 \text{FDet} \frac{}{p^f, (p, k)^n \Rightarrow k^o} \quad \text{FDet} \frac{}{q^f, (q, k)^n \Rightarrow k^o} \\
 \text{OR} \frac{}{\mathbf{d} : (p \vee q)^f, (p, k)^n, (q, k)^n \Rightarrow k^o} \\
 \text{Qnor} \frac{}{\mathbf{a} : \sim(p \vee q)^f, \sim k^o, (p, k)^n, (q, k)^n \Rightarrow (p \vee q)_{\text{nor}}^?} \quad \text{FDet} \frac{}{p^f, (p, k)^n \Rightarrow k^o} \\
 \text{MinQnor} \frac{}{\mathbf{b} : \sim p^f, \sim k^o, (p, k)^n \Rightarrow p_{\text{nor}}^?} \quad p > p \vee q \\
 \hline
 \mathbf{c} : \sim(p \vee q)^f, \sim k^o, (p, k)^n, (q, k)^n \Rightarrow \neg(\sim p^f \wedge \sim k^o)
 \end{array}$$