Foundations of Mechanistic Reasoning PhDs in the Humanities project

Dean McHugh

ILLC, University of Amsterdam

ILLC Open Day 4 October 2019



INSTITUTE FOR LOGIC, LANGUAGE AND COMPUTATION



Dean McHugh

Foundations of Mechanistic Reasoning

Goal: analyse the logical structure of hypothetical reasoning

- Planning
- Decision-making
- Moral responsibility; praise, blame
- Causality

Cases when our reasoning goes beyond actuality

Case study: glyphosate



Figure: Protests outside European Commission, 24 October 2017

Dean McHugh Foundations of Mechanistic Reasoning

Report Finds Traces of a Controversial Herbicide in Cheerios and Quaker Oats



Glyphosate is a popular weedkiller used on crops worldwide, but it has been at the center of a debate over its presence in foods. A new report found traces in Cheerios, Quaker Oats and other breakfast foods. Seth Priman/Associated Press

f y

A .

By Mihir Zaveri

Aug. 15, 2018

Monsanto banned from European parliament

MEPs withdraw parliamentary access after the firm shunned a hearing into allegations that it unduly influenced studies into the safety of glyphosate used in its RoundUp weedkiller



Arthur Neslen



▲ People protest against a planned \$660n takeover of Monsanto by Bayer and Monsanto's glyphosate herbicides. In Brusels, July 2017, Photograph: Yees Herman/Resters

Dean McHugh Foundations of Mechanistic Reasoning





European Chemicals Agency

- Only statistical evidence is valid
 - Epidemiological data
 - Studies on animals
 - Mostly conducted by industry itself





European Chemicals Agency

- Only statistical evidence is valid
 - Epidemiological data
 - Studies on animals
 - Mostly conducted by industry itself

World Health Organisation

- "The mechanistic data provide strong evidence" that glyphosate causes cancer
- But what is *mechanistic evidence*?



Mathematical foundation

■ Given binary variables *X* and *Y*, say *X* raises the probability of *Y* just in case *P*(*y* | *x*) > *P*(*y*).

■ Given binary variables *X* and *Y*, say *X* raises the probability of *Y* just in case *P*(*y* | *x*) > *P*(*y*).

Probability-raising is symmetric.

X raises the probability of *Y* iff *Y* raises the probability of *X*.

■ Given binary variables *X* and *Y*, say *X* raises the probability of *Y* just in case *P*(*y* | *x*) > *P*(*y*).

Probability-raising is symmetric.

X raises the probability of *Y* iff *Y* raises the probability of *X*.

Proof.

$$P(y \mid x) > P(y)$$

$$\frac{P(x \mid y)P(y)}{P(x)} > P(y) \quad \text{Bayes rule}$$

$$P(x \mid y) > P(x) \quad \times \frac{P(x)}{P(y)}$$

■ Given binary variables *X* and *Y*, say *X* raises the probability of *Y* just in case *P*(*y* | *x*) > *P*(*y*).

Probability-raising is symmetric.

X raises the probability of *Y* iff *Y* raises the probability of *X*.

Proof.

$$\begin{split} P(y \mid x) > P(y) \\ \frac{P(x \mid y)P(y)}{P(x)} > P(y) & \text{Bayes rule} \\ P(x \mid y) > P(x) & \times \frac{P(x)}{P(y)} \\ \\ \Box \end{split}$$

... Probability-raising does not represent causal asymmetry

Example

Seeing someone smoke raising the probability that they cough

is equivalent to

Seeing someone cough raising the probability that they smoke

Dean McHugh

Foundations of Mechanistic Reasoning

Asymmetry by intervention

Observation



Seeing someone cough raises one's credence that they smoke

Intervention



Making someone cough does *not* raise one's credence that they smoke

Bayes net

Edges in the graph represent direct causal dependence.



The rooster's crow does not cause sunrise

Bayes net

• Edges in the graph represent direct causal dependence.



The rooster's crow does not cause sunrise

Is causality all just intervention?



There are causal relations at the big bang

Is causality all just intervention?



- There are causal relations at the big bang
- But what would it mean to *intervene* in the big bang?
- Intervention is too anthropocentric

Dean McHugh



Figure: Turning on the light at time *t*



Figure: Turning on the light at time t

Fact

No binary relation is nonempty, dense, and anti-transitive.

$$X \longrightarrow Z$$

Figure: Proof



Figure: Turning on the light at time t

Fact

No binary relation is nonempty, dense, and anti-transitive.



Figure: Proof

Dean McHugh

Foundations of Mechanistic Reasoning

Definition (Dense causal chain)

A Bayesian net has a *dense causal chain* just in case it contains variables *X* and *Z* such that:

1 X has a causal effect on Z

$$P(z \mid do(x)) \neq P(z)$$

- **2** *X* is a parent of *Z*
- There is another parent *Y* of *Z* such that *X* and *Z* are independent conditional on any set containing *Y*

Theorem

No Bayesian net has a dense causal chain.

Definition (Dynamical system)

- A *path* is a linearly ordered set of states.
- A *dynamical system* is a set of paths.
- Interventions amount to cutting and pasting paths
- The truth conditions of causal claims are given in terms of dynamical systems
- Causality is a logical pattern of temporal succession

Temporal modality













But there is change without causality

Causality

Change



- There's no causality without change,
- But there is change without causality



[...] we are ignorant of those powers and forces, on which [the] regular course and succession of objects totally depends.

Hume, Enquiry §4