From Linguistics to Philosophy and back again

The meaning of conditional sentences

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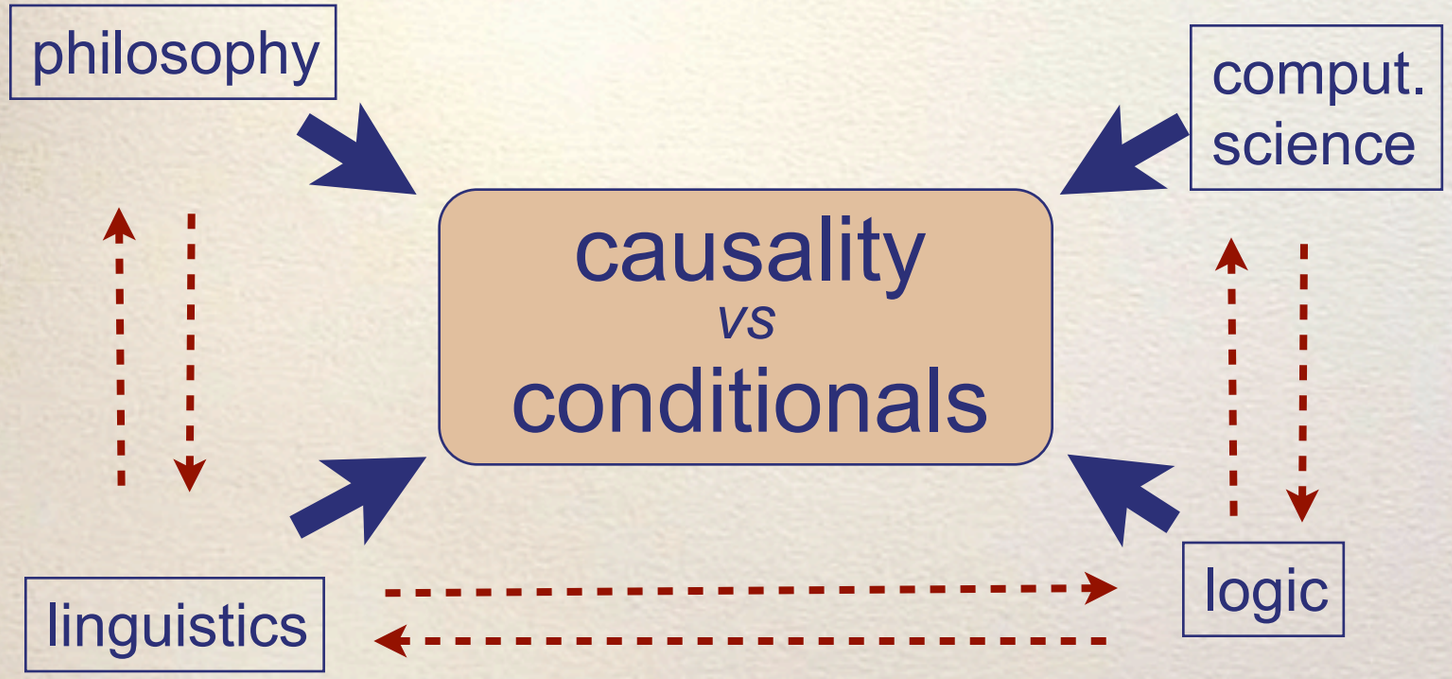
specific reading of conditionals, counterfactuals as well as indicatives; two goals: 1. convince you that semantics of this reading based on causal reasoning, 2. show you ways to formalize causal reasoning

1 Introduction
1.1 Outline



The topic of todays talk is the relation between causality and the meaning of conditionals. It's an old very fascinating topic. For one thing because there are so many different scientific areas where people have thought about the relation between causality and the semantics conditionals. More areas interested in topic: psychology. I mention these four because they all will show up in todays talk. and you can learn from all of these different perspectives. ... On the other hand, you can learn a lot from the interaction between causality and conditionals that might be useful in a much more general context.

This is where I came from: just interested in finding an adequate semantics for conditional sentences. But this topic is so intriguing that before you know you end uo having an opinion about philosophical question you were determined never to touch in your life! People start calling you a philosopher and you can only hope that your parents will never know.

1 Introduction
1.2 Fake Tense

Fake Tense (Iatridou 2000)

In English subjunctive conditionals the Simple Past and also the Past Perfect appear not to be interpreted as semantic past tense or past perfect.

(1) *a. If Peter left in time, he will be in A'dam this evening.*
b. If Peter left in time, he would be in A'dam this evening
c. If Peter had left in time, he would have been in A'dam this evening

1 Introduction
1.3 The ideal solution

The past-as-past approach (Ippolito and others)

- The Simple Past and/or the Perfect carry their standard meaning in subjunctive conditionals.
- The Logical Form of subjunctive conditionals does not match surface appearance.

NOT: PAST(antecedent > PAST(MODAL(consequent))

BUT: PAST(MODAL(antecedent > consequent))

1 Introduction
1.3 The ideal solution

The past-as-past approach (Ippolito and others)

- The Simple Past and/or the Perfect carry their standard meaning in subjunctive conditionals.
- The Logical Form of subjunctive conditionals does not match surface appearance.

Interpretation rule for subjunctive conditionals

A subjunctive conditionals with antecedent A and consequent C is true iff:

$$\exists t<t_0\ \forall w \in MB(w_0)(\text{antecedent}(w) \rightarrow \text{consequent}(w)).$$

1 Introduction
1.3 A problem

- Identity of the past is not sufficient to model the truth conditions of subjunctive conditionals!

Counterexample

A coin will be thrown and you have bet $5 on heads. Unfortunately, tails comes up and you loose. You say:

(2)If I had bet on tails, I would have won.

- You need the worlds in the **MB** to vary with respect to you bet, but to agree on the later event that the coin comes up tails!

1 Introduction
1.3 A problem

Two open issues:

1. If past-as-past approach does not work to explain fake tense, what does?

⇦ another time

2. If pastness does not determine similarity for counterfactual reasoning, what does?

⇦ today

A semantic problem ...

... and its philosophical analysis

specific reading of conditionals, counterfactuals as well as indicatives; two goals: 1. convince you that semantics of this reading based on causal reasoning, 2. show you ways to formalize causal reasoning

2 A semantic problem

2.1 Central claim

A conditional sentence '*If A then C*' is true iff:

Antecedent + Facts of w_0 $\Rightarrow_L$ Consequent

Central Claim

The semantics of (the dominant reading of) conditionals relies on a CAUSAL notion of consequence.

Forget all you probably already know about conditional sentences. How would my grandma describe the truth conditions of conditional sentences. Probably she would say something like: well, my child, I really can't see what the use of this question is, but I guess in case the consequent somehow follows from the antecedent. Of course, we know that things are not that simple: when you check whether the consequent follows from the antecedent you also take into account certain regularities, certain laws. And at least since Goodman, we also know that there are some singular facts of the evaluation world that can be used in the derivation. Then, tehre has been a lot of work done on the relevant singular facts and some work on the relevant laws. But I want to make the point that already the notion of inference that goes into this receipt is problematic. More in particular, I want to claim ...

2 A semantic problem
2.2 The argument

Observation

Conditionals reason along causal dependencies.

Causality and correlations:

An advertisement of an insurance company:
"Independent research has shown that people who buy our insurance products live longer than the average American. Thus: ...

(1) *If you buy our products, you will (probably) live longer."*

Let me present some arguments in favor of this strong claim. Well, the observation that ... is not new. It has been around now for quite some time. This is one of the examples discussed in this context. Suppose you get a letter from an insurance company and it runs like this ... . You will certainly not buy any of these product, because given the context that is provided the conditional is certainly false, right? Well, why is this? Because ... . But this is not very precise. We need to make our point more clearly. What do linguists do if they want to show that something is relevant for language form, use or interpretation – they use minimal pairs. So lets try.

2 A semantic problem
2.2 The argument

<u>Minimal pair 1:</u> Backtracking counterfactuals

(2) *??If Bill had come out smiling, the interview would have gone well.*

➡ Counterfactual backtracking based on causal dependencies is highly marked.

(3) *If Mary were 40 now, she would have been born in 1968.*

➡ Counterfactual backtracking based on analytical laws is fine.

2 A semantic problem
2.2 The argument

<u>Minimal pair 2:</u> Complex dependencies

Suppose there is a circuit such that the light is on (L) exactly when both switches are in the same position (up or down). At the moment switch one is down (¬S1), switch two is up (S2) and the lamp is off (L).

(1) If switch one had been up, the lamp would have been on. (S1 > L)

2 A semantic problem
2.2 The argument

<u>Minimal pair 2:</u> Complex dependencies

There are three lights called S1, S2 and L. The lights regularly change from on to off and back again. After observing the lights for a while you realize that there is a certain pattern in the way they are lit: either all lamps are on or only one of the lamps is on. At the moment S1 is off, S2 is on and L is off.

2 A semantic problem
2.2 The argument

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2 A semantic problem
2.2 The argument

Minimal pair 2: Complex dependencies

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2 A semantic problem
2.2 The argument

Minimal pair 2: **Complex dependencies**

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$$(S1 \leftrightarrow S2) \leftrightarrow L$$

2 A semantic problem
2.2 The argument

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(2) If S1 had been on, L would have been on. (S1 > L)

2 A semantic problem

2.3 Summary

Observation

Conditionals reason along causal dependencies.

Interpretation

sensibility to causal dependence is an epiphenomenon

the truth conditions of conditionals depend on causal dependencies

Lewis

present talk

2 A semantic problem
2.3 Summary

A conditional sentence is true iff:

Antecedent + Facts of w_0 $\Rightarrow_L$ Consequent

Central Claim

The semantics of (the dominant reading of) conditionals relies on a CAUSAL notion of consequence.

But then the central challange of the approach is to develop such a cuasl notion of consequence -- which brings us to Logic.

Causal reasoning

3 Causal reasoning

3.1 Introduction

NEED:

1. a richer notion of model that contains a representation D of direct causal dependencies,

causal networks, Pearl '00

2. a causal notion of consequence |≡.

logic programming, van Lambalgen et al.

3 Causal reasoning

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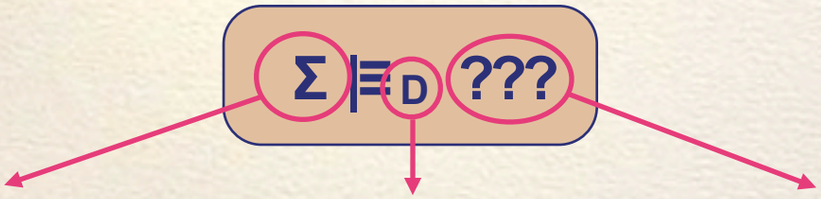
3 Causal reasoning

3.2 A causal notion of entailment

GOAL: define a causal notion of entailment



primitive facts

model of causal dependencies

causally entailed facts

3 Causal reasoning

3.2 A causal notion of entailment

<u>The idea:</u> A fixed point construction

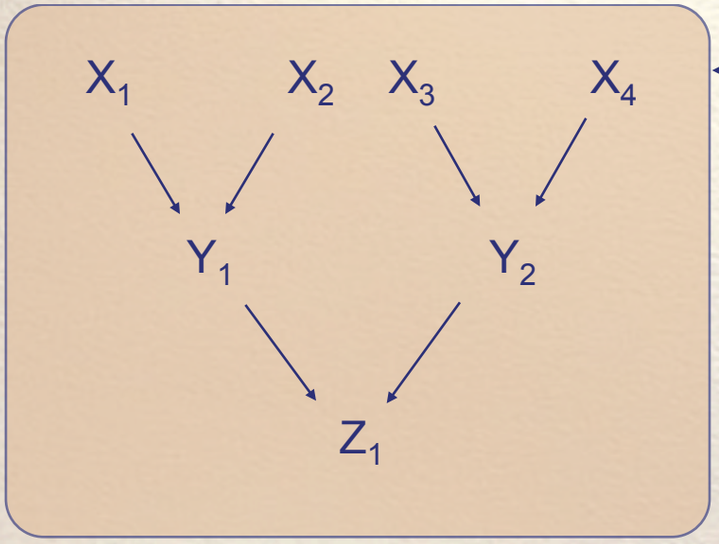
➡ we define the facts causally entailed by **Σ** as the sentences true in a particular minimal model of **Σ** and **D**

➡ this minimal model is constructed by iteratively applying a monotone operator T to models of **Σ**

3 Causal reasoning

3.2 A causal notion of entailment

<u>The idea:</u> A fixed point construction



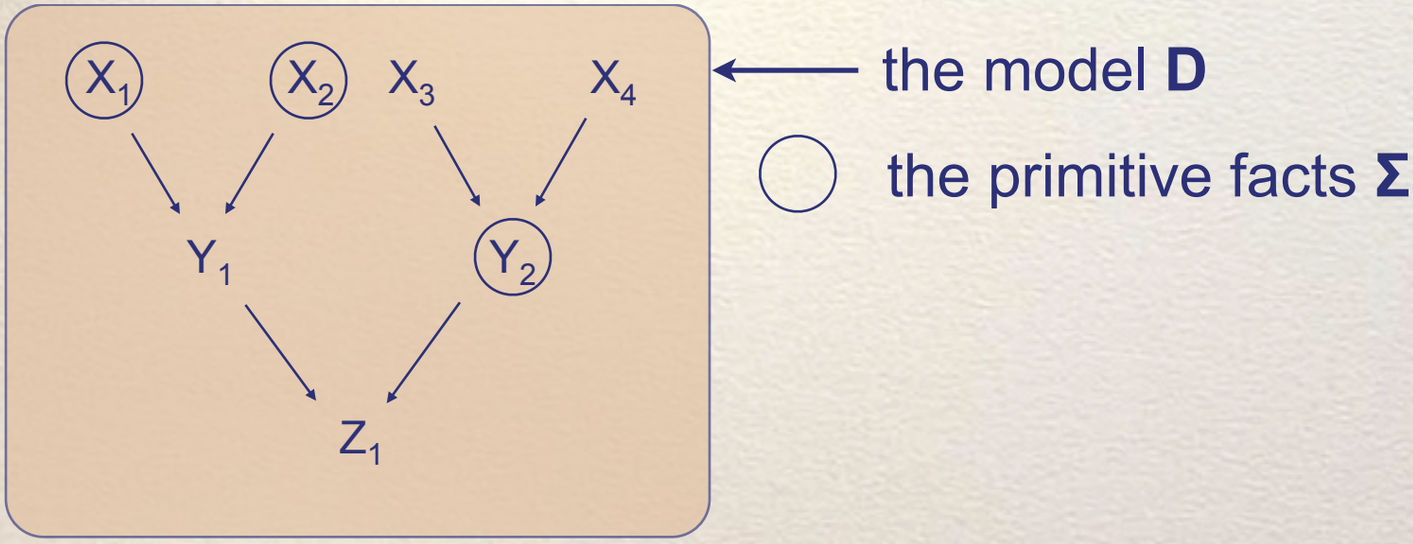
← the model **D**

The idea is ... – and this actually where we borrow knowledge from computational science, more particularly from logic programming. Let me explain the idea with a small example. Assume that this is the structure of causal dependencies you are working with. The letters stand for propositional variables, the arrow represent direct causal dependencies.

3 Causal reasoning

3.2 A causal notion of entailment

<u>The idea:</u> A fixed point construction

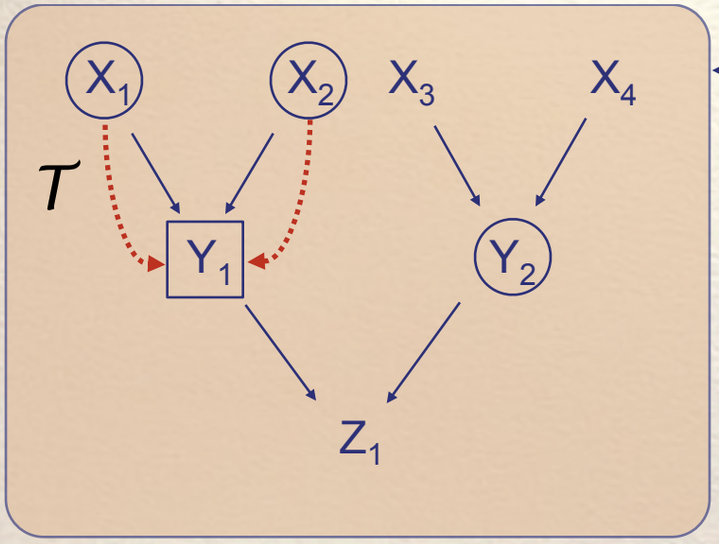


Let us furthermore assume that we want to calculate the causal consequences of the following set sigma of primitive facts. So, the truth values of ... are fixed.

3 Causal reasoning

3.2 A causal notion of entailment

The idea: A fixed point construction



the model **D**

the primitive facts **Σ**

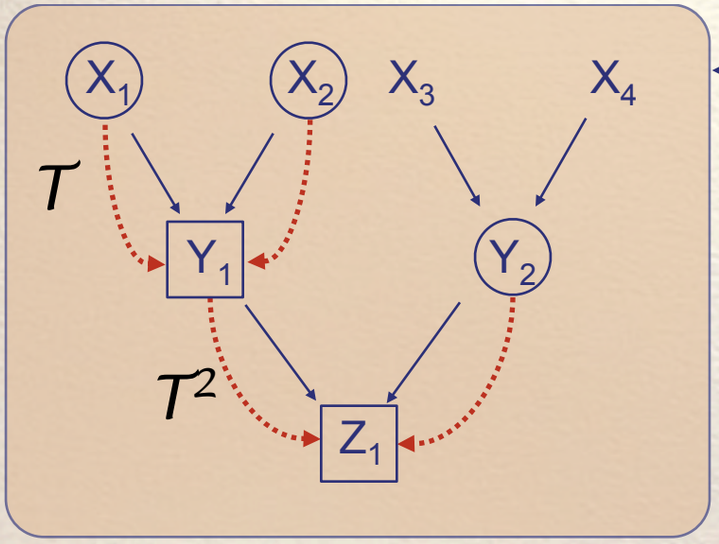
causally entailed facts

To find these causal consequences we use an operator on models that determines direct causal consequences. SO, a first application of tau to our initial model will additionally determine the value of Y1 given the value of its direct causes X1 and X2.

3 Causal reasoning

3.2 A causal notion of entailment

The idea: A fixed point construction



the model **D**

the primitive facts **Σ**

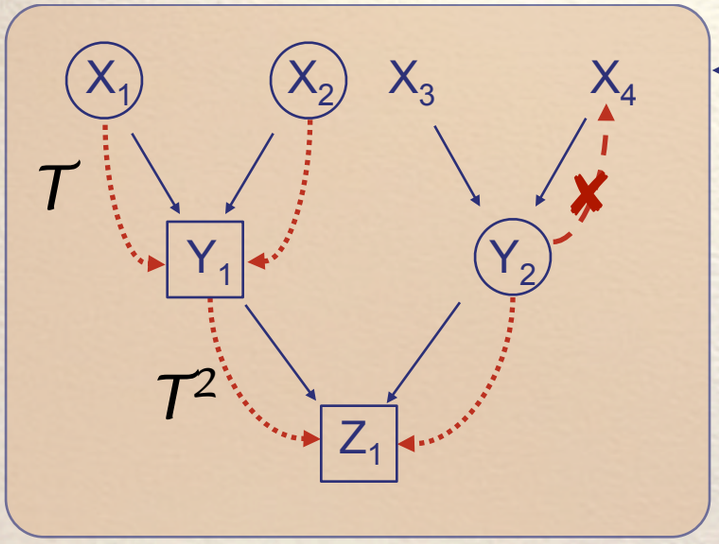
causally entailed facts

Applying tau again additionally determine the value of Z1. But given the way tau is defined, we will never come ina situation where tau determines

3 Causal reasoning

3.2 A causal notion of entailment

<u>The idea:</u> A fixed point construction



the model **D**

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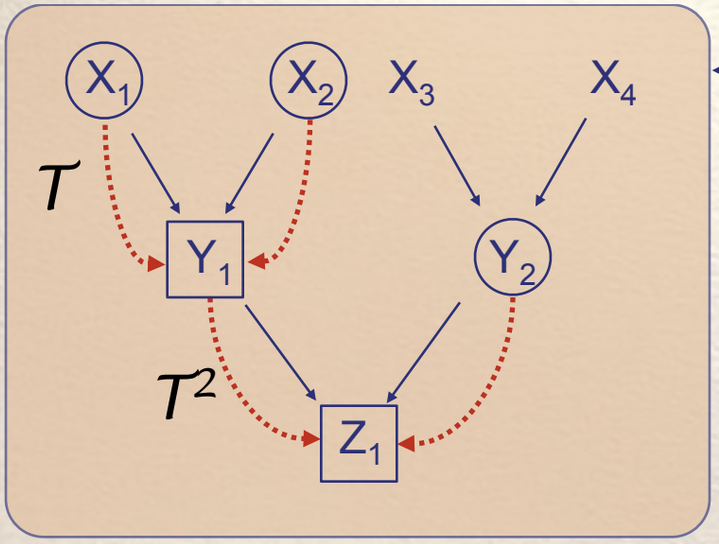
causally entailed facts

the value of a cause from the value of the effect. That means that in this stage ...

3 Causal reasoning

3.2 A causal notion of entailment

The idea: A fixed point construction



the model **D**

the primitive facts **Σ**

causally entailed facts

.. another application of tau won't change anything anymore. Thus, we have reached a fixed point. In fact one can prove the following general result ...

3 Causal reasoning

3.2 A causal notion of entailment

Fact

The operator $\mathcal{T}_D$ has a fixed point. The least fixed point s_Σ^* of $\mathcal{T}_D$ applied to a situation s_Σ is reached in finitely many steps.

☛ this least fixed point is the model we use to define the causal consequences of F

$$\Sigma \mid\equiv_D \psi \quad \text{iff} \quad \mathbf{s}_\Sigma^*(\psi) = 1$$

3 Causal reasoning

3.2 A causal notion of entailment

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3 Causal reasoning
3.3 Nonmonotonicity properties

- ➡ we use the semantics of logic programming
- ➡ but no negation as failure!!!
- ➡ still non-monotonic!!!

Fact

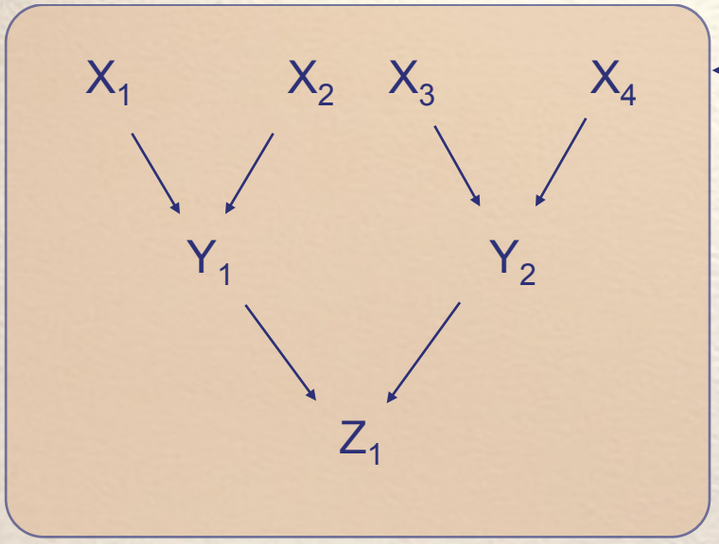
Information that the expected effect does not hold defeats causal inference:

If A causes B, then $\{A\} \mid\equiv_D B$, but $\{A, \neg B\} \mid\equiv_D \neg B$.

3 Causal reasoning

3.3 Nonmonotonicity properties

Illustration:



← the model **D**

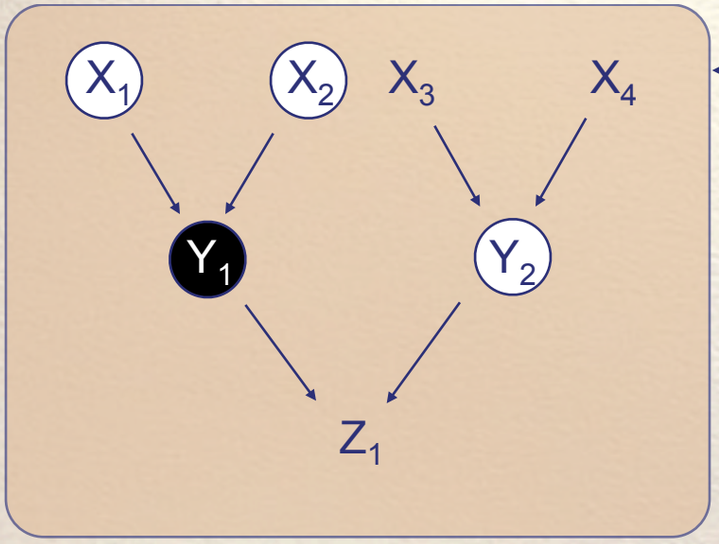
$X_1 \wedge X_2 \leftrightarrow Y_1$

$Y_1 \wedge Y_2 \leftrightarrow Z_1$

3 Causal reasoning

3.3 Nonmonotonicity properties

Illustration:



the model **D**

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the primitive facts **Σ**

3 Causal reasoning

3.3 Nonmonotonicity properties

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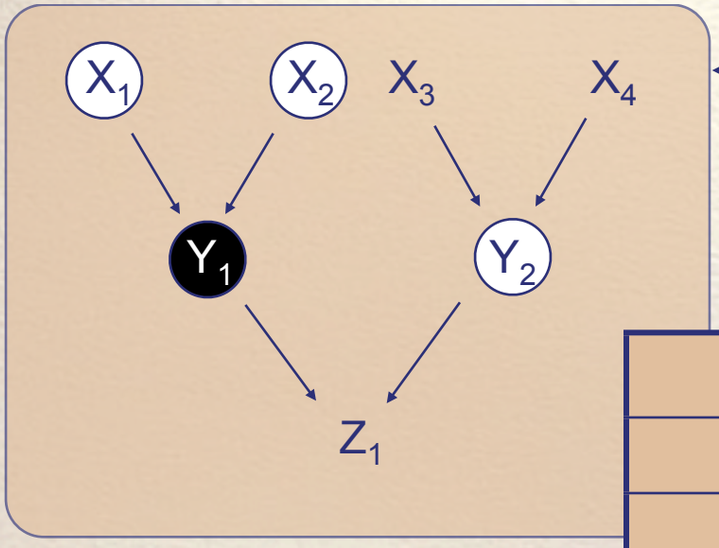

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$X_1 \wedge X_2 \leftrightarrow Y_1$

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	X_1	X_2	X_3	X_4	Y_1	Y_2	Z_1

3 Causal reasoning

3.3 Nonmonotonicity properties

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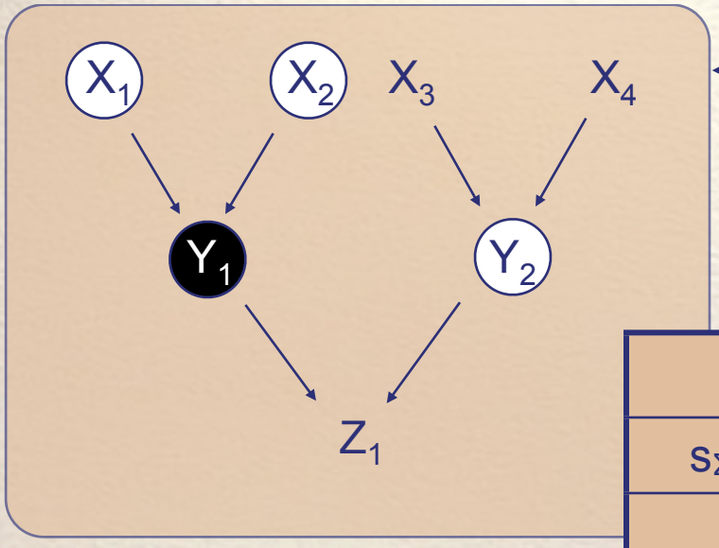

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$X_1 \wedge X_2 \leftrightarrow Y_1$

$Y_1 \wedge Y_2 \leftrightarrow Z_1$

	X_1	X_2	X_3	X_4	Y_1	Y_2	Z_1
s_Σ	1	1	u	u	0	1	u

3 Causal reasoning

3.3 Nonmonotonicity properties

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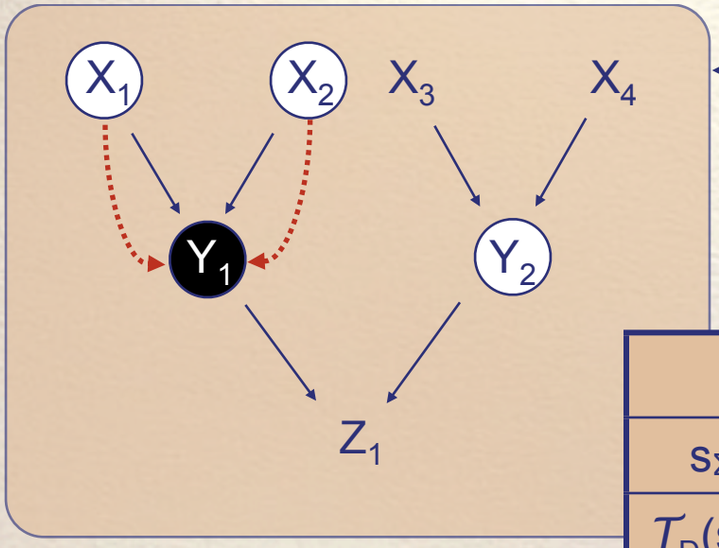

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$X_1 \wedge X_2 \leftrightarrow Y_1$

$Y_1 \wedge Y_2 \leftrightarrow Z_1$

	X_1	X_2	X_3	X_4	Y_1	Y_2	Z_1
s_Σ	1	1	u	u	0	1	u
$\mathcal{T}_D(s_\Sigma)$	1	1	u	u	0	1	0

3 Causal reasoning

3.3 Nonmonotonicity properties

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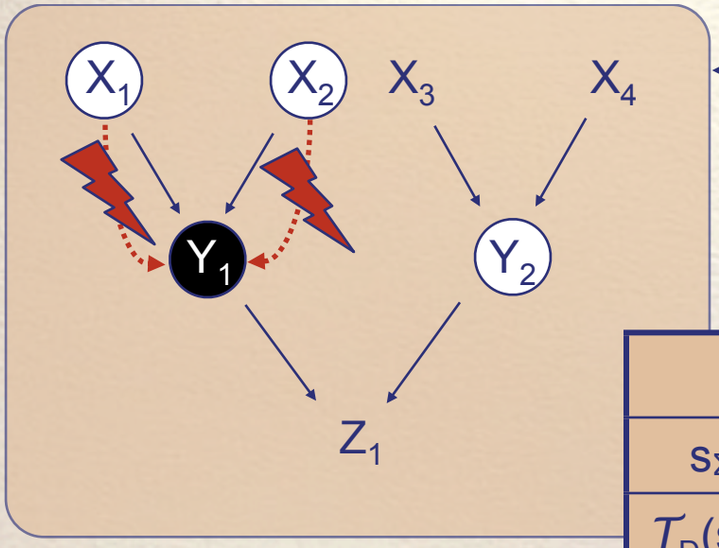

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3 Causal reasoning

3.3 Nonmonotonicity properties

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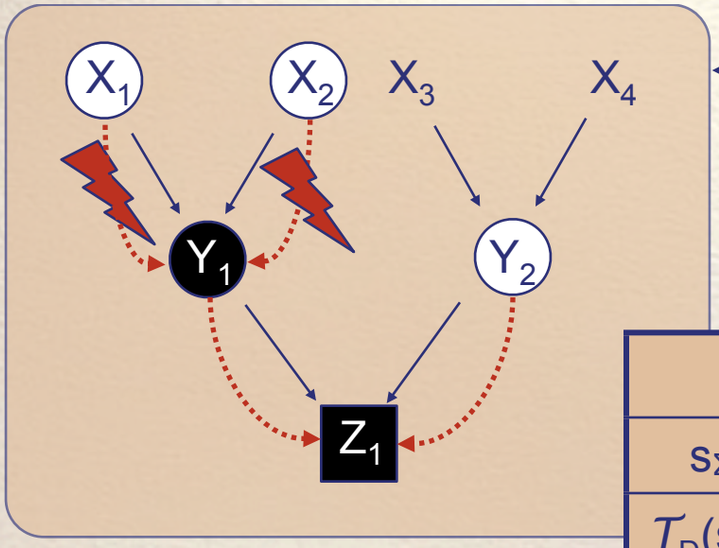

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3 Causal reasoning

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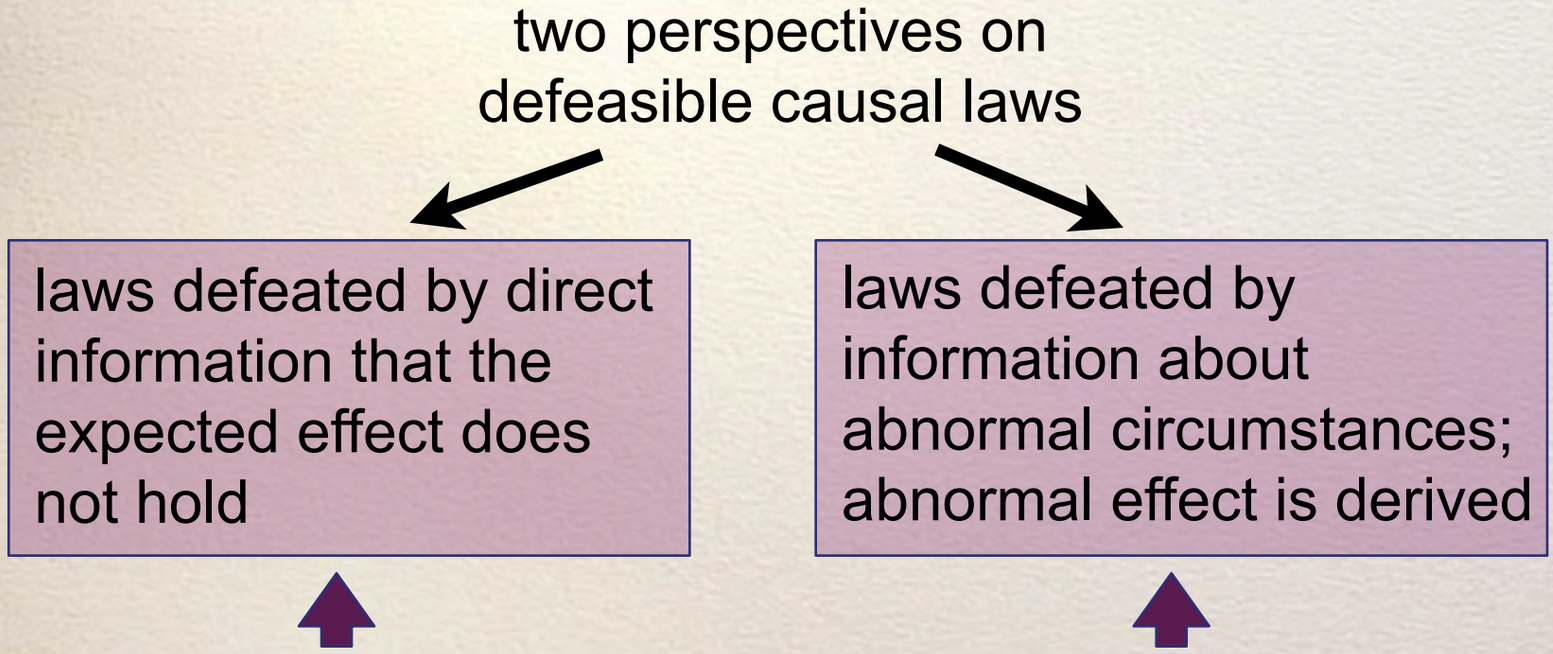


The semantics of conditionals

A new approach

4 The semantics of conditionals

4.1 The big picture

A conditional sentence '*If A then C*' is true iff:

Antecedent + Facts of w_0 $\Rightarrow_L$ Consequent

basis of w_0 — causal entailment

$A \quad B_D(w_0) \quad |\equiv_D \quad C$

With this notion of consequence at hand we now turn again to our initial linguistic question: how to define the truth conditions of conditional sentences. More conqrete: we want to give a precise version of this basic receipt. We know that the antecedent and the consequent go into the definition – but what about the rest? Of course we ant to use our notion of entailment here – that's we developed it for. Now, there are still some questions open ... but it turns out the rest is really simple: you just have to restate standard premise semantics using causal entailment instead of standard logical entailment. In act I could just stop here and leave the rest to you – Well, I'm not going to do that.

First the set of singular facts that matters. Here I use aconcept of Veltman 2005: For the dominant reading of bare conditionals this set is given by the basis of the evaluation world ....

4 The semantics of conditionals
4.2 The basis

Definition: ***basis***

The basis $B_L(w_0)$ of the evaluation world w_0 is the minimal set of primitive facts (literals) of w_0 from which all other facts of w_0 follow.

Veltman '05

causally follows.

... well, what is the basis of some possible world? ...
... The basis is intuitively the set of initial conditions of a world; the st of chance events.

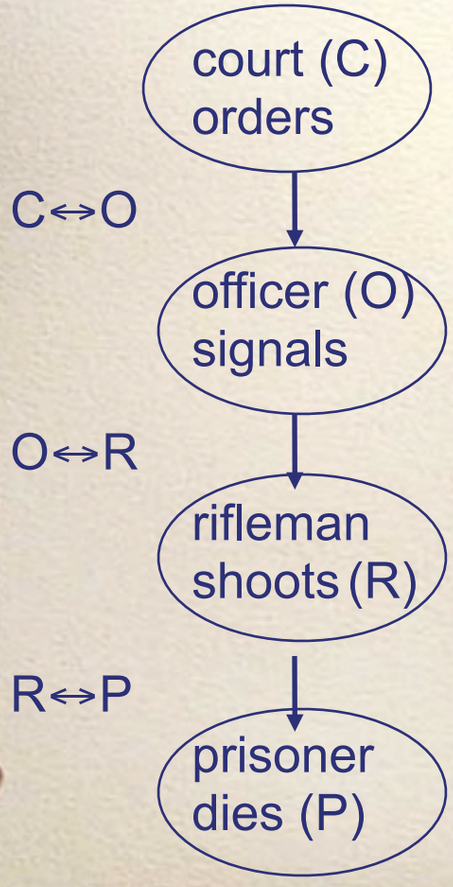
4 The semantics of conditionals

4.2 The basis

There is a court, an officer, a rifleman and a prisoner. If the court orders the execution of the prisoner, the officer will give a signal to the rifleman, the rifleman will shoot and the prisoner will die.

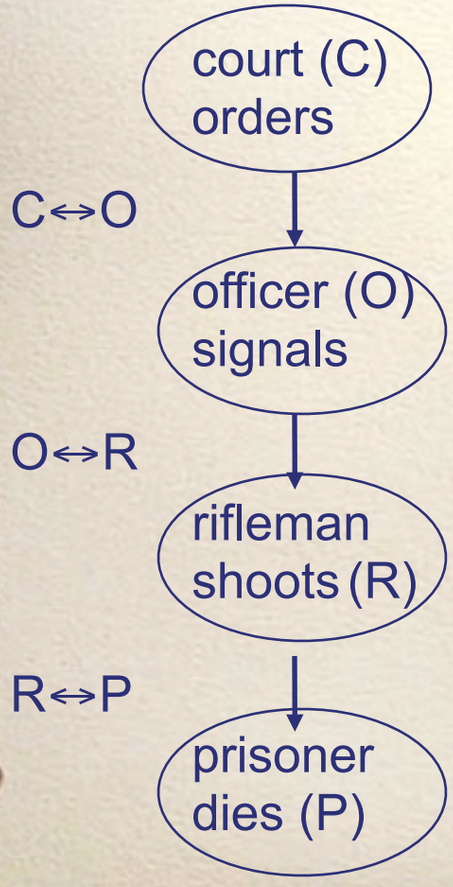
4 The semantics of conditionals

4.2 The basis



4 The semantics of conditionals

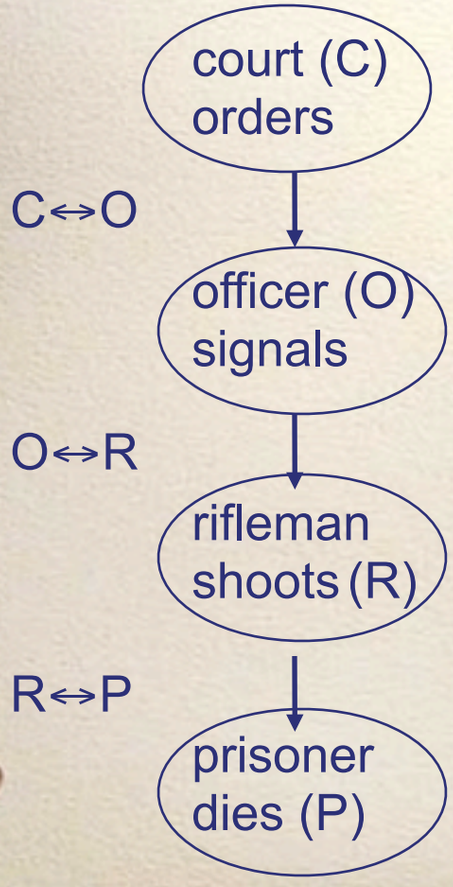
4.2 The basis



	C	O	R	P
w0	1	1	1	1
w1	0	0	0	0
w2	1	0	0	0
w3	1	1	0	0
w4	1	1	0	1

4 The semantics of conditionals

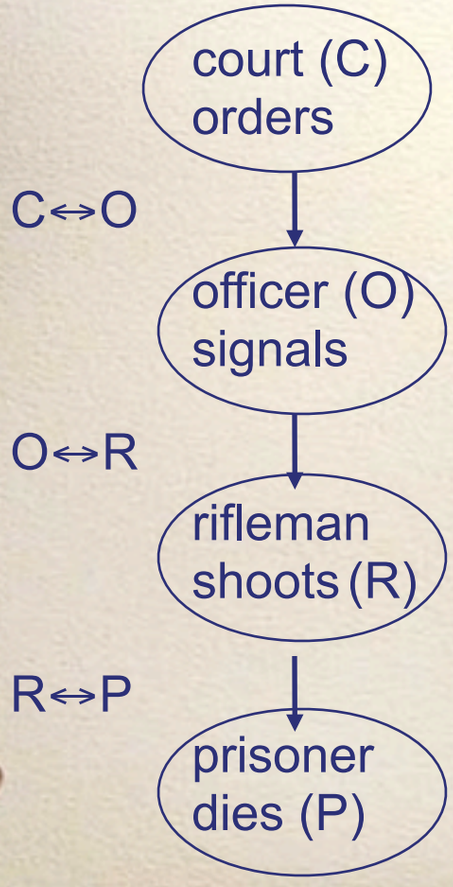
4.2 The basis



	C	O	R	P
w0	(1)	1	1	1
w1	0	0	0	0
w2	1	0	0	0
w3	1	1	0	0
w4	1	1	0	1

4 The semantics of conditionals

4.2 The basis



	C	O	R	P
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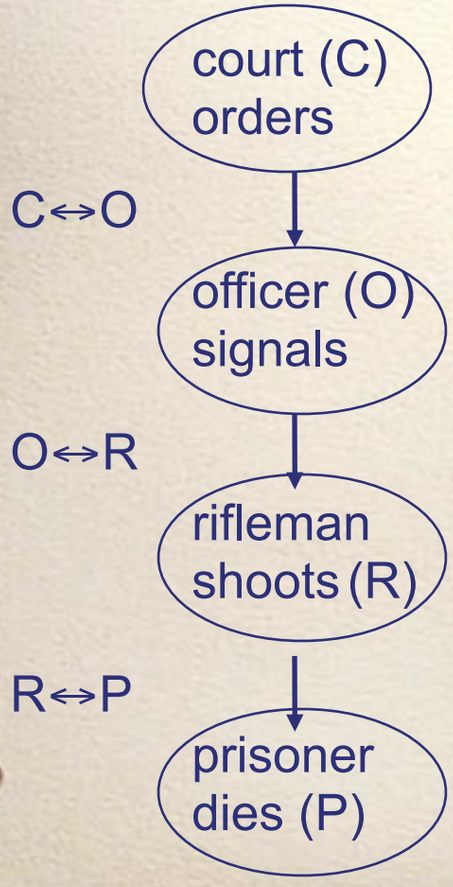
w1	(0)	0	0	0
w2	1	0	0	0
w3	1	1	0	0
w4	1	1	0	1

4 The semantics of conditionals

4.2 The basis



	C	O	R	P
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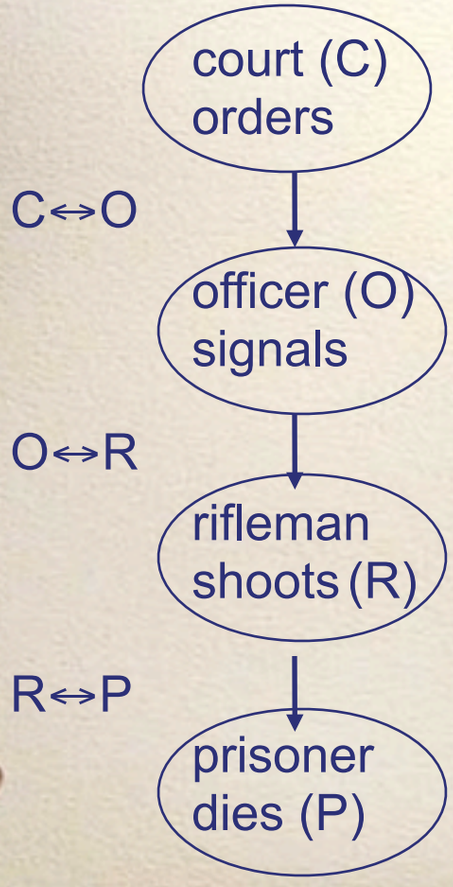
4 The semantics of conditionals

4.2 The basis



	C	O	R	P
w0	(1)	1	1	1
w1	(0)	0	0	0
w2	(1)	(0)	0	0
w3	1	1	0	0
w4	1	1	0	1

4 The semantics of conditionals

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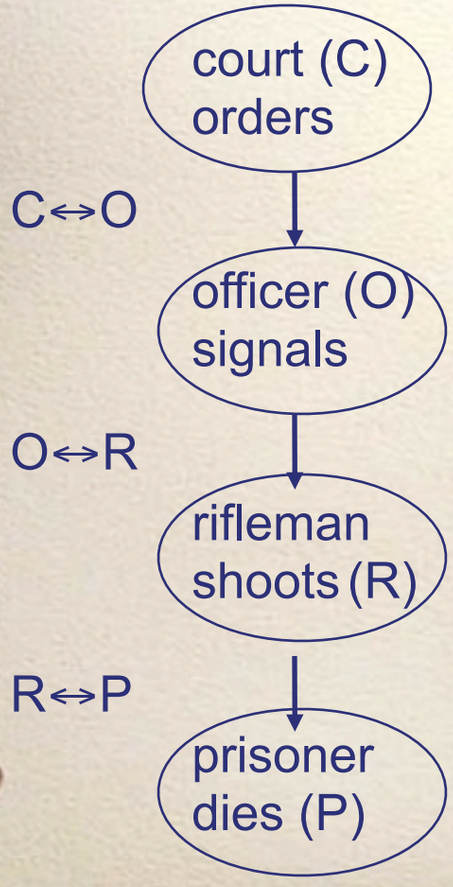

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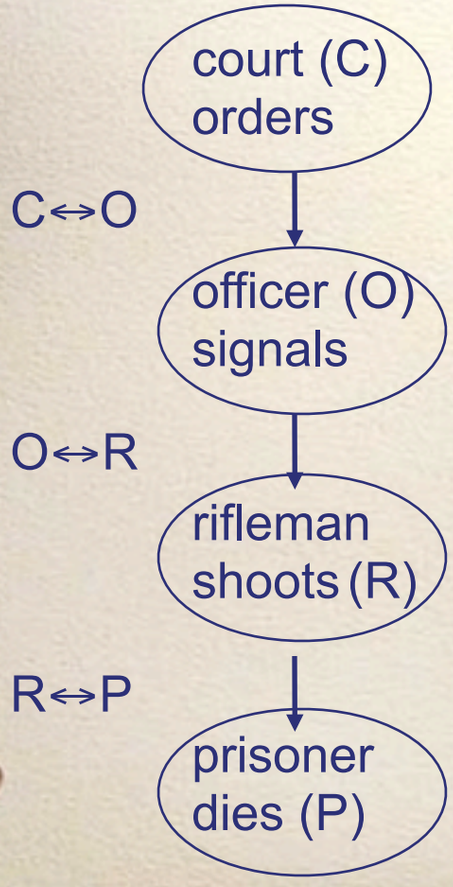

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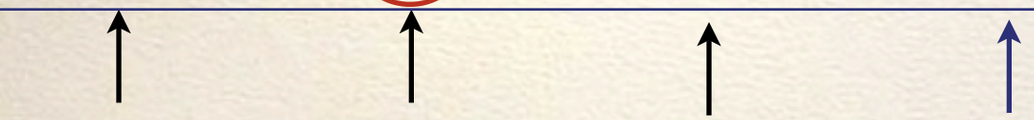
4 The semantics of conditionals

4.3 The big picture again

A conditional sentence '*If A then C*' is true iff:

Antecedent + Facts of w_0 $\Rightarrow_L$ Consequent



witness sets

causal premise semantics

Basis

causal entailment

$W_A(A)$ $\cup C$ $B_D(w_0)$ $|\equiv_D$ C

4 The semantics of conditionals

4.4 The witness set

Definition: ***witness sets***

A witness set s(A) of sentence A is a minimal sets of primitive facts that forces A no matter of the causal circumstances, i.e. all consistent extension of s(A) causally entail A.

4 The semantics of conditionals

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Examples:

A is atomic ⇒ unique witness set: {A}

4 The semantics of conditionals

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Definition: ***witness sets***

A witness set s(A) of sentence A is a minimal sets of primitive facts that forces A no matter of the causal circumstances, i.e. all consistent extension of s(A) causally entail A.

Examples:

A is $p \wedge q$ $\Rightarrow$ unique witness set: {p, q}

4 The semantics of conditionals

4.4 The witness set

Definition: ***witness sets***

A witness set s(A) of sentence A is a minimal sets of primitive facts that forces A no matter of the causal circumstances, i.e. all consistent extension of s(A) causally entail A.

Examples:

A is $p \vee q$ $\Rightarrow$ two witness sets: {p}, {q}

minimal witness sets: minimal sets of primitive facts that force A no matter of the causal circumstances – comes down to minimal set of literals that logically entail A

4 The semantics of conditionals

4.5 Summary

A conditional sentence '*If A then C*' is true iff:

Antecedent + Facts of w_0 $\Rightarrow_L$ Consequent

- ***Causal Premise Semantics***
  - *No matter how you force A in w_0 (by intervention), C will causally follow.*

$W_D(A)$ $\cup C$ $B_D(w_0)$ $|\equiv_D$ C

Philosophical Assessment

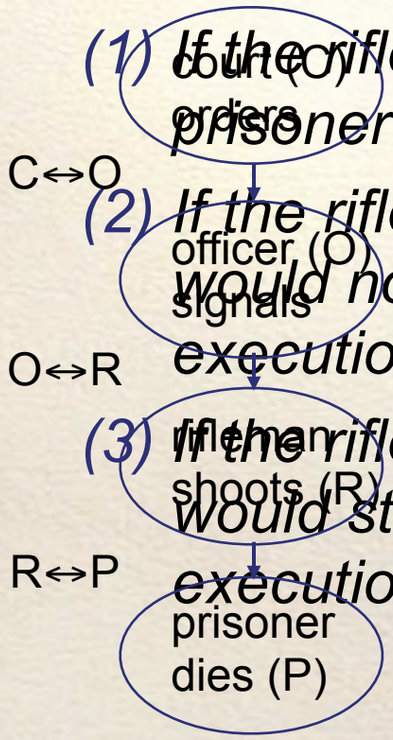
5 Philosophical assessment

5.1 Predictions

There is a court, an officer, a rifleman and a prisoner. If the court orders the execution of the prisoner, the officer will give a signal to the rifleman, the rifleman will shoot and the prisoner will die. The court orders the execution, the officer gives the signal, the rifleman shoots and the prisoner dies.

5 Philosophical assessment

5.1 Predictions



(1) *If the rifleman hadn't shot, the prisoner would not have died.* TRUE

(2) *If the rifleman hadn't shot, the court would not have ordered the execution.* FALSE

(3) *If the rifleman hadn't shot, the court would still have ordered the execution.* TRUE

5 Philosophical assessment

5.1 Predictions

- Approach makes the correct predictions for the target examples
  - backtracking
  - complex dependencies (circuit example)
- Approach can account for critical data beyond the primary target
  - Kit Fine's Nixon example
  - Lewis' problem of over-minimalization

5 Philosophical assessment
5.1 Predictions

Lewis' problem of over-minimalization

- We observe: (A ∨ B) > C entails A > C, B > C.

  (1) *If the weather had been fine or the sun had cooled down, we would have had a bumping crop*.

- In the similarity framework this inference is not generally valid
  - if f(A) > f(B), then '*if A or B, then C'* is true in case '*If A, then C'* is true.

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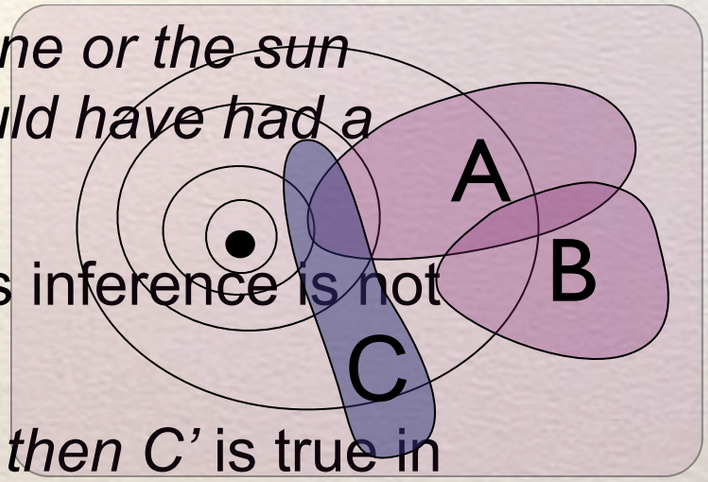

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Lewis' problem of over-minimalization

- We observe: (A $\vee$ B) > C entails A > C, B > C.

  (1) *If the weather had been fine or the sun had cooled down, we would have had a bumping crop*.

- The present approach correctly predicts the inference to be valid
  - this is a consequence of quantifying over all witness sets of the antecedent

5 Philosophical assessment

5.1 Predictions

- **BUT:** the predictions made depend on the causal structure you assign to a concrete example

5 Philosophical assessment

5.1 Predictions

The King Ludwig example

King Ludwig of Bavaria likes to spend his weekends at Leoni Castle. Whenever the Royal Bavarian flag is up and the lights are on, the King is in the Castle. At the moment the lights are on, the flag is down, and the King is away.

(2) If the flag were up, then the King would be in the castle.

(3) If the flag were up, then the light would be out.

5 Philosophical assessment

5.2 Is this really about causation?

- conditionals exploit certain invariant relationships, certain dependencies
- what unifies these relationships is that the expressed dependency is one of manipulation and control:
  - *A stands in this relation to B if manipulating A will change B in a systematic way;*
  - *by manipulating A one can control B*
- an invariant relationship with these properties I call *causal* relation

5 Philosophical assessment

5.2 Is this really about causation?

This is going a long way:

It is a simple fact of basic math that if you add two natural numbers that are both even or uneven, the sum will be even, but if one of the numbers is even and the other uneven the sum is uneven. Suppose you're explaining this fact to some school kids and you have on the board 3 + 4 = 7. You say ...

(7) If the first number had been even, the result would have been even.

(8) If the result had been even, the first number would have been even.

5 Philosophical assessment

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But this is a convention!!!

Beth '55: *In everyday usage of causality we make no difference between conventional rules and real causality.*

(7) If the first number had been even, the result would have been even.

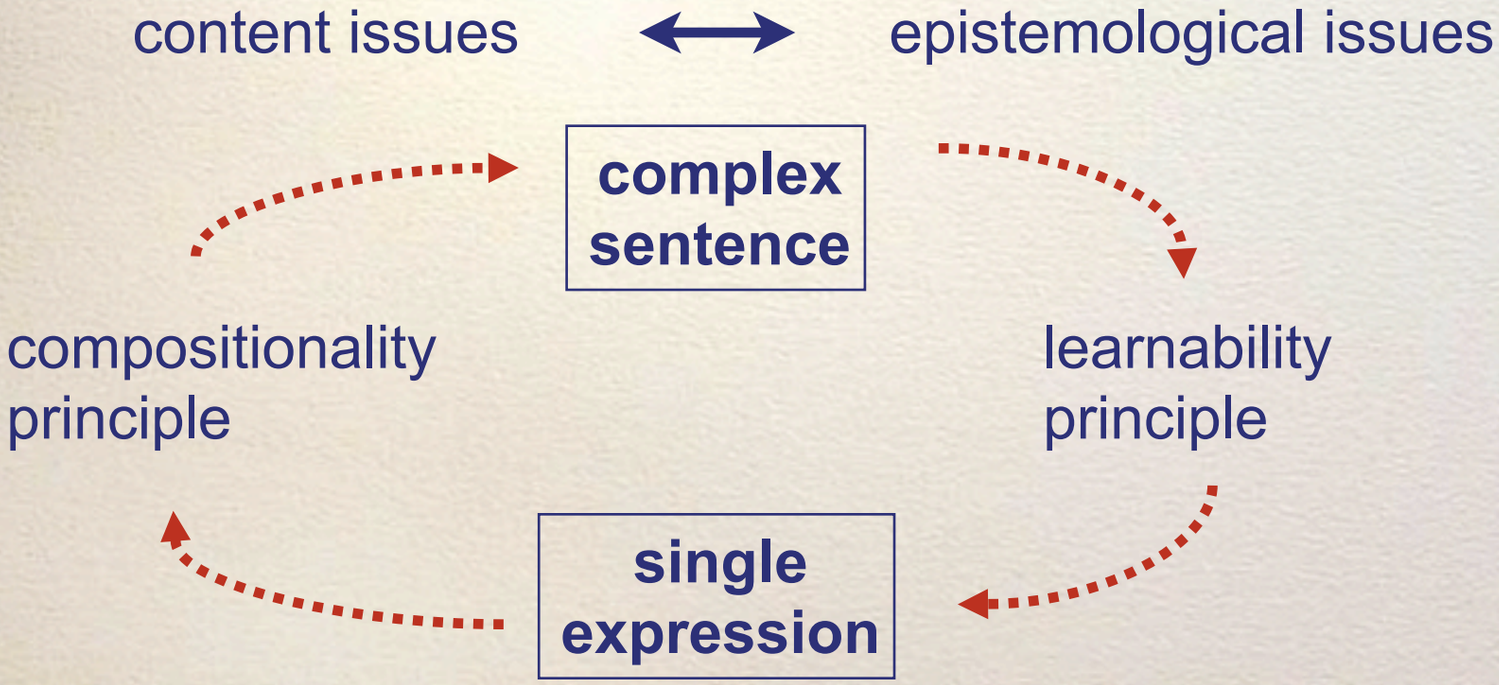
(8) If the result had been even, the first number would have been even.

5 Philosophical assessment
5.3 causal and conditional dependence

• We have to distinguish the content of claims exploring causal relationships from epistemological issues of how we test and establish causal relation ships.

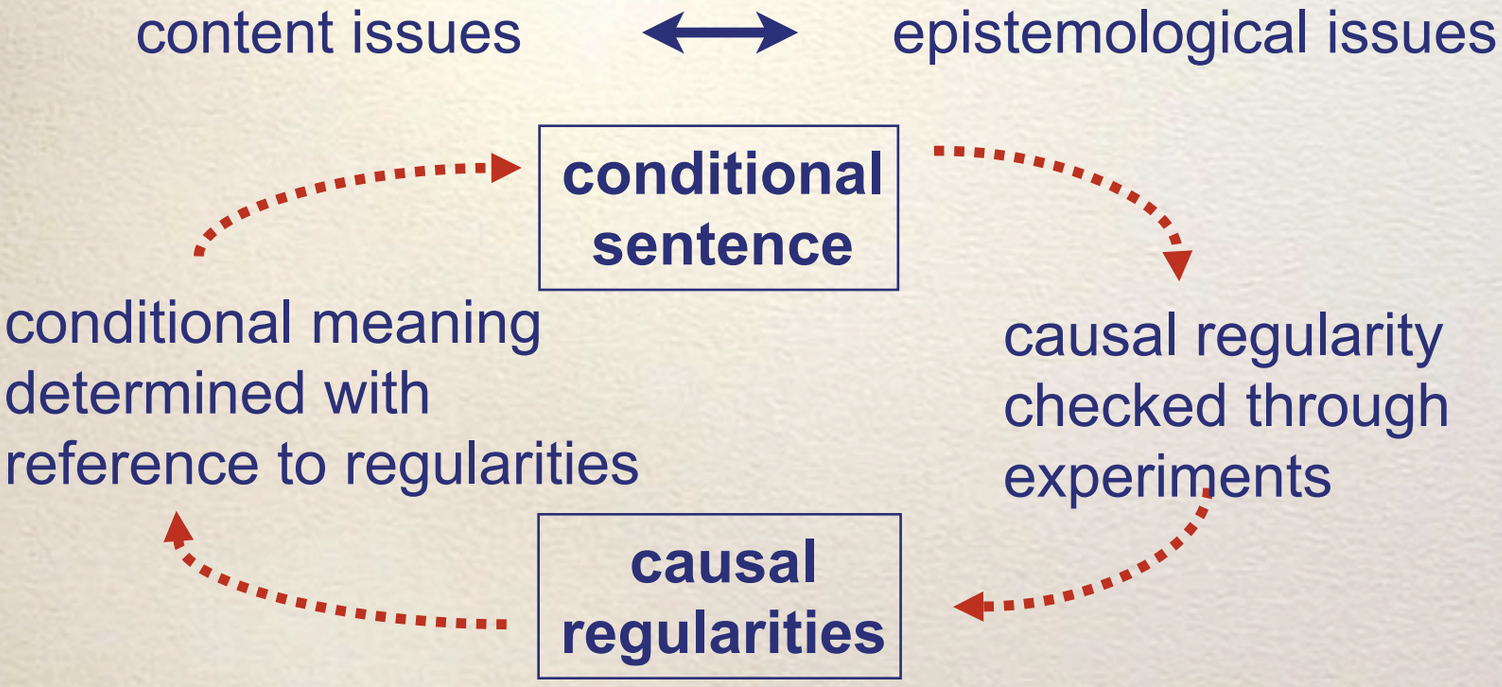
5 Philosophical assessment

5.3 causal and conditional dependence



5 Philosophical assessment

5.3 causal and conditional dependence



5 Philosophical assessment
5.3 causal and conditional dependence

- We have to distinguish the content of claims exploring causal relationships from epistemological issues of how we test and establish causal relation ships.

- the present theory takes causal relationships to be given

- how to establish the information the theory builds on is an important but independent issue

5 Philosophical assessment

5.4 What is causality

Beth, *Algemeene Beschouwingen over causaliteit*:

“So beschouwd, is het causaliteitsbeginsel dus geen principe a priori; maar het is ook geen natuurwet en zeker geen conventie. We kunnen misschien het beste zeggen, dat het causaliteitsbeginsel op een mede door historische factoren bepaalde wijze uitdrukking geeft aan een algemeen-menselijke neiging, op grond van spontaan geäpperciëerde causale (en andere) verbanden een meer, en zo mogelijk alles, omvattende causale structuur op te bouwen, die ons in staat stelt het universum waarin wij leven als een kosmos te begrijpen”

STREONG STATEMNT: causality, as presupposed by the meaning ofc onditionals is a heuristic, something we use because it is enourmously effecting in dealing with realitysomething that can be wrong, and something we can improve upon using experiments. But as heuristic it is not something that can be reduced to something else.

5 Philosophical assessment

5.4 What is causality

Beth, *Algemeene Beschouwingen over causaliteit*:

“From this perspective, the principle of causality is not a principle a priori; but it is also not a law of nature and certainly not a convention. Maybe, the best we can say is that the principle of causality expresses, partly determined by historical factors, a human tendency to build, based on spontaneously experienced causal (and other) relations, a more, and, if possible, all, including causal structure, which enables us to understand the universe we live in.”

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Conclusions

Back to linguistics again ...

6 Conclusions

6.1 Summarizing the results

- I have presented a formalization of a causal notion of consequence.
- This causal notion of consequence has been used to give an account of the meaning of conditionals.
- In terms of this approach we make correct predictions for the data problematic for other approaches.

6 Conclusions

6.1 Summarizing the results

Central predictions:

• improve on Veltman 2005 w.r.t. counterfactuals involving causal reasoning, without losing the achievements of this approach

• predict strong exclusion of backtracking: making the antecedent true leaves its causal past unchanged

• epistemic counterfactuals come out as false (Hamburger example, Duchess example)

6 Conclusions

6.2 Back to linguistics: mood

ontic reading (about causal dependence in actual world)		
epistemic reading (about belief revision)		

6 Conclusions

6.2 Back to linguistics: mood

	indicative conditionals	subjunctive conditionals
ontic reading (about causal dependence in actual world)		
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6 Conclusions

6.2 Back to linguistics: mood

	indicative conditionals	subjunctive conditionals
ontic reading (about causal dependence in actual world)	dominates for future	dominates always
epistemic reading (about belief revision)	for past and present only available reading	available, but weak

6 Conclusions

6.2 Back to linguistics: mood

The general pattern

- The ontic reading always dominates the epistemic reading.
- For indicative conditionals about the present or past the ontic reading is for semantic reasons not available (revision and meaning of indicative clash)

6 Conclusions

6.2 Back to linguistics: mood

Open questions

- What is the semantic function of the indicative/ subjunctive distinction?
- What is the foundation of the distinction between ontic and epistemic reading?
- Do languages express the distinction between the readings?

6 Conclusions

6.2 Back to linguistics: disjunction

- This approach can account for the distributive reading of disjunctive antecedents
- But the explanation sits in the interpretation rule for conditionals

  ➡ does not extend to distributive readings of disjunction in other contexts
- We should combine present approach with a more general explanation of his problem

  - van Rooij 2007, Alonso-Ovalle 2009, Groenendijk

6 Conclusions

6.2 Back to linguistics

The issue

- How to link philosophical and linguistic approaches to conditionals?
- How to link a general interpretation rule to the form of conditional sentences?

➡ **Compositional Semantics**