Breaking de Morgan's law in counterfactual antecedents

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Research questions

- Is the meaning of a declarative clause identical to its truth-conditions?
- Are $\neg(A \wedge B)$ and $\neg A \vee \neg B$ equivalent in language, as per de Morgan's law?
- Is minimizing departure from actuality sufficient to analyze counterfactuals?

Take-home messages

- While $\neg(A \wedge B)$ and $\neg A \vee \neg B$ have the same truth-conditions, they are not semantically equivalent.
- Conditional antecedents provide an environment that teases them apart.
- This calls for a notion of sentence meaning which is more fine-grained than truth-conditions.
- Counterfactuals cannot be analyzed just in terms of minimal change.

Introduction

A bulb is controlled by two switches. The light is on if both switches are in the same position, otherwise off. Right now, both switches are up, and the light is on.

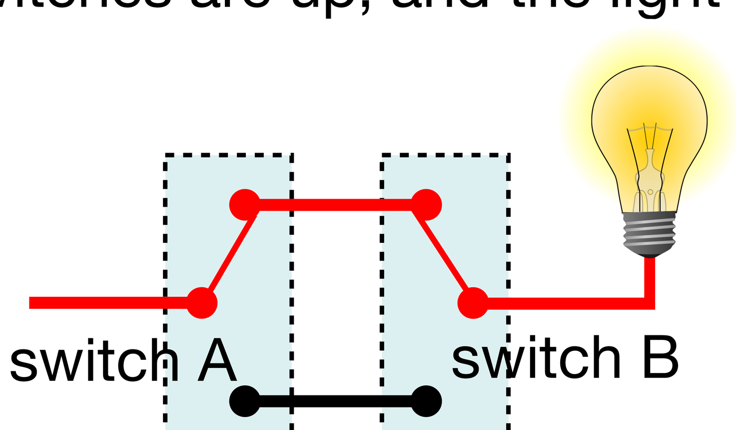

Fig. 1: Both switches are up

(1a) If A was down, the light would be off.
(1b) If B was down, the light would be off.
(2) If switch A or switch B was down, the light would be off.
(3) If switch A and switch B were not both up, the light would be off.
(4) If switch A and switch B were not both up, the light would be on.

An MTurk survey suggests de Morgan's law fails in counterfactuals

	Stimuli (abbreviated)	*N*	True	False	Indeterminate
(1a)	If $\neg A$, then "off".	255	**66.3%**	2.4%	31.4%
(1b)	If $\neg B$, then "off".	234	**65.4%**	3.0%	31.6%
(2)	If $\neg A \vee \neg B$, then "off".	346	**69.9%**	3.5%	26.6%
(3)	If $\neg(A \wedge B)$, then "off".	356	**22.5%**	36.2%	41.3%
(4)	If $\neg(A \wedge B)$, then "on".	200	**21.5%**	31.5%	47.0%

- Here, we write 'A' for "switch A is up", '¬A' for "switch A is down". Idem for B.
- Participants saw Fig. 1 along with a short text and gave truth-value judgments.
- Differences across blocks are highly significant: $\chi^2(8, N{=}1391)=375.9$, $p<0.0001$.
- Not so within blocks: $\chi^2(4, N{=}835) = 2.78$, $p{=}0.595$; $\chi^2(2, N{=}556) = 1.85$, $p{=}0.397$.

The challenge for truth-conditional semantics

- The antecedents of (2) and (3) have the same truth-conditions: both are true in worlds where one or both switches are down (we have tested this separately).
- In a truth-conditional semantics, this means that they are fully equivalent.
- By compositionality, (2) and (3) should be equivalent. But we found a difference.

The challenge for similarity-based accounts of counterfactuals

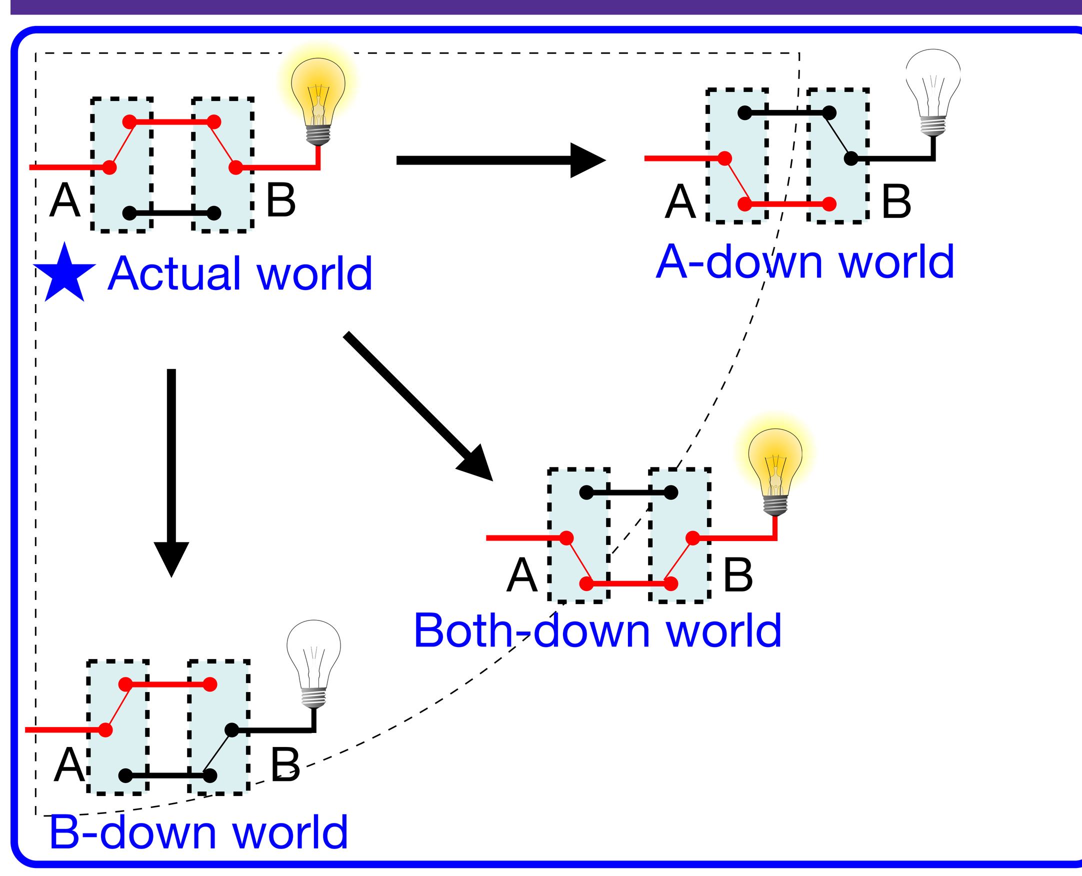

Fig. 2: All worlds equally similar; why is (1) true?

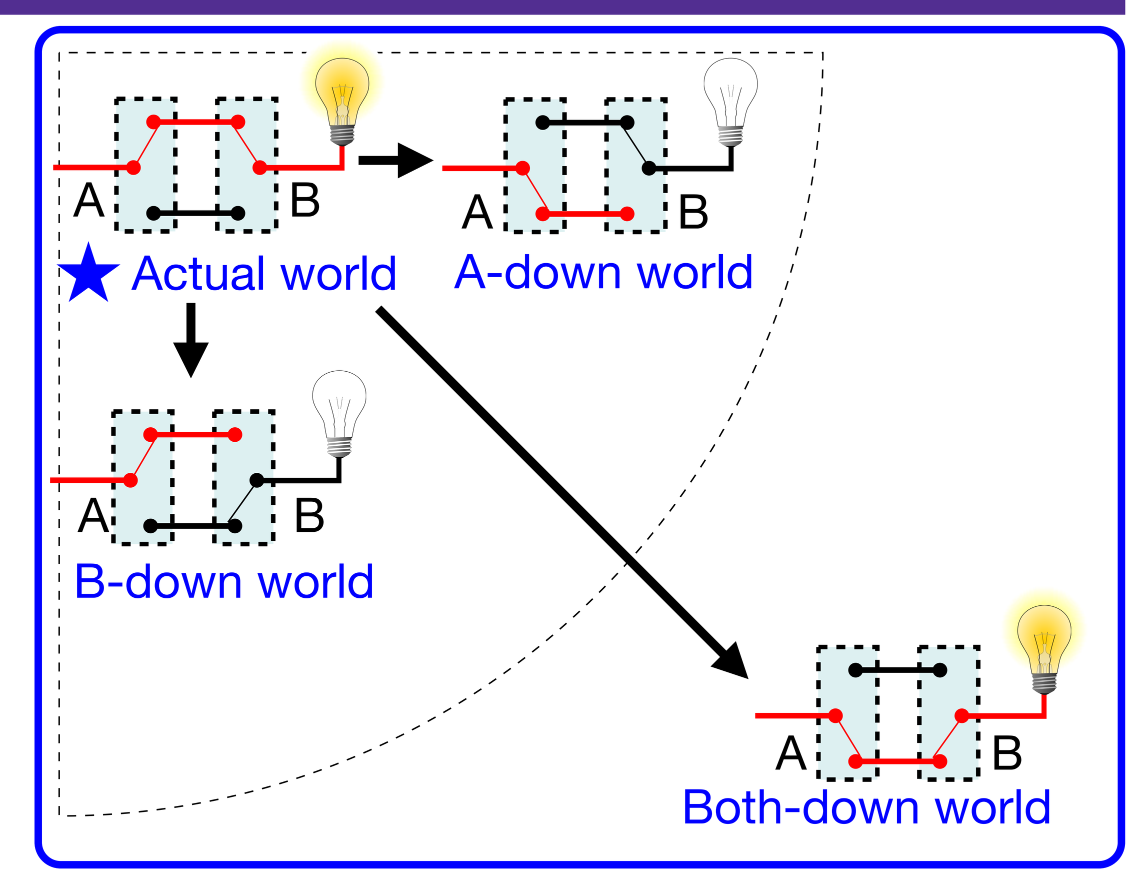

Fig. 3: "Both-down" less similar; why isn't (3) true?

Explaining the failure of de Morgan's law: inquisitive semantics

- InqSem (Ciardelli et al 13): a sentence meaning is given by a set of alternatives.
- The sentence is true at those worlds which are included in some alternative.
- $\neg A \vee \neg B$ and $\neg(A \wedge B)$ have **identical truth-conditions, but different meanings**: $\neg A \vee \neg B$ has two alternatives (Fig. 4), while $\neg(A \wedge B)$ has only one (Fig. 5).
- Each alternative for the antecedent provides an assumption: the counterfactual is true if the consequent follows on all of them. (Alonso-Ovalle 09, Ciardelli 16).
- This predicts that (2) is interpreted as (1a) $\wedge$ (1b), and differently from (3).

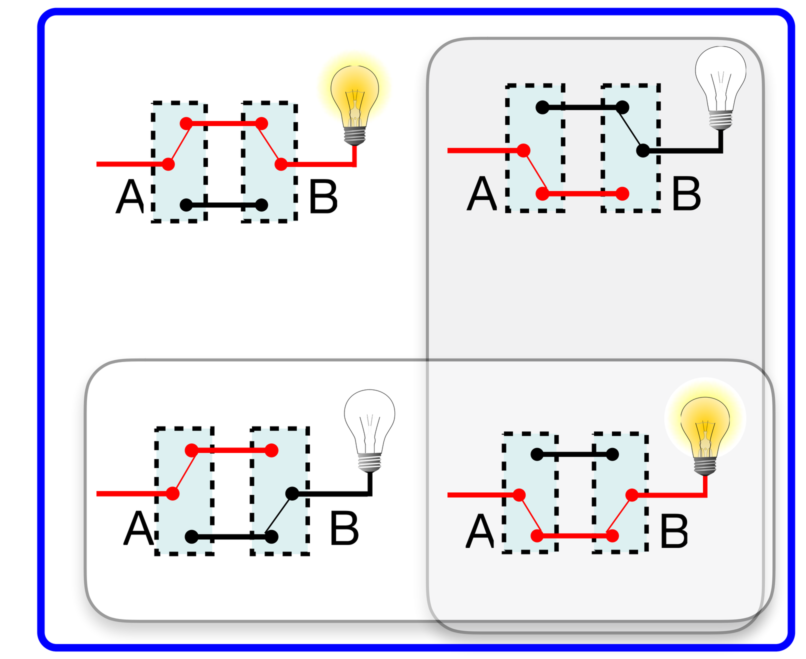

Fig. 4: "A or B is down"

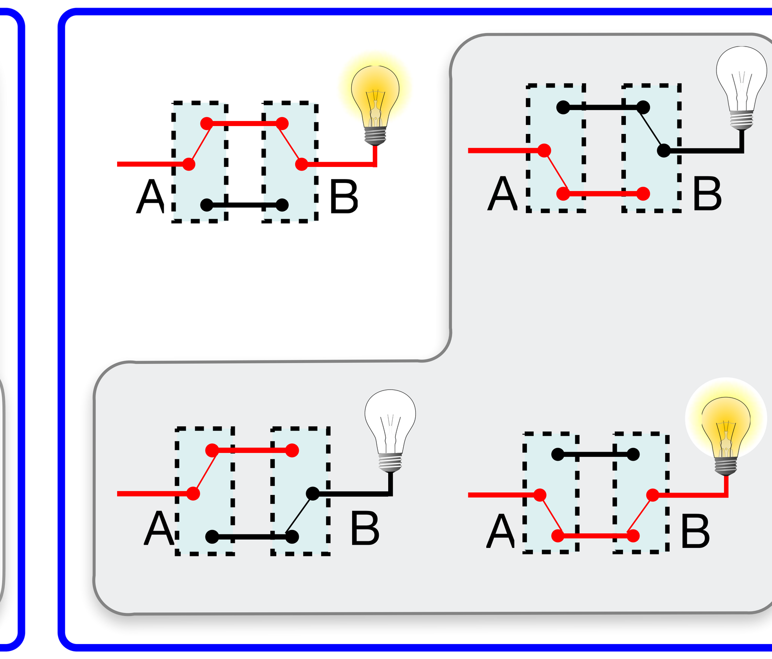

Fig. 5: "A and B are not both up"

Predicting our data: causal networks+grounds

- We build on causal accounts (Pearl 00, Kaufmann 13).
- A causal graph encodes dependencies of variables:

- Minimal change recipe (Kaufmann 13, simplified):
  1. start from the actual setting of the variables;
  2. change this minimally to make the antecedent true;
  3. propagate this change according to causal laws;
  4. check if the consequent is true.
- Problem for the interpretation of (3):
  - two minimal ways to make the antecedent of (3) true: {A=up,B=down} and {A=down,B=up};
  - each of these settings implies that the light is on;
  - so, (3) is erroneously predicted true.
- Our proposal: **the consequent must follow on each way to make the antecedent true in the graph.**
- To capture this, we introduce the notion of *ground*.
- Formally, a ground for a proposition *p* is a *p*-setting of a minimal set of variables that determines whether *p*.
- The antecedent of (1a) has just one ground:{A=down}; this ground yields light=off, so (1a) is predicted true.
- The antecedent of (3) has three grounds: {A=up,B=down}, {A=down,B=up}, {A=down,B=down}; the last yields light=on, so (3) is not predicted true.

References

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