What might be known

Epistemic modality and uncertain contexts

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Introduction

Starting point: epistemics in dynamics

In standard dynamic semantics

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- A declarative containing an epistemic modal operator, such as:

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- A declarative containing an epistemic modal operator, such as:

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  is meaningful but not informative.

- A question containing an epistemic modal operator, such as:

  (2) **Might** Hitch be the culprit?

  cannot be interpreted as genuine request for information.

Introduction

Aim

(1) Hitch **might** be the culprit.

(2) **Might** Hitch be the culprit?

-
- how to make (1) informative;
- how to make (2) inquisitive

Epistemic modality

(Kratzer, 1981, 1991)

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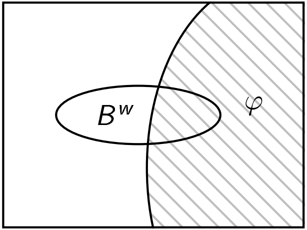
Quantification over possible worlds

$\Diamond(B)(\varphi)$ is true in w iff $[\![B]\!]^w \cap [\![\varphi]\!] \neq \varnothing$



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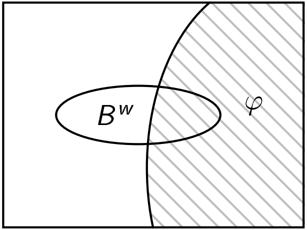

Modal base B : a body of knowledge.

Dynamic semantics

CCP and Update (Heim, 1992; Groenendijk et al., 1996)

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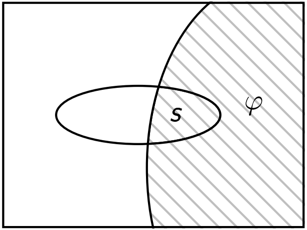

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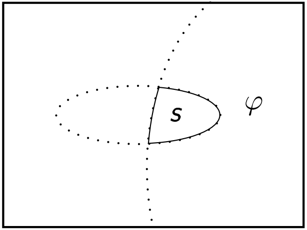

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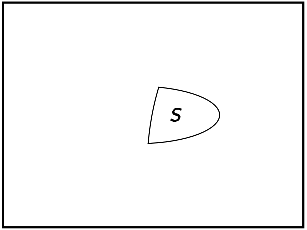

Eliminating worlds = growth of information
"*à la* Stalnaker (1978)"

Dynamics of epistemic modalities

Groenendijk et al. (1996), von Fintel and Gillies (2007)

CCP of an epistemic possibility $\Diamond\varphi$

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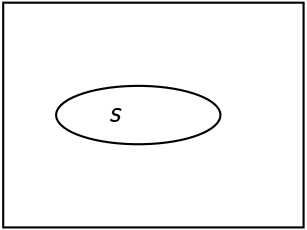

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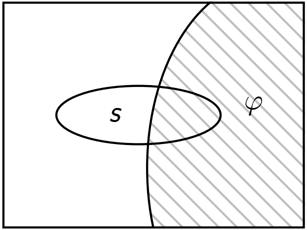

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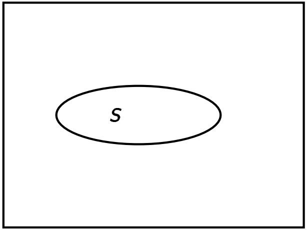

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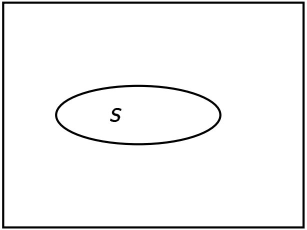

Actually you can learn stuff from an epistemic modal assertion.
Now what is learned and what is known is precisely in s.

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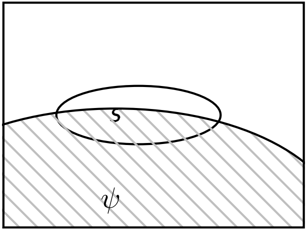

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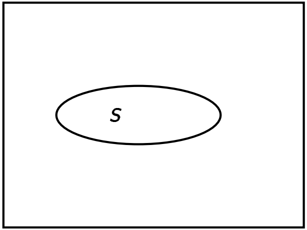

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Questions

(Groenendijk and Stokhof, 1984, 1989)

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$$[\![?\varphi]\!] = \{\langle w, w'\rangle \in \mathcal{W} \times \mathcal{W} \mid [\![\varphi]\!]^{w'} = [\![\varphi]\!]^{w}\}$$

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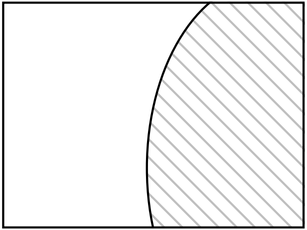
Proposition $[\![\varphi]\!]$



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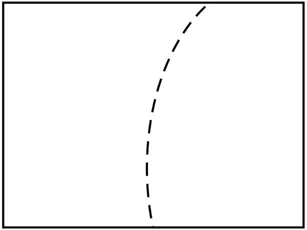

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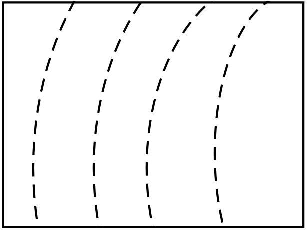
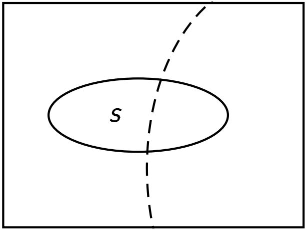


Inquisitiveness

Groenendijk (1999)

Inquisitiveness of $?\varphi$ in s

$?\varphi$ is inquisitive w.r.t s iff $[\![?\varphi]\!]$ actually divides s into several parts (ie iff there exist w_1 and w_2 in s s.t. $[\![\varphi]\!]^{w_1} \neq [\![\varphi]\!]^{w_2}$).



Epistemic modality in questions

A paradox: $?\Diamond\varphi$ cannot be inquisitive

(2) *A*: Might Hitch be the culprit? $\rightsquigarrow$ $?\Diamond\varphi$

A does not know whether Hitch might or might not be the culprit
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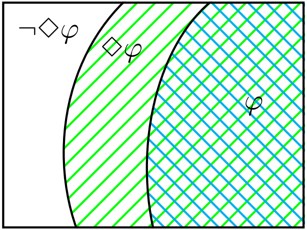

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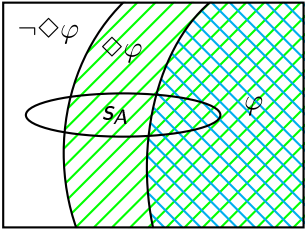

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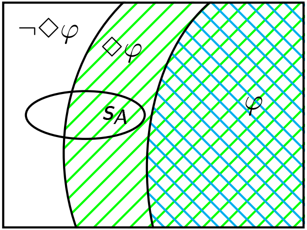

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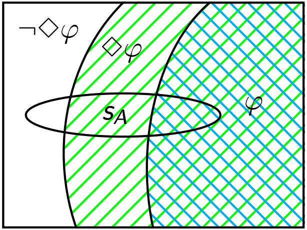

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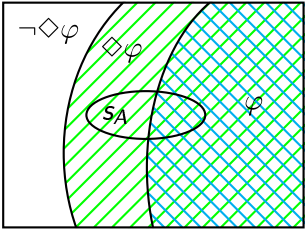

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Proposal

Information spaces

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- Evaluate epistemics w.r.t. a set of information states. Let's call it an information *space*.
- Let S be a set of information states ($S \subset \wp(\mathcal{W})$):

CCP of modal sentences

$$S[\![\Diamond\varphi]\!]^{\mathrm{ccp}} = \{s \in S \mid s[\![\Diamond\varphi]\!]^{\mathrm{ccp}} = s\} = \{s \in S \mid s \cap [\![\varphi]\!] \neq \varnothing\}$$
$$S[\![\Box\varphi]\!]^{\mathrm{ccp}} = \{s \in S \mid s[\![\Box\varphi]\!]^{\mathrm{ccp}} = s\} = \{s \in S \mid s \subset [\![\varphi]\!]\}$$

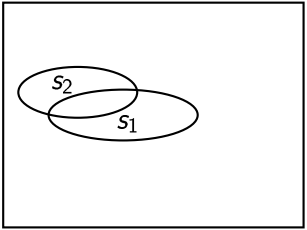
General case

$$S[\![\psi]\!]^{\mathrm{ccp}} = \{s' \mid \exists s \in S,\ s[\![\psi]\!]^{\mathrm{ccp}} = s'\}$$

Update of an information space

Illustration

$S = \{s_1 \; ; s_2\}$



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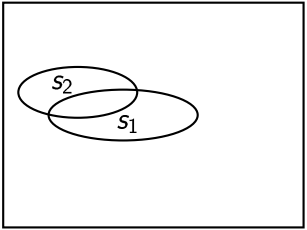

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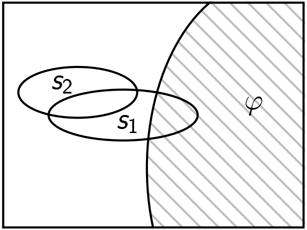

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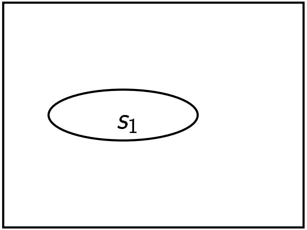

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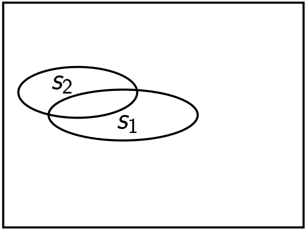

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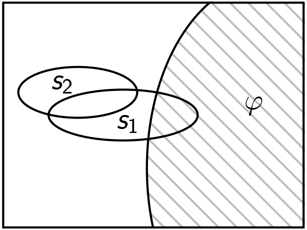

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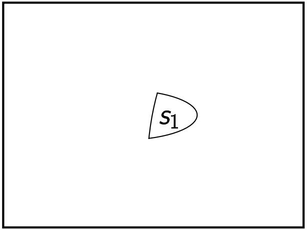
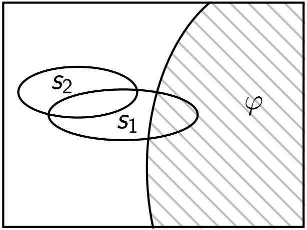


Epistemic modality in questions

Inquisitiveness rescued

Inquisitiveness of $?\Diamond\varphi$

$?\Diamond\varphi$ is inquisitive in S if there are at least $s_1 \in S$ and $s_2 \in S$ s.t. $s_1 \cap [\![\varphi]\!] \neq \varnothing$ and $s_2 \cap [\![\varphi]\!] = \varnothing$.



Consistency and Support

In standard Update Semantics (simplified)

1. φ is *consistent* with s iff $s[\![\varphi]\!]^{\text{ccp}}$ exists and $s[\![\varphi]\!]^{\text{ccp}} \neq \varnothing$.
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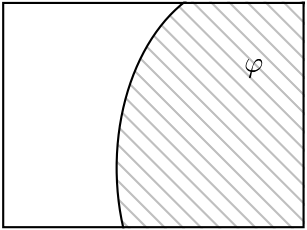
4. φ is *maximally consistent* with S iff $S[\![\varphi]\!]^{\mathrm{ccp}}$ exists and for every $s \in S[\![\varphi]\!]^{\mathrm{ccp}}$, $s[\![\varphi]\!]^{\mathrm{ccp}} \neq \varnothing$.

Consistency and Support

...illustrated



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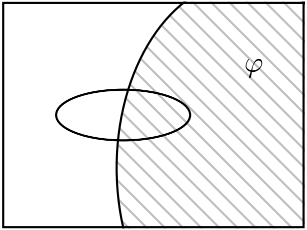

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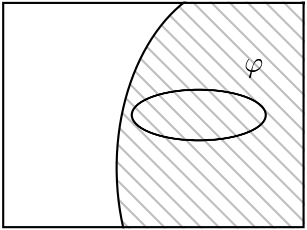

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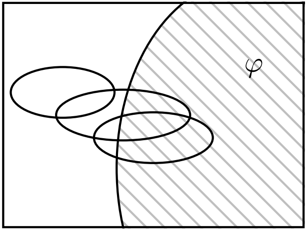

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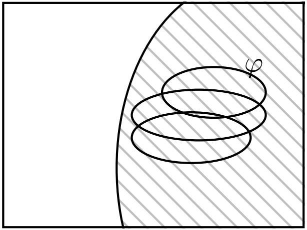
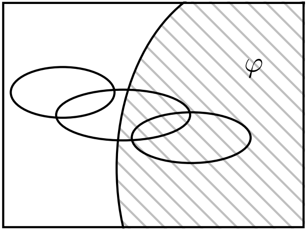


Consistency and Support

...illustrated

φ is minimally supported by S



Consistency and Support
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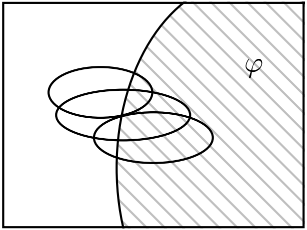
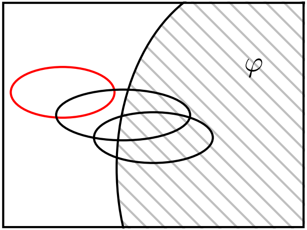


Inquisitiveness of $?\Diamond\varphi$

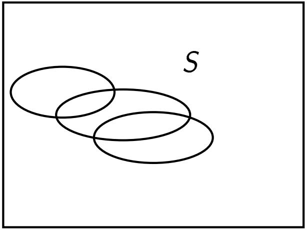
$?\Diamond\varphi$ is inquisitive in S iff φ is consistent but not maximally consistent with S.



Information spaces and common ground

S derives from CG

An information space is a structured common ground (CG).
$S \subseteq \wp(CG)$ and $CG = \bigcup S$



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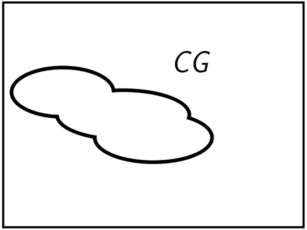

CG is an epistemic information state.

What do information spaces stand for?

Multi-agent perspective

What does it mean to have multiples information states in the context?

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Multi-agent perspective

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Related works:

- **Gunlogson (2001)**: the Common Ground (or context set) is the union of the speaker's and adressee's public beliefs → two information states
- **Stephenson (2007)**: the epistemic modal base is relative to a *judge* parameter/index → as many states as judges.
- **von Fintel and Gillies (2008)**: an epistemic (*might*) modal sentence is evaluated w.r.t. a "cloud" of contexts delimited by some groups of speakers and/or adressees.

What do information spaces stand for?

From the speaker viewpoint

(2) Might Hitch be the culprit?
"Is there *any available evidence* consistent with the proposition 'Hitch is the culprit'?"

Evidence = propositions whose truth value is not known.
Evidence $\notin CG$

Back to Kratzer (1981, 1991)

Ordering sources

Ordering sources = sets of propositions to complement modal bases, in order:

- to account for graded modal forces ;
- to solve some logical problems with non realistic modal bases (e.g. counterfactuals, deontic/samaritan paradox...);
- to look at more or less reliable information in addition to a(n epistemic) modal base.

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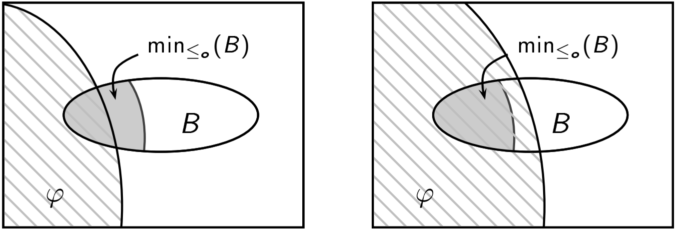
An ordering source O induces an order $\leq_o$ among worlds of any modal base.
Let $\min_{\leq_o}([\![B]\!]^w)$ be the (sub)set of worlds in $[\![B]\!]^w$ that come closest to $\cap O$.

Back to Kratzer (1981, 1991)

Human possibilities and necessities

$$[\![\Diamond(B,O)(\varphi)]\!]^w = 1 \text{ iff } \min_{\leq_O}([\![B]\!]^w) \cap [\![\varphi]\!] \neq \varnothing$$
$$[\![\Box(B,O)(\varphi)]\!]^w = 1 \text{ iff } \min_{\leq_O}([\![B]\!]^w) \subset [\![\varphi]\!]$$



$\Diamond(B,O)(\varphi)$ and $\Box(B,O)(\varphi)$

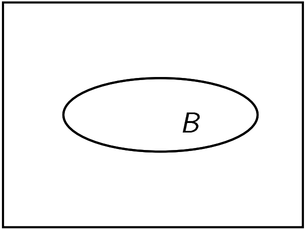
Example

(1) Hitch might be the culprit.

- The facts ($\in$ the epistemic modal base):
  A crime happened. There are no established facts and no clear evidence that Hitch is either innocent or culprit. We don't have much information on Hitch's personal schedule at the moment of the crime. We only know that Hitch is a good guy.
- Ordering sources:
  - Empty ordering source: $O = \varnothing$, (1) is true.
  - We have the stereotypical belief that normally good guys don't commit crimes
    $O = \{\textit{good guys don't commit crimes}\}$: (1) is false.
  - Julia provided us with an alibi: she was with Hitch at the moment of the crime and she says that he is innocent (but can we trust Julia?):
    $O = \{\textit{Hitch is innocent}\}$: (1) is false.

From multiple ordering sources to multiple information states

Take an epistemic modal base B, and consider different ordering sources O_1, O_2, O_3..., you'll get several epistemic information states (namely $\min_{\leq_{o1}}(B)$, $\min_{\leq_{o2}}(B)$, $\min_{\leq_{o3}}(B)$...).



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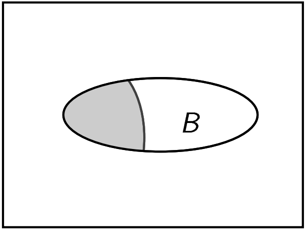

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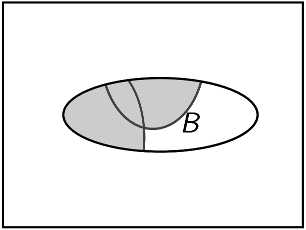

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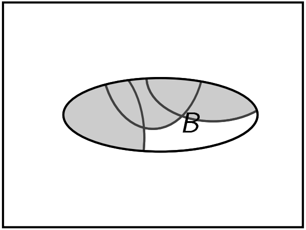

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- B comes from the set of established facts in the context, what the speakers know.
- O is a set of propositions that the speakers can take into account to draw inferences.
- We need to handle different Os at once (ie in a same given context).

Groenendijk et al. (1996) again

- An information state = a set of possibilities.

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- An information state = a set of possibilities.
- A possibility = a possible world w (first approximation)

Groenendijk et al. (1996) again

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Former simpler information states (viz. s):
$\sigma^s = \{w \mid \exists o \exists g \; \langle w, o, g \rangle \in \sigma\}$

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CCP of $\Diamond\varphi$ in σ

$\sigma[\![\Diamond\varphi]\!]^{\text{ccp}} = \{\langle w, o, g\rangle \in \sigma \mid \min_{\leq_o}(\sigma^s) \cap [\![\varphi]\!] \neq \varnothing\}$

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CCP of φ in σ

$$\sigma[\![\varphi]\!]^{\mathrm{ccp}} = \{\langle w, o, g\rangle \in \sigma \mid [\![\varphi]\!]^{w,g} = 1\}$$

Back to EMQs

... and to a more static analysis

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Intension of ψ w.r.t. a context σ : $[\![\psi]\!]^{\sigma} = \sigma[\![\psi]\!]^{\mathrm{ccp}}$

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Relational meaning of a non-modal question

$$[\![?\varphi]\!]^{\sigma} = \{\langle\langle w, o, g\rangle, \langle w', o', g\rangle\rangle \in \sigma \times \sigma \mid [\![\varphi]\!]^{w,g} = [\![\varphi]\!]^{w',g}\}$$

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Back to EMQs

… and to a more static analysis… and to information spaces S

For a simpler formulation:

Relational meaning of an EMQ

$$[\![?\Diamond\varphi]\!]^S = \{\langle s, s'\rangle \in S \times S \mid s \cap [\![\varphi]\!] \neq \varnothing \Leftrightarrow s' \cap [\![\varphi]\!] \neq \varnothing\}$$

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- EMQs do not only ask about the (state of) world but also about the context.

Concluding remarks

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- Requirement (H2): several possible values must be assigned to the variable O, ie several ordering sources must be present in the context.

Perspectives and future work

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- Constituent questions:

(3) Qui peut/pourrait être le coupable ?
Who may/might be the culprit?

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- Epistemic adverbs

(5) a. #Hitch est-il peut-être le coupable ?
Is Hitch perhaps the culprit?
b. #Hitch est-il sûrement/certainement le coupable ?
Is Hitch surely/certainly the culprit?

Perspectives and future work

- Embedded EMQs:

(6) a. The detective knows whether Hitch might be the culprit.
b. The detective wonders whether Hitch might be the culprit.

- Relationship between EMQ and special/biased questions

(7) Où peut bien se cacher le coupable ?!
Where (the hell) can the culprit be hidden?!

(8) Comment Hitch peut-il être le coupable ?
How can Hitch be the culprit?

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