

Causation as a Tool for Intelligibility

Hugh Desmond

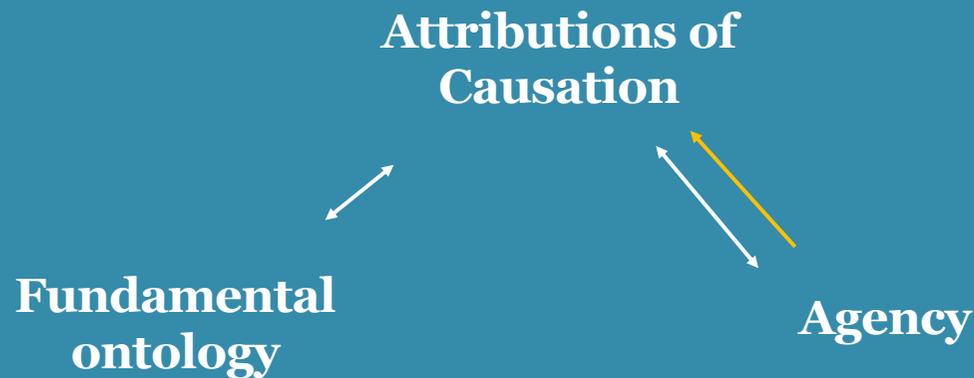
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Overview

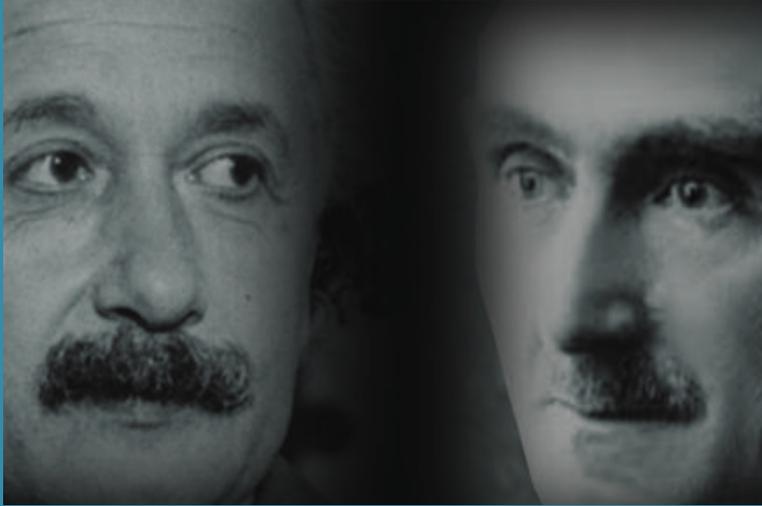


That's a causal relation



1. **Situating the agential (perspectival/pragmatist) approach**
2. **Situating causation in reference to *two aims of science*: understanding & prediction**
3. **Causation IS a tool for scientific agency**: parallel conditions of causation in scientific context and agential context.

Time and Agency: a centenary?



April 6th, 1922

Bergson:

“All that I want to establish is simply this: once we admit the theory of relativity as a physical theory, all is not finished.”

Provocative response by Einstein:

“Il n’y a donc pas un temps des philosophes ; il n’y a qu’un temps psychologique différent du temps du physicien.”

The Einstein-Russell Challenge?

Not materially different to Russell's challenge:

- Causation no role to play in scientific/intellectual enquiry
- Same backdrop of the rise of physics and ensuing jurisdictional struggles with philosophy (re-enactments by Hawking, Krauss, ...)

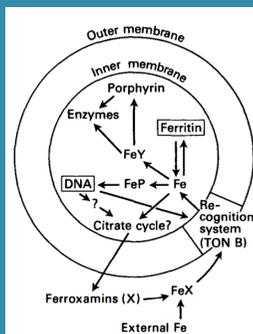
(less urgent today with (1) the “rise” of the special sciences, (2) physics not delivering on all early promises)

Two options in the literature

- Show how fundamental physics *allows for appearance of* processes that assume some folk-causation properties (esp. via S-T)
- **Reanalyze the concept of causation as an agential phenomenon & carve out parts of science where this concept is relevant**

No genuine competition

1. Agency has a causal-*physical* origin in time (via evolution)

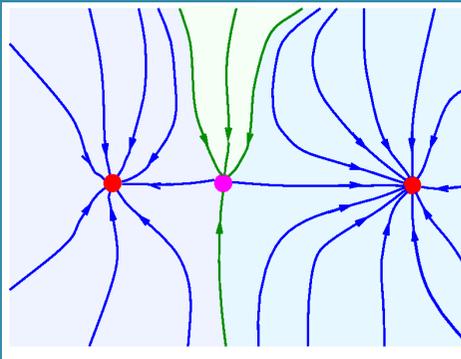


No genuine competition

1. Agency has a causal-*physical* origin in time

How to naturalize agency?

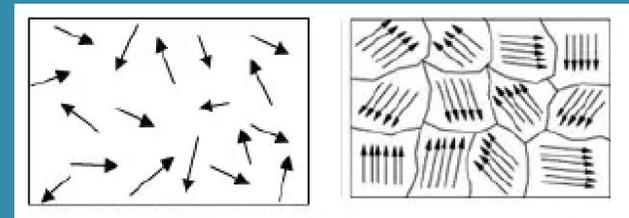
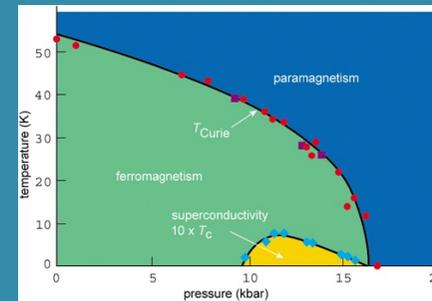
Naturalized intentionality
Goal-directedness



Approach to equilibrium

(Phil bio; cog sci; AI engineering)

Naturalized Deliberation
Weighing of interests



Phase transition with symmetry breaking

(Desmond ms.)

No genuine competition

That's a causal relation



2. Causation has an *agential* origin

- Science is a human activity, relying on judgment calls, values, trust
- Attributing causality to some relation between events is done on the basis of **judging**: *deliberating and deciding on evidence*

Two potential misunderstandings

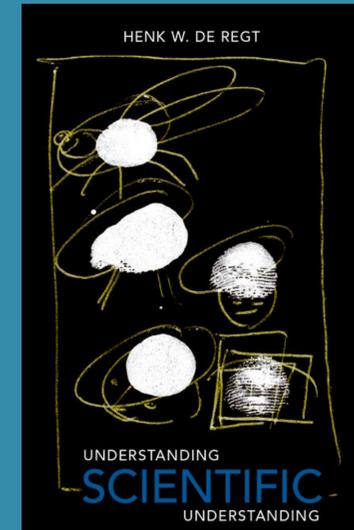
1. Grounding causation in a type of reasoning process is **not** to deny the existence of mind-independent world
2. This is a normative enquiry, not psychological/ empirical

Overview

1. Situating the “agential” approach
2. Situating causation in reference to *two aims of science: understanding & prediction*
3. Causation as a tool for scientific agency: parallel conditions of causation in scientific context and agential context.

Understanding

“Intelligibility = the value that scientists attribute to the cluster of qualities of a theory that facilitate the use of the theory” (de Regt 2017)



- **Paradigmatic example:** *visualizability (space-time description)* of Schrödinger’s wave equation vs. non-visualizability of Heisenberg’s matric mechanics
 - Helps explain the relative popularity of former compared to latter
 - Wave mechanics could more easily be applied to new problems (spectrum of hydrogen)
- Also later developments (concept of “electron spin” and Feynman diagrams) illustrate the continued importance of understanding-as-visualizability

Causation and Understanding

- Finding a *causal explanation* has long been viewed as crucial for achieving *understanding*.
 - Newtonian action at a distance vs. Cartesian objections (e.g. Huygens) that this was unintelligible.
 - In medical sciences: pure evidential relations (clinical trial) vs. finding a causal mechanism
 - In computer science: “understandable AI” (machine learning yields prediction but not understanding)

Causation and Understanding

- Finding a *causal explanation* has long been viewed as crucial for achieving *understanding*.
 - Useful for *scientific agency* (“manipulability” of theory, and applicability to new problems)
 - Useful for science education

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RESEARCH REPORT

Conceptual Understanding of Causal Reasoning in Physics

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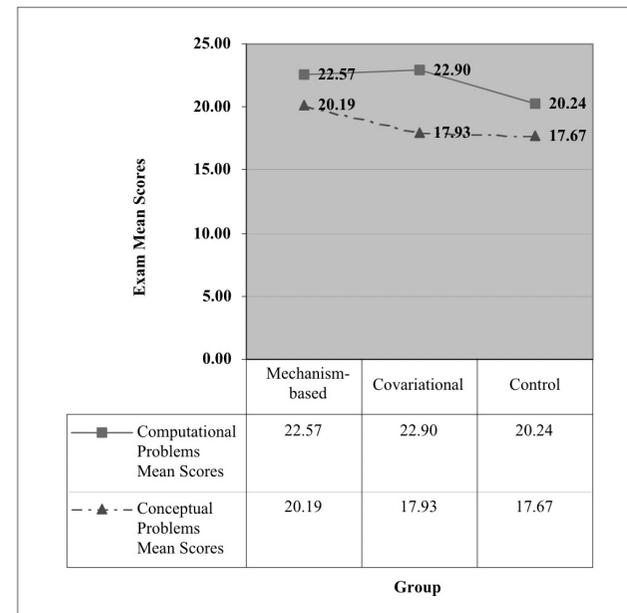


Figure 6. Comparison of computational problem mean scores and conceptual problem mean scores of the mechanism-based, covariational and control groups

The difficult question: what *grounds* this usefulness?

- Ontic interpretation

Understanding involves grasping the “real” structure of phenomena; causal explanation yields understanding because the world is made out of a causal nexus and explanations pick out the relevant bits (Strevens; Woodward)

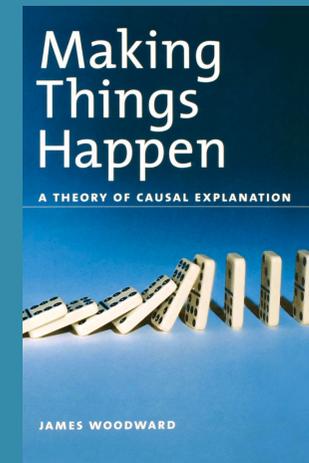
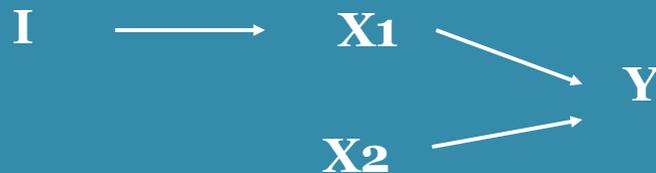
- Agential interpretation

Causal explanation is a product of human deliberation, of human choice

Causation and Prediction

- In the positivist view, prediction is the *only* value and understanding a mere “feeling” (Reichenbach, Hempel, ...)
- In the more ontic view (Craver, Woodward, ...), no fundamental tradeoff between understanding and prediction
- One way to view the upshot of interventionism is that it precisely specifies what causation means in terms of *prediction* (via a particular kind of prediction: *control*)

$$Y = a_1X_1 + a_2X_2 + U$$



Crux of the argument

1. Should we view causal explanation *ontically* or *agentially*?
2. The ontic view involves a *sleight of hand*:
 - causation seems to safeguard predictiveness because the target system is *already idealized*
 - In real-world systems, causal information cannot be used for exact predictions but only for *prudential deliberation* (economics; engineering; medicine)
 - This is not apparent when we focus on physics, because only “slight” idealization is necessary to gain exact predictiveness
3. Causation is a tool to make a phenomenon more amenable to *agency*
4. Not pure idealism: causation is not a *projection* (like a visual illusion) but is something that some parts of reality *allow for*

Digression: Legal Deliberation about Causation

- Cf. deliberation about evidence (Fernandes; Price)
- A causes X. What is the nature of that causation?

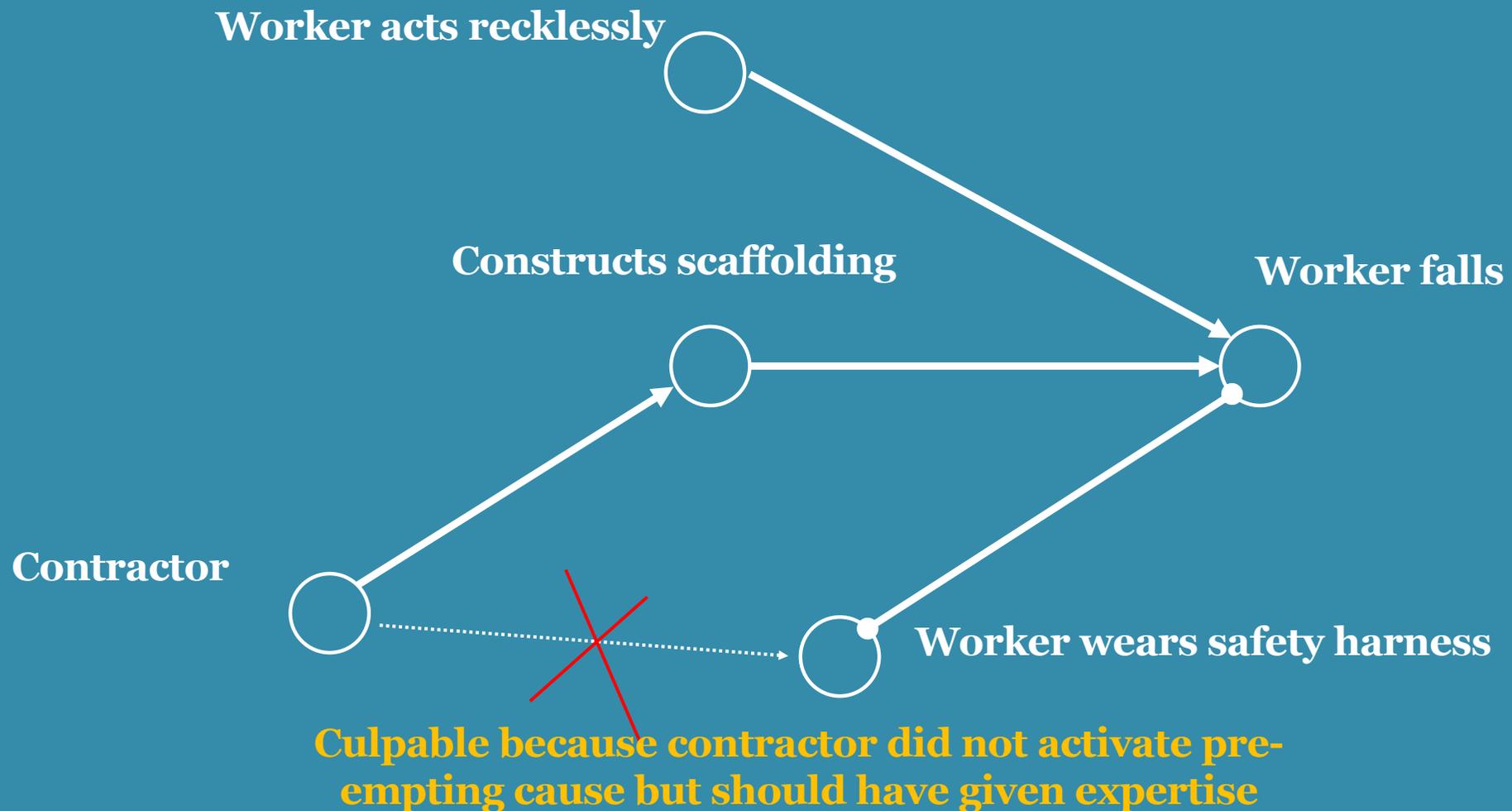
Actus Reus: the sequence of events

Mens rea: to what degree was the act *agential* (to what degree A responsible or events outside of A)

Purposely
Knowingly
Recklessly
Negligence

→ Agent did not know but *could and should have known* it could have happened

Negligence *in metaphysics framework*



Deliberation about causation/culpability

- The function of the concept of culpability is *not* prediction.
- Almost always it is *understanding*: (1) to determine guilt/innocence and (2) to determine proportionate sanction.

Three core elements:



1. Weighing of evidence
2. No foregone conclusions: *small* details about very particular circumstances can matter a *great deal*
3. Decision: there is a *truth* of the matter

My idea: something fundamentally similar goes on in science

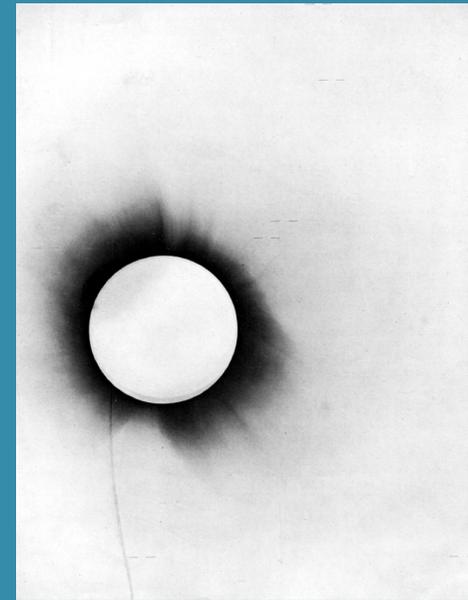
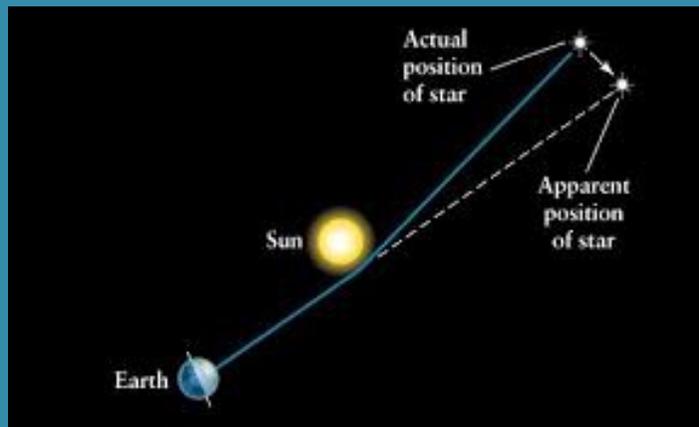
Real predictiveness in Special Sciences

Biology, economics, psychology: not *spectacular*

This is “spectacular”

Observation:

Prediction (1915):



1919 Eclipse (Eddington)

An exact prediction that not only goes beyond common sense, but against common sense

Biology

Is the theory of natural selection predictive?

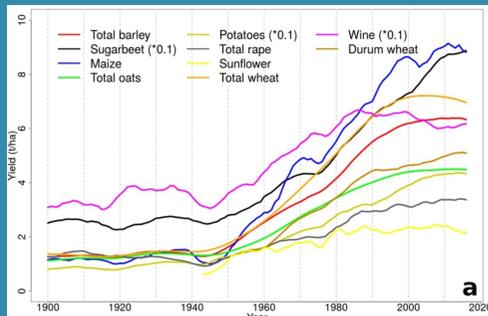
$$\Delta z = 1/w \text{Cov}(w, z) + 1/w E(w \Delta z) \quad (\text{Price equation})$$

$$R_{\text{eff}} = H^2 S_{\text{eff}} \quad (\text{Breeder's equation})$$

Change term “force term”

$$a = F/m$$

Some successes!



But prediction/control only possible in
CONTROLLED ENVIRONMENTS

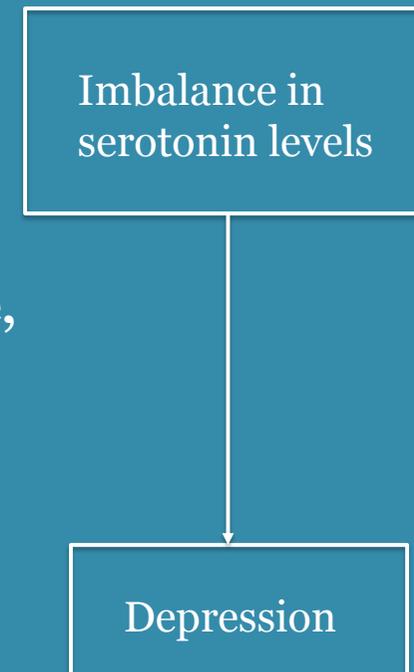


Psychology

Clinical depression

(DSM-5 uses agential language: loss of “interest”, sense of “worthlessness”, “indecisiveness”)

It would be “nice” if it we could find a nice, simple, neat mechanistic-interventionist model



No joke...



a Depression hurts. a

Depression isn't just feeling down. It's a real illness with real causes. Depression can be triggered by stressful life events, like divorce or a death in the family. Or it can appear suddenly, for no apparent reason.

Some people think you can just will yourself out of a depression. That's not true. Many doctors believe that one thing that may cause depression is an imbalance of serotonin – a chemical in your body. If this happens, you may have trouble sleeping. Feel unusually sad or irritable. Find it hard to concentrate. Lose your appetite. Lack energy. Or have trouble feeling

pleasure. These are some of the symptoms that can point to depression – especially if they last for more than a couple of weeks and if normal, everyday life feels like too much to handle.

To help fight depression, the medicine doctors now prescribe most often is Prozac®. Prozac isn't a "happy pill." It's not a tranquilizer. It won't turn you into a different person.

Some people do experience mild side effects, like upset stomach, headaches, difficulty sleeping, drowsiness, anxiety and nervousness. These tend to go away within a few weeks of starting treatment, and usually aren't serious enough to



a Prozac can help. a

make most people stop taking it. However, if you are concerned about a side effect, or if you develop a rash, tell your doctor right away. And don't forget to tell your doctor about any other medicines you are taking. Some people should not take Prozac, especially people on MAO inhibitors.

As you start feeling better, your doctor can suggest therapy or other means to help you work through your depression. Prozac has been carefully studied for nearly 10 years. But remember, Prozac is a prescription medicine, and it isn't right for everyone. Only your doctor

can decide if Prozac is right for you – or for someone you love. Prozac has been prescribed for more than 17 million Americans. Chances are someone you know is feeling sunny again because of it.

prozac
fluoxetine hydrochloride

Welcome back.

Please see important information on following page.
<http://www.lilly.com>

“Many doctors believe that one thing that may cause depression is an imbalance of serotonin – chemical in your body.”

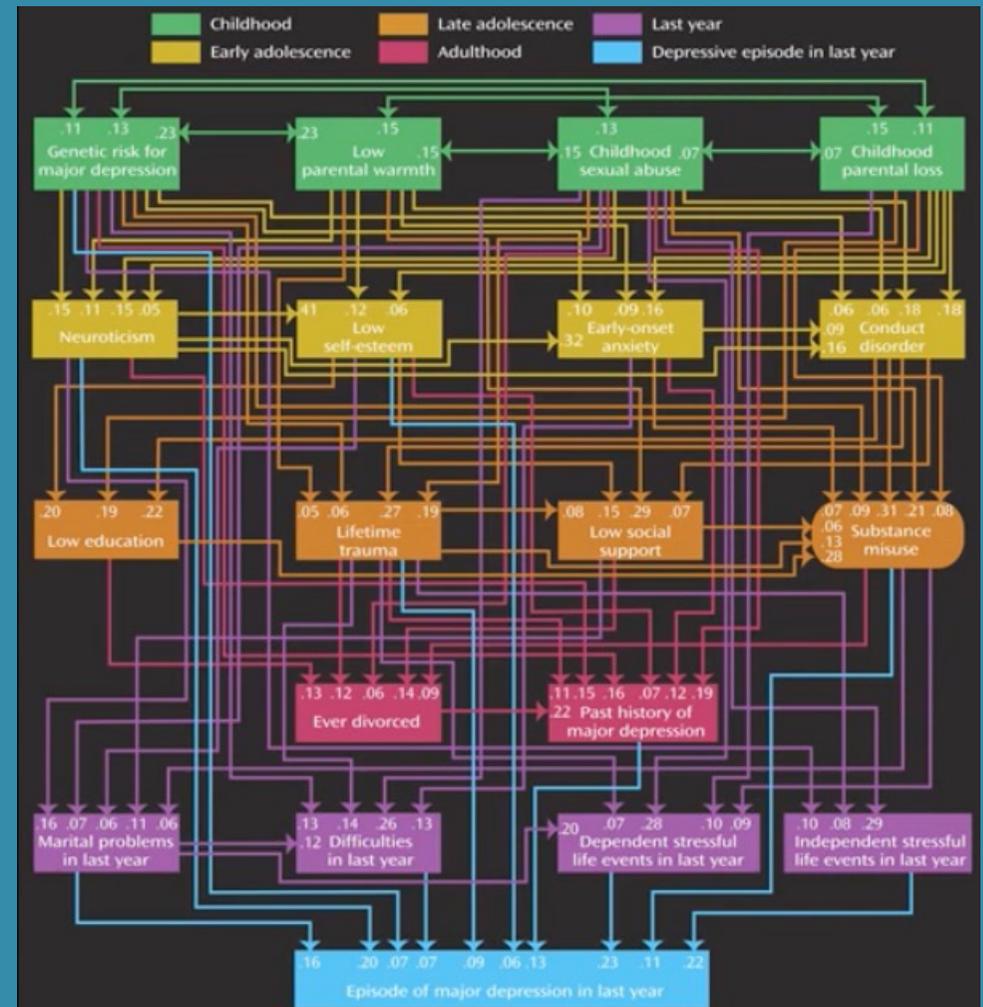
“Prozac has been carefully studied for nearly 10 years.”

Psychology

A more realistic model

Somewhat predictive
(e.g. “low parental warmth raises probability of depression”)

But nowhere nearly enough as we would like

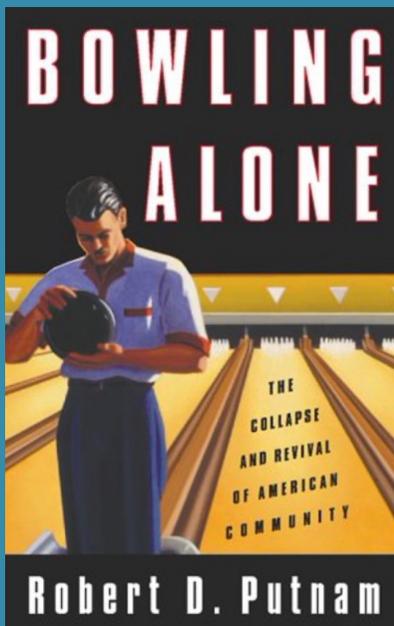


Depression seems to be non-idealizable

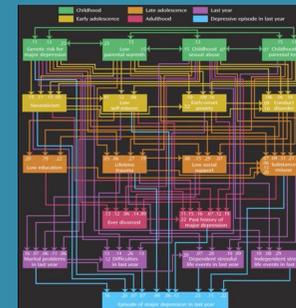
“Idealizable”: represent in a model (mathematical/causal) in such a way that *exact prediction* becomes possible

Why?

Education; divorce; substance use; social support

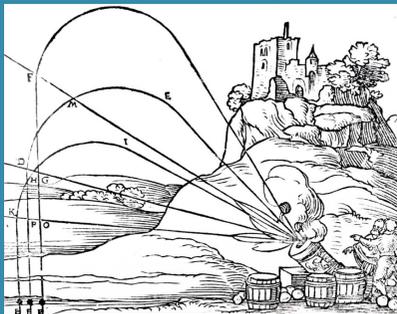
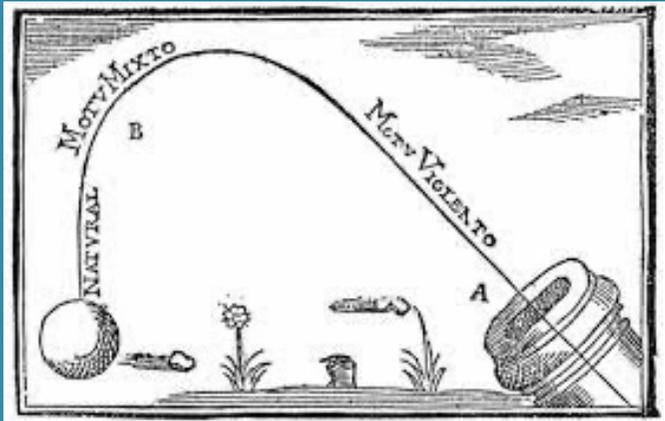


This helps explain why depression *seems to be* so intractable: it's connected to sociological, political, and even large-scale historical trends.



Depression is not like Projectile Motion

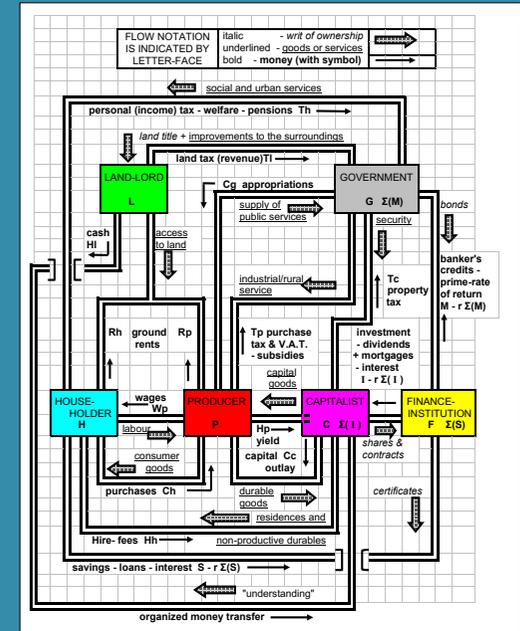
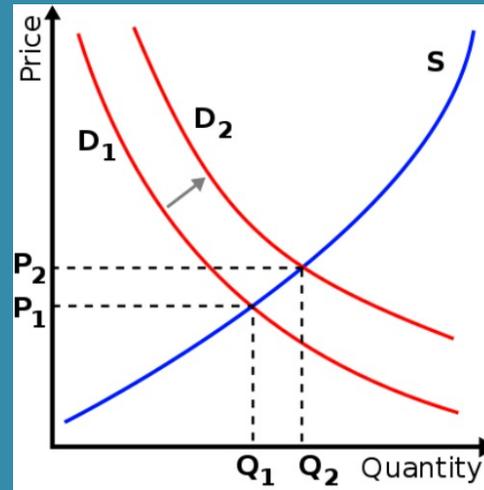
- Strategy of idealization: ignore friction, ignore Aristotelian/scholastic metaphysics (!), make an exact model, add some corrective factor later



Same with biology, economics...



The “entangled bank”



No further illustration needed:
idealization in economics does not allow
for exact prediction

Perfect Prediction: Laws and Machines

1. D-N explanation: outcomes can be deduced from initial conditions + covering laws.

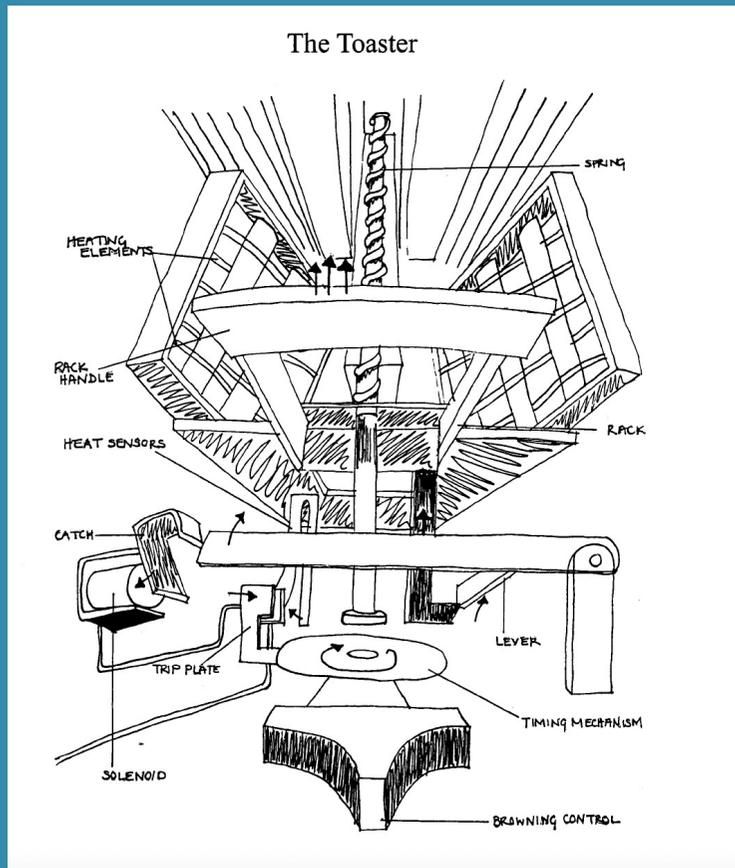
No deliberation needed.

2. Machines & functional wholes

Outputs can be predicted from inputs

User of machine does not need causal knowledge (given proper functioning of the machine in “normal” environment)

Only when they need to *troubleshoot: that's when an engineering-stance is crucial*



Cartwright, Nancy. 2001. "Modularity: It Can - and Generally Does, Fail." In *Stochastic Causality*, edited by Domenico Costantini, Maria Carla Galavotti, and Patrick Suppes, 71.

As long as the toaster is functioning perfectly, the movement lever **predicts** the movement of the rack?

But does it *a causal difference-maker*?

- “Lever variable” (up/down) produces a whole load of other changes as well

You can't *surgically* intervene on the lever to observe change in rack *while* keeping all other components constant

The relevant counterfactual is at the level of the functional whole (input → output)

At the level of parts, the causal nexus is **entangled**

A more systematic account elsewhere

- A tension between *predictiveness* and *causal character* (“Pragmatic-modal account of (non)causal explanation”)
- When explanation is perfectly predictive, we are more likely to *identify* explanans and explanandum (e.g., see as mathematically equivalent)
- Causation dispensable when exact prediction is attainable



(2019)

- Extrapolation here: helps account for why causation dispensable for predictiveness of D-N explanations and that of mechanistic explanations

Default use of scientific knowledge

Most areas of reality not amenable to *predictive* lawful or mechanistic explanation

When professionals use causal knowledge, it is not for exact prediction

Medicine

- General causal relationships (between therapy & outcome) known only with relatively large uncertainty.
- Clinical trials yield *population-level* knowledge, but physicians must treat *individuals*.
- Sometimes not a problem (bacterial infection), but often is a problem (esp. mental health)

Engineering

- Hardly ever a question of “applying the science”
- Prudential management of uncertainty (“margin of safety”, “robustness”)
- Some degree of control is reached through a lot of *debugging* (= retrospective)

Prudential deliberation

- Many professions define themselves (and safeguard their legitimacy!) as being *science-based*

Medicine is the [science^{\[1\]}](#) and [practice^{\[2\]}](#) of caring for a patient, managing the [diagnosis](#), [prognosis](#), [prevention](#), [treatment](#), [palliation](#) of their [injury](#) or [disease](#), and [promoting their health](#). Medicine encompasses a variety of [health care](#) practices evolved to maintain

Engineering is the use of [scientific principles](#) to design and build machines, structures, and other items, including bridges, tunnels, roads, vehicles, and buildings.^[1] The discipline of engineering encompasses a broad range of more specialized [fields of engineering](#),

- But, they are *much older* than science and to this day, scientific training alone is woefully inadequate for professional competence (medicine, engineering)
- Why? Here is a stab at a “prudential” reasoning scheme:
 1. **Many contributing causes present**
 2. **It is known what effects each cause would produce *if acting in isolation***
 3. **The *relative strength* remains unknown**

 4. **Certain courses of action (therapy/design) are to be preferred if they *minimize risk* (or: *minimize maximal risk, ...*)**

Drawing some conclusions

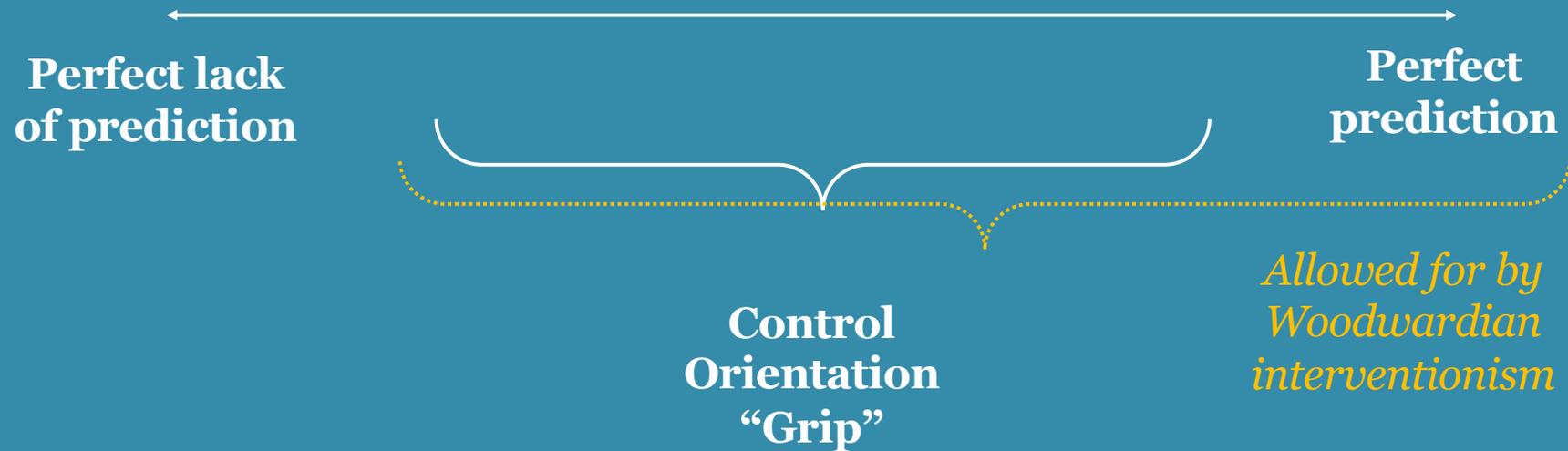
- One (*the?*) important route to ontic view of causation and causal explanations is via prediction (IBE: the reality of causation best explains its predictiveness)
- But once predictiveness is achieved, causation becomes dispensable
- Why? No need for agential deliberation on what will likely happen.

Prediction vs. Agential deliberation

- Conversely, causal knowledge allows for a specific type of control: prudential deliberation

Confusing *Map* with *landscape*

interpretation of causal explanation is classic case of confusing the *map* for the *landscape*.



Significant because the absence of perfect predictiveness is evidence that causation is a tool for agency

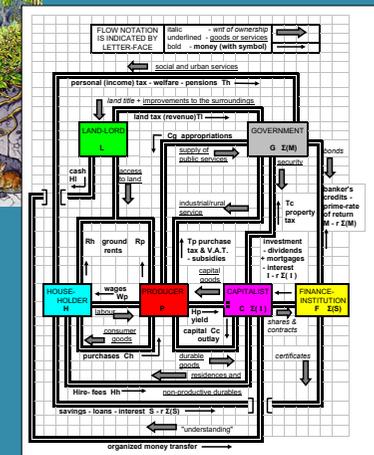
Some Final Metaphysical Remarks

- Default or “null” view is not the view of fundamental physics
- Neat, mathematicised view is *derived* from **messy, complex reality**



Jamesian stance: “Reality and life exceeds our logic, overflows and surrounds it” (James 2015, 212)

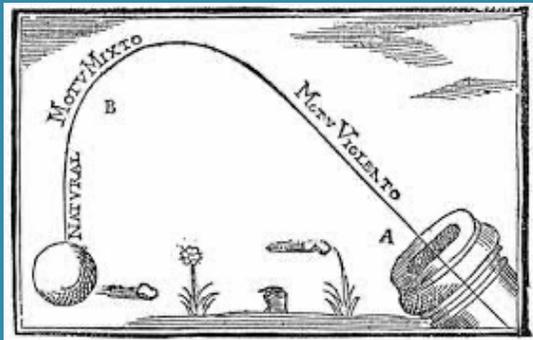
James, William. 2015. *A Pluralistic Universe*. Fb&c Limited.



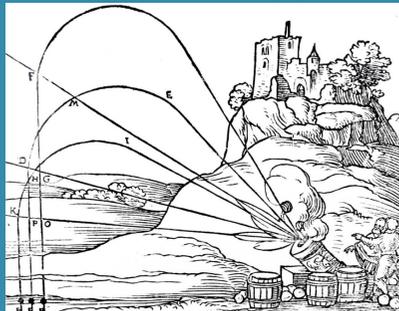
Some Final Metaphysical Remarks

Why did Russell/Einstein take fundamental physics as the “null” view

A sociological explanation: the great prestige of physics



- The years between 1865 (Maxwell) – 1945 (Manhattan project) were heady days for physics
- Don't forget that mathematicized physics started out as a weird, marginal area of “natural philosophy”!
- **Galileo:** was *acutely* concerned with getting approval from the gunners, who were not *at all* persuaded his type of “speculative” mathematical modeling



propositions in which this topic abounds, but I wish for now to close the treatise with a table which I have proved and calculated for artillery and mortar trajectories, showing their flights and with what proportion they increase and diminish according to the various degrees of elevation. The practice of this table will be useful to gunners, its theory of great delight to philosophers (*speculativi*).”¹

Some Final Metaphysical Remarks

And by the way, has physics come true on its promises about prediction since 1922?

- **Schrödinger's "What is Life" (1944):** prospect of using thermodynamics to find predictive conditions for the emergence of living systems (replication; metabolism)
- Progress in finding law-like generalizations in for non-equilibrium thermodynamics (extremal principles) has – as far as I know – stalled
- Principle of maximal entropy production, or minimal entropy production?
- Lot of excitement post WW-II (Prigogine, Onsager), but now?

Dissipative adaptation in driven self-assembly

Jeremy L. England

In a collection of assembling particles that is allowed to reach thermal equilibrium, the energy of a given microscopic arrangement and the probability of observing the system in that arrangement obey a simple exponential relationship known as the Boltzmann distribution. Once the same thermally fluctuating particles are driven away from equilibrium by forces that do work on the system over time, however, it becomes significantly more challenging to relate the likelihood of a given outcome to familiar thermodynamic quantities. **Nonetheless, it has long been appreciated that developing a sound and general understanding of the thermodynamics of such non-equilibrium scenarios could ultimately enable us to control and imitate the marvellous successes that living things achieve in driven self-assembly.** Here, I suggest that such a theoretical understanding may at last be emerging, and trace its development from historic first steps to more recent discoveries. Focusing on these newer results, I propose that they imply a general thermodynamic mechanism for self-organization via dissipation of absorbed work that may be applicable in a broad class of driven many-body systems.

Hype?

Schrödinger's dream as distant as ever

Some Final Metaphysical Remarks



Most areas of reality are situated here

Science, in settling for “control” (instead of “exact prediction”), must (1) choose its targets of interest (2) shape its explanations in light of *human agency*

Concluding slogans

1. Reality is *amenable* to causal interpretation
2. But it does not *dictate* causal interpretation
3. Humans *choose* a causal interpretation

Thank you!