Causal Premise Semantics

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Perspectives on Modality
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Outline

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Premise Semantics for modals

Kratzer (1981a)

(1) John must be at home. *Must*(*John home*)

(2) John may be at home. *May*(*John home*)

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- Two contextually given bodies of *background assumptions*:
  - Modal base: what is *established* in the relevant sense
    - epistemic (subjective; beliefs)
    - circumstantial (objective; facts)
  - Ordering source: what is *preferred* in the relevant sense
    - stereotypical (normalcy)
    - deontic (obligations)
    - bouletic (desires)

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- *[In view of the curfew,]* John must be at home.

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➽ Variety of modal flavors
  - *[In view of the curfew,]* John must be at home.
  - *[In view of what we know,]* John may be at home.

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(1) John must be at home. *Must*(*John home*)

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(3) Prejacent: John is at home. *John home*

- Interpretation relative to two sets of propositions:
  modal base *M*; ordering source *O*

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- Try all ways of adding propositions from O to M, maintaining consistency.
  - If you inevitably get a set that entails (3), then (1) is true.
  - If there is a way to keep adding without ruling out (3), then (2) is true.

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  - If you inevitably get a set that entails (3), then (1) is true.
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- Terminology
  - Premise set: a consistent set of propositions containing M and some subset of O.
  - $\mathrm{Prem}^K(M, O)$: the set of all premise sets obtained from M, O.

Premise Semantics for conditionals

Kratzer (1981a)

(4) If the lights are on,
John must be at home. $Must_{lights\ on}(John\ home)$

(5) *Antecedent:* The lights are on. *lights on*

(3) *Consequent:* John is at home. *John home*

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  1. Add the antecedent (temporarily) to the modal base;
  2. Evaluate the matrix clause relative to the modified modal base.

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  1. Add the antecedent (temporarily) to the modal base;
  2. Evaluate the matrix clause relative to the modified modal base.

➽ $Must_{lights\ on}(John\ home)$ is true relative to (M, O) if and only if $Must(John\ home)$ is true relative to $(M{+}lights\ on, O)$.

Premise Semantics for counterfactuals

Goodman (1947); Kratzer (1981a,b, 1989); Kaufmann (2012)

(6) If that match is scratched, it will light. [indicative]

(7) If that match were scratched, it would light. [counterf.]

(8) If that match had been scratched, it would have lit. [counterf.]

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  Present and Past of an underlying modal stem *'woll'* .

(Abusch, 1997, 1998; Condoravdi, 2002; Kaufmann, 2005)

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  Adding the antecedent to M requires adjustments to avoid inconsistency. (Stalnaker, 1975; Iatridou, 2000; Schulz, 2012)

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  (Kaufmann, 2005; Grønn and von Stechow, 2011; Schulz, 2008, 2012)

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- I am glossing over some morphological details in this talk.
  (Kaufmann, 2005; Grønn and von Stechow, 2011; Schulz, 2008, 2012)
- I am interested in *objective* readings of counterfactuals (circumstantial modal base, stereotypical ordering source)

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(8) If that match had been scratched, it would have lit.

Goodman's idea:

- When we say (8), we mean that conditions are such – i.e. the match is well made, is dry enough, oxygen enough is present, etc. – that "The match lights" can be inferred from "The match is scratched."
- [T]he connection we affirm may be regarded as joining the consequent with the conjunction of the antecedent and other statements that truly describe relevant conditions.

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- {*scratched*, *was dry*} ⇒ *lit*

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(9) If that match had been scratched, it would have been wet. ✗

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- $\{scratched, was\ dry\}$ $\Rightarrow$ *lit*
- $\{scratched, didn't\ light\}$ $\Rightarrow$ *was wet*

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Kratzer's formalization:

- The modal base M is empty.

  Thus the antecedent can be added consistently:
  $M + \mathit{scratched} = \{\mathit{scratched}\}$

- The propositions in O characterize the actual state of affairs.

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Two problems:

1. Still no explanation for the falsehood of (9)
2. Similarity to what happened is not (always) the right criterion.

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[Two fair coins, A and B. Coin A was tossed and came up heads.]

(10) If coin B had been tossed, it would have come up heads. ✗

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➽ Need to hold on to *some of* the contents of M.

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➽ Need to hold on to *some of* the contents of *M*.

Q1: Which parts of *M* to hold on to?

Q2: How to put those parts of *M* together with bits of *O*?

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Kaufmann (2012)

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- Two ways of deriving premise sets from M, O:
  - by adding subsets of O to M (traditional)
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- The relevant structure is a contextual parameter, like M itself.
  - temporal precedence
  - causal dependencies
  - …

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BUT not all interpretations are attested for counterfactuals.

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- Break up M, respecting its structure.
- The relevant structure is a contextual parameter, like M itself.
  - temporal precedence *[wrong for cf but right for other expressions]*
  - causal dependencies *[right for cf and for yet other expressions]*
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- Different structures ⇒ different interpretations.

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Temporal interpretation: Re-run history

(8) If the match had been scratched (at t_1), it would have lit (at t_2).

- Propositions are indexed to times
- Modal base M: Completely characterizes history until now
  – i.e., inconsistent with the antecedent of (8)

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BUT does this work for other counterfactuals?

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BUT does this work for other counterfactuals? No.

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A problem for past predominance

[A fair coin is about to be tossed. At t_1, you bet on heads. At t_2, the coin is tossed. At t_3, it comes up heads and you win.]

(11) If I had bet on tails, I would have lost.

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  - Before t_1, both heads and tails are possible.
  - Neither outcome is more likely than the other.
  - ➠ (11) is predicted to be false.

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  The toss comes after the betting, yet is *unaffected* by it.

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- What went wrong:
  The toss comes after the betting, yet is *unaffected* by it.
- Instead of temporal precedence, consider *causal precedence*.

Premise Semantics for counterfactuals

Causality

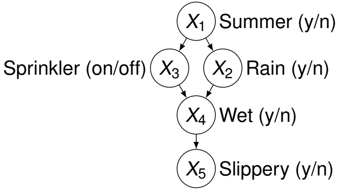
Pearl (2000):

(12) In the last decade, owing partly to advances in graphical models, causality has undergone a major transformation: from a concept shrouded in mystery into a mathematical object with well-defined semantics and well-founded logic . . . Put simply, causality has been mathematized.

Premise Semantics for counterfactuals

Causal networks

- Causal network: ordered set $\langle U, E \rangle$
  - U: set of variables (questions)
  - E: asymmetric relation over U
  - Arrows indicate *causal influence*



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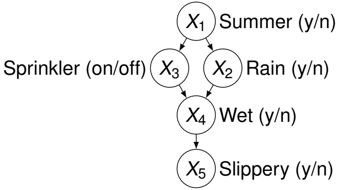
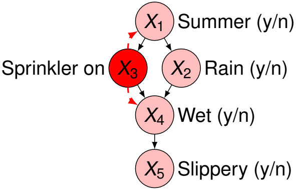
  - E: asymmetric relation over U
  - Arrows indicate *causal influence*
- The answers to X's parents determine how X is answered. (Markov Assumption)

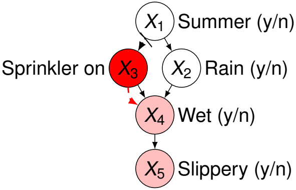


Premise Semantics for counterfactuals

Causal networks

- Two modes of inference:
  - Observation: *finding* the sprinkler on (left)
  - Intervention: *turning* the sprinkler on (right)





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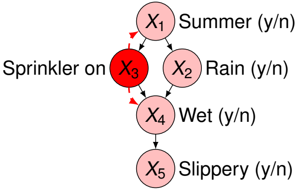
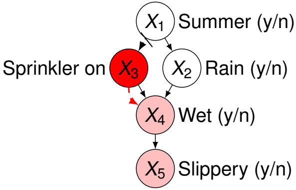
Causal networks

- Two modes of inference:
  - Observation: *finding* the sprinkler on (left)
  - Intervention: *turning* the sprinkler on (right)
- Intervention is said to be involved in counterfactual inference.

(Pearl, 2000)





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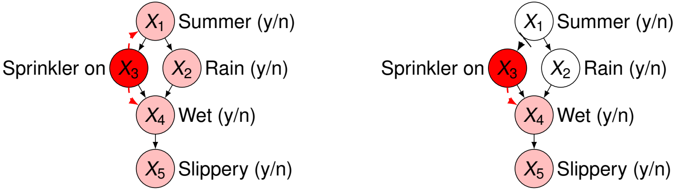
Causal networks

- Two modes of inference:
  - Observation: *finding* the sprinkler on (left)
  - Intervention: *turning* the sprinkler on (right)
- Intervention is said to be involved in counterfactual inference.

(Pearl, 2000)

- This is true with some caveats

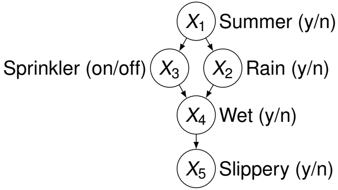
(Sloman and Lagnado, 2004; Dehghani, Iliev, and Kaufmann, 2012)



Premise Semantics for counterfactuals
Causal networks

Premise Semantics:

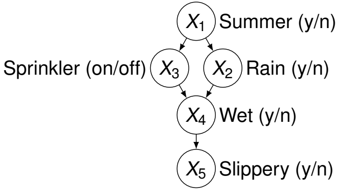
- No explicit representation of the graph.
- Rather: a characterization of the parameters that give rise to a causal interpretation.



Premise Semantics for counterfactuals
Causal networks

Premise Semantics:

- No explicit representation of the graph.
- Rather: a characterization of the parameters that give rise to a causal interpretation.
  - Modal base: Contains answers to all questions in the graph (circumstantia – no epistemic ignorance)
  - Ordering source: Encodes, for each possible answer to X, how (un)likely it is given the settings of X's parents, for all X

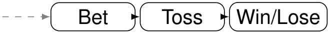


Premise Semantics for counterfactuals

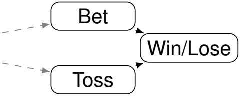
Temporal vs. causal interpretation

(11) If I had bet on tails, I would have lost.

Temporal order



Causal structure



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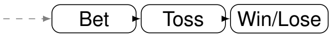

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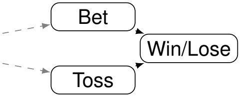

Interruption: Changing $\boxed{\text{Bet}}$ discards everything after $\boxed{\text{Bet}}$.

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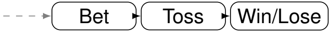

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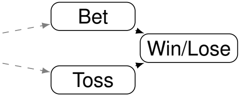

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➸ Similar to the temporal case, but relative to a non-linear order.

Summary so far

A uniform rule for building premise sets from M, O:

- pairs $(m{+}\mathit{Antecedent}, o)$, where
  - m is a subset of M, *subject to some condition* (initial history, closed under causal ancestors, etc.)
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  - ➜ Indicatives are not sensitive to the temporal/causal contrast.
  - Which way the modal base is split depends not only on the context: Counterfactual conditionals seem to favor a *causal* interpretation.
  - ➜ Is this the same for *all* counterfactual inferences, including those which arise with other linguistic expressions?

Outline

Kratzer Premise Semantics for modals

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- Notation: $\mathrm{Prem}^K(f(w), g(w))$ instead of Φ for Kratzer premise sets.

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Kratzer Premise Semantics for conditionals

- Update of modal base f with proposition p:

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Basic idea

- Kratzer premise sets again:

$$\overset{K}{\text{Prem}}(f(w), g(w)) = \{f(w) \cup Y \mid Y \subseteq g(w) \text{ and } f(w) \cup X \text{ is consistent}\}$$

Basic idea

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$$\overset{K}{\text{Prem}}(f(w), g(w)) = \{f(w) \cup Y \mid Y \subseteq g(w) \text{ and } f(w) \cup X \text{ is consistent}\}$$

- Goal: "break up" $f(w)$.

$$\text{Prem}(f(w), g(w)) = \{X \cup Y \mid X \subseteq f(w), Y \subseteq g(w) \text{ and } \ldots\}$$

Premise set pairs

- Let $f(w) = \{p, q\}, \quad g(w) = \{r, s\}$

  Then $\mathrm{Prem}^K(f(w), g(w)) = \{\{p, q\}, \{p, q, r\}, \{p, q, s\}, \{p, q, r, s\}\}$

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- Cartesian product (writing '$X.Y$' for $\langle X, Y\rangle$):

$$\mathbf{f}_{id}(w) \times \mathbf{g}_{\wp}(w) = \{pq., pq.r, pq.s, pq.rs\}$$

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- Lexicographic order:

$$X.Y \leq X'.Y' \text{ iff (i) } X \subseteq X' \text{ and (ii) if } X = X' \text{ then } Y \subseteq Y'$$

Premise set pairs

$$\mathbf{f}_{id}(w), \mathbf{g}_{\wp}(w)$$

$$\begin{tikzcd} & pq.rs & \\ pq.r \arrow[ur, no head] & & pq.s \arrow[ul, no head] \\ & pq. \arrow[ul, no head] \arrow[ur, no head] & \end{tikzcd}$$

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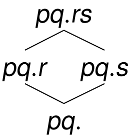

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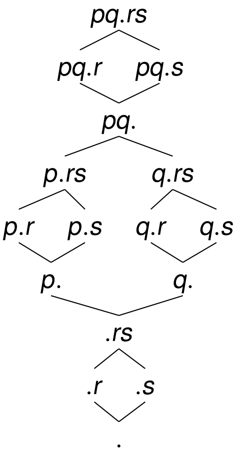

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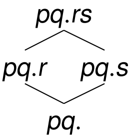

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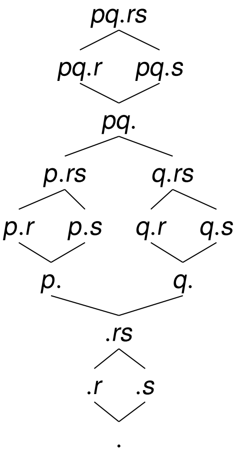

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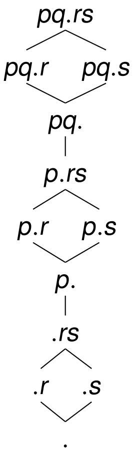

Premise set sequences

- *Sequence structures* recursively defined:
  - If Φ is a set of sets of propositions, then $\langle \Phi, \subseteq \rangle$ is a sequence structure.
  - If $\langle \Phi_1, \leq_1 \rangle, \langle \Phi_2, \leq_2 \rangle$ are sequence structures, then so is $\langle \Phi_1, \leq_1, \rangle * \langle \Phi_2, \leq_2 \rangle$, defined as $\langle \Phi_1 \times \Phi_2\ ,\ \leq_1 * \leq_2 \rangle$.

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Comments:

- Sequence structures are *partially ordered*
  (set inclusion for basic structures; preserved by lexicographic order)
- Product formation by '$*$' is *associative*
  (since both Cartesian products and lexicographic orders are)

Premise structures

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- Kratzer-style premise sets are a special case.

Modals and conditionals

- *Must*(q) is true at $\mathbf{f}, \mathbf{g}, w$ iff q is a necessity at $\text{Prem}((\mathbf{f} * \mathbf{g})(w))$.

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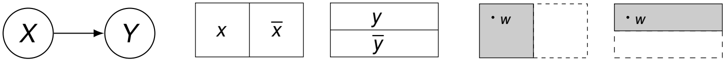
- *Modal*$_p(q)$ is true at $\mathbf{f}, \mathbf{g}, w$ iff *Modal*(q) is true at $\mathbf{f}[p], \mathbf{g}, w$.

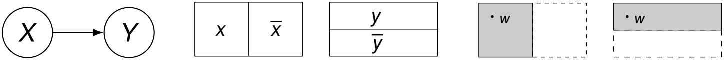
Outline

Basics



Causal Networks	Possible worlds
Outcome	Possible world
Event	Proposition
Variable	Partition

Modal base



- A causal structure for W is a pair $C = \langle U, < \rangle$, where
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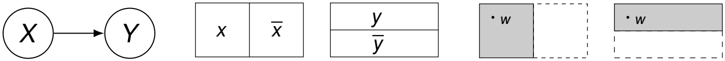

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- Π^U_w (*causally relevant truths at w*):
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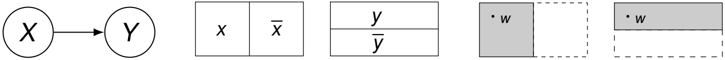

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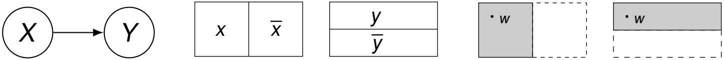
- At each world w, the premise background $\mathbf{f}_c$ returns the set of those subsets of Π^U_w that are *closed under ancestors*.

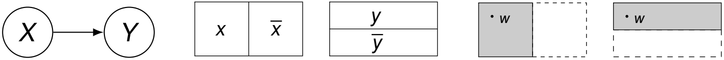
Modal base



Let X = *'whether it is sunny'*; Y = *'whether the streets are dry'*

- $\mathbf{f}_c(w) := \{X \subseteq \Pi_w \mid X \text{ is closed under ancestors in } \Pi_w\}$

Modal base



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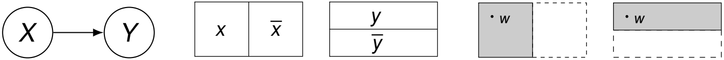
- $\mathbf{f}_c(w) := \{X \subseteq \Pi_w \mid X \text{ is closed under ancestors in } \Pi_w\}$
- $\Pi = \{x, \overline{x}, y, \overline{y}\}$
  $\Pi_w = \{x, y\}$ *[for $w \in xy$]*
  $\mathbf{f}_c(w) = \{\emptyset, \{x\}, \{x, y\}\}$
  $\text{Prem}(\mathbf{f}_c[\overline{x}](w)) = \{\overline{x}.\}$
  $\text{Prem}(\mathbf{f}_c[\overline{y}](w)) = \{\overline{y}., \overline{y}.x\}$

Modal base



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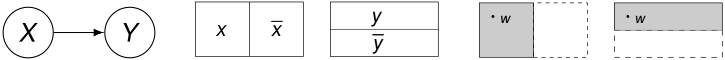
- $\mathbf{f}_c(w) := \{X \subseteq \Pi_w \mid X \text{ is closed under ancestors in } \Pi_w\}$
- $\Pi = \{x, \overline{x}, y, \overline{y}\}$
  $\Pi_w = \{x, y\}$ *[for $w \in xy$]*
  $\mathbf{f}_c(w) = \{\emptyset, \{x\}, \{x, y\}\}$
  $\text{Prem}(\mathbf{f}_c[\overline{x}](w)) = \{\overline{x}.\}$
  $\text{Prem}(\mathbf{f}_c[\overline{y}](w)) = \{\overline{y}., \overline{y}.x\}$

(13) a. If were $\overline{x}$, would (still) be y. *[false at $w \in xy$]*
b. If were $\overline{y}$, would (still) be x. *[true at $w \in xy$]*

Modal base



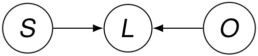
Let X = *'whether it is sunny'*; Y = *'whether the streets are dry'*

- $\mathbf{f}_c(w) := \{X \subseteq \Pi_w \mid X \text{ is closed under ancestors in } \Pi_w\}$
- $\Pi = \{x, \overline{x}, y, \overline{y}\}$
  $\Pi_w = \{x, y\}$ *[for $w \in xy$]*
  $\mathbf{f}_c(w) = \{\emptyset, \{x\}, \{x, y\}\}$
  $\text{Prem}(\mathbf{f}_c[\overline{x}](w)) = \{\overline{x}.\}$
  $\text{Prem}(\mathbf{f}_c[\overline{y}](w)) = \{\overline{y}., \overline{y}.x\}$

(13) a. If were $\overline{x}$, would (still) be y. *[false at $w \in xy$]*
b. If were $\overline{y}$, would (still) be x. *[true at $w \in xy$]*

(14) a. If it were raining, the streets would (still) be dry. *[false]*
b. If the streets were wet, it would (still) be sunny. *[true]*

Ordering source



(15) If that match had been scratched, it would have lit.

Ordering source

$$\begin{tikzcd} S \arrow[r] & L & O \arrow[l] \end{tikzcd}$$

(15) If that match had been scratched, it would have lit.

(16) a. $\Pi = \left\{s, \overline{s}, o, \overline{o}, l, \bar{l}\right\}$

b. $\Pi_w = \left\{\overline{s}, o, \bar{l}\right\}$

c. $\mathbf{f}_c(w) = \left\{\emptyset, \{\overline{s}\}, \{o\}, \{\overline{s}, o, \bar{l}\}\right\}$

d. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

Ordering source

$$S \rightarrow L \leftarrow O$$

(15) If that match had been scratched, it would have lit.

(16)
a. $\Pi = \left\{s, \bar{s}, o, \bar{o}, l, \bar{l}\right\}$
b. $\Pi_w = \left\{\bar{s}, o, \bar{l}\right\}$
c. $\mathbf{f}_c(w) = \left\{\emptyset, \{\bar{s}\}, \{o\}, \{\bar{s}, o, \bar{l}\}\right\}$
d. $\text{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

- (17) is correctly predicted to be true at w:

(17) If that match had been scratched, there would (still) have been oxygen.

Ordering source

$$S \rightarrow L \leftarrow O$$

(15) If that match had been scratched, it would have lit.

(16) a. $\Pi = \left\{s, \overline{s}, o, \overline{o}, l, \overline{l}\right\}$

b. $\Pi_w = \left\{\overline{s}, o, \overline{l}\right\}$

c. $\mathbf{f}_c(w) = \left\{\emptyset, \{\overline{s}\}, \{o\}, \{\overline{s}, o, \overline{l}\}\right\}$

d. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

➽ (17) is correctly predicted to be true at *w*:

(17) If that match had been scratched, there would (still) have been oxygen.

BUT But the truth of (15) is not yet accounted for.

Ordering source

$$S \rightarrow L \leftarrow O$$

(15) If that match had been scratched, it would have lit.

(16)
a. $\Pi = \left\{s, \overline{s}, o, \overline{o}, l, \overline{l}\right\}$
b. $\Pi_w = \left\{\overline{s}, o, \overline{l}\right\}$
c. $\mathbf{f}_c(w) = \left\{\emptyset, \{\overline{s}\}, \{o\}, \{\overline{s}, o, \overline{l}\}\right\}$
d. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

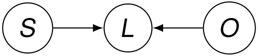
- (17) is correctly predicted to be true at *w*:

(17) If that match had been scratched, there would (still) have been oxygen.

BUT But the truth of (15) is not yet accounted for.

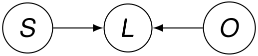
That's what the ordering source does.

Ordering source



- I make minimal assumption as to what is in the ordering source **g**.
- Except that it respects a *Causal Markov Condition* relative to the causal structure.
- Roughly: If *p* is a (conditional) necessity/possibility under **g** given only *p*'s parents, it is also a necessity/possibility given its parents and other non-descendants. (For details, ask me for the paper.)

Ordering source



(18) If that match had been scratched, it would have lit.

Ordering source

$$S \longrightarrow L \longleftarrow O$$

(18) If that match had been scratched, it would have lit.

(19)

a. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

b. $\mathbf{g}_\ell(w) = \{\emptyset, \{o\}, \{(s \wedge o) \leftrightarrow l\}, \{o, (s \wedge o) \leftrightarrow l\}\}$

c. $\max \mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w)) = \{s.o.((s \wedge o) \leftrightarrow l)\}$

Ordering source

$$S \rightarrow L \leftarrow O$$

(18) If that match had been scratched, it would have lit.

(19) a. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

b. $\mathbf{g}_\ell(w) = \{\emptyset, \{o\}, \{(s \wedge o) \leftrightarrow l\}, \{o, (s \wedge o) \leftrightarrow l\}\}$

c. $\max \mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w)) = \{s.o.((s \wedge o) \leftrightarrow l)\}$

➽ (18) comes out true at w.

Ordering source

$$S \rightarrow L \leftarrow O$$

(18) If that match had been scratched, it would have lit.

(19) a. $\mathrm{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

b. $\mathbf{g}_\ell(w) = \{\emptyset, \{o\}, \{(s \wedge o) \leftrightarrow l\}, \{o, (s \wedge o) \leftrightarrow l\}\}$

c. $\max \mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w)) = \{s.o.((s \wedge o) \leftrightarrow l)\}$

➽ (18) comes out true at w.

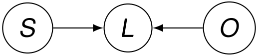
Consider a world, v just like w, except that oxygen was not present.

(20) a. $\mathrm{Prem}(\mathbf{f}_c[s](v)) = \{s., s.\overline{o}\}$

b. $\mathbf{g}_\ell(v) = \{\emptyset, \{o\}, \{(s \wedge o) \leftrightarrow l\}, \{o, (s \wedge o) \leftrightarrow l\}\}$

c. $\max \mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(v)) = \{s.\overline{o}.(s \wedge o) \leftrightarrow l\}\}$

Ordering source



(18) If that match had been scratched, it would have lit.

(19) a. $\text{Prem}(\mathbf{f}_c[s](w)) = \{s., s.o\}$

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c. $\max \text{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w)) = \{s.o.((s \wedge o) \leftrightarrow l)\}$

➠ (18) comes out true at *w*.

Consider a world, *v* just like *w*, except that oxygen was not present.

(20) a. $\text{Prem}(\mathbf{f}_c[s](v)) = \{s., s.\overline{o}\}$

b. $\mathbf{g}_\ell(v) = \{\emptyset, \{o\}, \{(s \wedge o) \leftrightarrow l\}, \{o, (s \wedge o) \leftrightarrow l\}\}$

c. $\max \text{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(v)) = \{s.\overline{o}.(s \wedge o) \leftrightarrow l\}\}$

➠ (18) comes out false at *v*.

Ordering source

$\mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w))$

$\cancel{s.o.o((s \wedge o) \leftrightarrow l)}$

$\cancel{s.o.o} \quad s.o.((s \wedge o) \leftrightarrow l)$

$s.o.$

$s..o((s \wedge o) \leftrightarrow l)$

$s..o \quad s..((s \wedge o) \leftrightarrow l)$

$s..$

$\mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(v))$

$s.\overline{o}.((s \wedge o) \leftrightarrow l)$

$s.\overline{o}.$

$s..o((s \wedge o) \leftrightarrow l)$

$s..o \quad s..((s \wedge o) \leftrightarrow l)$

$s..$

Ordering source

$$\mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(w))$$

$$\begin{array}{cc}
\multicolumn{2}{c}{\cancel{s.o.o((s \wedge o) \leftrightarrow l)}} \\
\cancel{s.o.o} & s.o.((s \wedge o) \leftrightarrow l) \\
\multicolumn{2}{c}{s.o.} \\
\multicolumn{2}{c}{s..o((s \wedge o) \leftrightarrow l)} \\
s..o & s..((s \wedge o) \leftrightarrow l) \\
\multicolumn{2}{c}{s..}
\end{array}$$

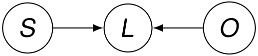
$$\mathrm{Prem}((\mathbf{f}_c[s] * \mathbf{g}_\ell)(v))$$

$$\begin{array}{cc}
\multicolumn{2}{c}{s.\overline{o}.((s \wedge o) \leftrightarrow l)} \\
\multicolumn{2}{c}{s.\overline{o}.} \\
\multicolumn{2}{c}{s..o((s \wedge o) \leftrightarrow l)} \\
s..o & s..((s \wedge o) \leftrightarrow l) \\
\multicolumn{2}{c}{s..}
\end{array}$$

- *o* is likely under **g**, but at *v* this is overridden by the facts.
- Modal base **f** pushes for *similarity* with the world of evaluation

  Ordering source **g** does not care; may pull away

Ordering source

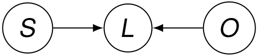


(21) If that match had not lit, it would not have been scratched.

(22) If that match had not lit, there would have been no oxygen.

Consider an ordering source $\mathbf{g_1}_\ell$ just like $\mathbf{g}_\ell$, but indifferent towards O_2.

Ordering source



(21) If that match had not lit, it would not have been scratched.

(22) If that match had not lit, there would have been no oxygen.

Consider an ordering source $\mathbf{g_1}_\ell$ just like $\mathbf{g}_\ell$, but indifferent towards O_2.

(23)
a. $\mathbf{f}_c(w) = \{\emptyset, \{s\}, \{o\}, \{s, o, l\}\}$
b. $\mathbf{f}_c[\bar{l}](w) = \left\{\bar{l}., \bar{l}.s, \bar{l}.o\right\}$
c. $\mathbf{g_1}_\ell(w) = \{\emptyset, \{(s \wedge o) \leftrightarrow l\}\}$
d. $\max \mathrm{Prem}\Big((\mathbf{f}[\bar{l}] * \mathbf{g_1})(w)\Big) =$
$\left\{\bar{l}.s.((s \wedge o) \leftrightarrow l), \bar{l}.o.((s \wedge o) \leftrightarrow l)\right\}$

Ordering source

$$S \rightarrow L \leftarrow O$$

(21) If that match had not lit, it would not have been scratched.

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d. $\max \mathrm{Prem}\Big((\mathbf{f}[\bar{l}] * \mathbf{g_1})(w)\Big) =$
$\left\{\bar{l}.s.((s \wedge o) \leftrightarrow l), \bar{l}.o.((s \wedge o) \leftrightarrow l)\right\}$

- Both (21) and (22) are false.

BUT each is true relative to *one* of the maximal sequences.

Ordering source

$$\mathrm{Prem}\big((\mathbf{f}_c[\bar{l}] * \mathbf{g_1})(w)\big)$$

$$\bar{l}.s.((s \wedge o) \leftrightarrow l) \qquad \bar{l}.o.((s \wedge o) \leftrightarrow l)$$

$$\bar{l}.s. \qquad \bar{l}.o.$$

$$\bar{l}..((s \wedge o) \leftrightarrow l)$$

$$\bar{l}..$$

Ordering source

$$\mathrm{Prem}\Big((\mathbf{f}_c[\bar{l}] * \mathbf{g_1})(w)\Big)$$

$$\bar{l}.s.((s \wedge o) \leftrightarrow l) \qquad \bar{l}.o.((s \wedge o) \leftrightarrow l)$$

$$\bar{l}.s. \qquad \bar{l}.o.$$

$$\bar{l}..((s \wedge o) \leftrightarrow l)$$

$$\bar{l}..$$

- Multiple non-equivalent maximal sequences.

Ordering source

$$\mathrm{Prem}\Big((\mathbf{f}_c[\bar{l}] * \mathbf{g_1})(w)\Big)$$

$$\bar{l}.s.((s \wedge o) \leftrightarrow l) \qquad \bar{l}.o.((s \wedge o) \leftrightarrow l)$$

$$\bar{l}.s. \qquad \bar{l}.o.$$

$$\bar{l}..((s \wedge o) \leftrightarrow l)$$

$$\bar{l}..$$

- Multiple non-equivalent maximal sequences.
- I call this an *inquisitive* premise structure.

Disjunctions

$$\text{Prem}((\{\{r\},\{s\}\} * \mathbf{f}_c)(w))$$

$$\begin{array}{ccc} r.pq & & s.pq \\ | & & | \\ r.p & & s.p \\ | & & | \\ r. & & s. \end{array}$$

(24) a. $\mathbf{f}_c(w) = \{\emptyset, \{p\}, \{p, q\}\}$

b. Assume that *'r or s'* denotes $\{\{r\}, \{s\}\}$.

Disjunctions

$$\text{Prem}((\{\{r\},\{s\}\} * \mathbf{f}_c)(w))$$

$$\begin{array}{cc} r.pq & s.pq \\ | & | \\ r.p & s.p \\ | & | \\ r. & s. \end{array}$$

(24) a. $\mathbf{f}_c(w) = \{\emptyset, \{p\}, \{p, q\}\}$

b. Assume that *'r or s'* denotes $\{\{r\}, \{s\}\}$.

As a consequence, (25a) entails (25b):

(25) a. If were *'r or s'*, would be t.

b. If were *'r'*, would be t and if were *'s'*, would be t.

Disjunctions

$$\mathrm{Prem}((\{\{r\},\{s\}\} * \mathbf{f}_c)(w))$$

$$\begin{array}{cc} r.pq & s.pq \\ | & | \\ r.p & s.p \\ | & | \\ r. & s. \end{array}$$

(24) a. $\mathbf{f}_c(w) = \{\emptyset, \{p\}, \{p, q\}\}$

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As a consequence, (25a) entails (25b):

(25) a. If were *'r or s'*, would be t.

b. If were *'r'*, would be t and if were *'s'*, would be t.

Similarly for interrogative antecedents (unconditionals).

The end

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