Current trends in philosophy of science

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Megatrends in PoS

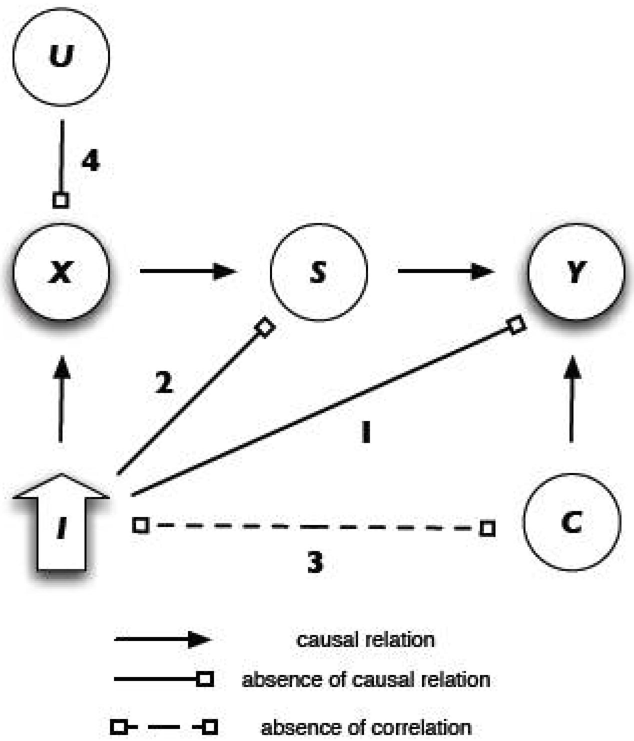
- Naturalism
  - Just say no to *a priori* philosophizing
  - Closer connection to practice
  - Argumentative resources from empirical sciences
  - Change in formal tools: from logical reconstructions to probability mathematics/statistics and computer simulation
- Philosophies of the special sciences
  - ”Global” philosophical problems and ”isms” less central
  - Questions closer to real methodological problems
  - → increasing specialization and fragmentation even within the philosophies of the special sciences
- Some buzzwords: model, mechanism, evidence

A solved philosophical problem: the concept of causality

- Causality and manipulability: G. H. von Wright, James Woodward, Judea Pearl
- *X causes Y, if we can bring about X by bringing about Y.*
  - This cannot be a reductive analysis of causation, because 'bringing about' is already a causal notion.
  - all proposed reductive analyses have failed, maybe we should be satisfied with a descriptive analysis
  - Goes nicely with the idea that controlled experiments are the best way to achieve causal knowledge.
- Woodward: causality as *invariance under interventions*
- a natural way to understand the difference between a *real causal relation and a mere correlation*

an ideal intervention

- *I changes the value of Y only via a* change in *X:*
- 1: *I does not change Y directly*
- 2: *I does not change the value of some causal intermediate S* between *X and Y except by* changing the value of *X*
- 3: *I is not correlated with some other variable C* that is a cause of Y
- 4: *I acts as a switch that* controls the value of *X irrespective of X's* other causes *U*

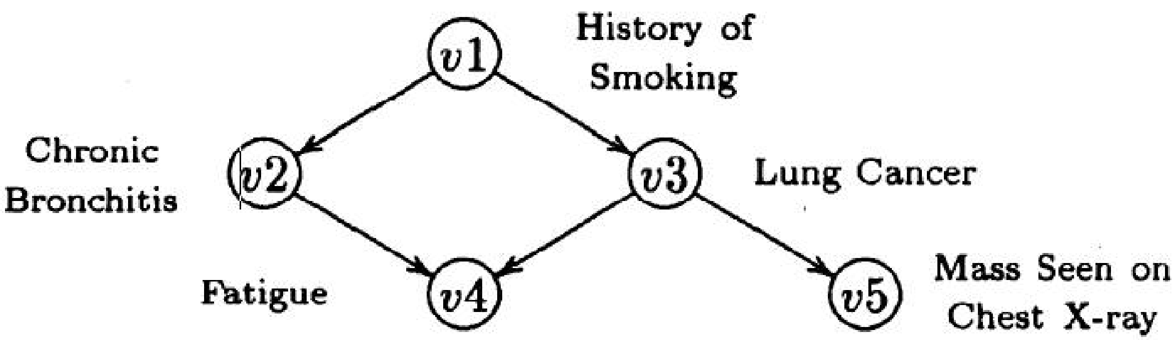


Why interventions?

- distinguish dependencies in the world from inferential dependencies
  - Observing vs. manipulating (E[X|Y = y'] not the same as E[X| Do(Y = y')])
- define causal order (asymmetry)
- disambiguate between different causal concepts
  - (contribution, net cause, condition vs. actual cause…)
- clarify cases of confounding and multiple causal pathways
- conceptual link to manipulation
- → An interdisciplinary (philosophy, statistics, computer science), formal theory of causality

Causal reasoning and inference

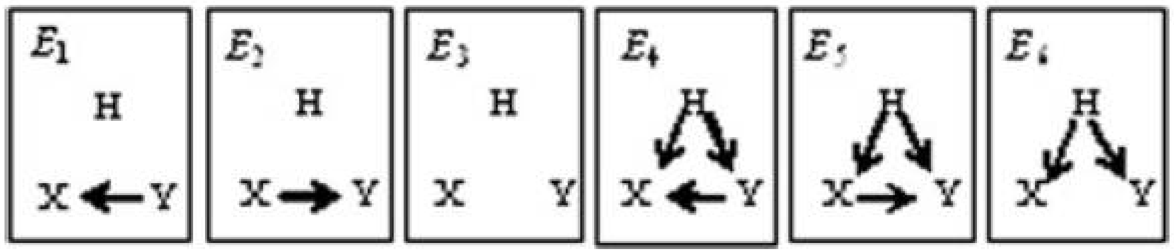
- Causal reasoning: deriving causal conclusions from a known causal structure
  - ($E[X|Y = y']$ not the same as $E[X| Do(Y = y')]$)!
  - Causal knowledge is required for predicting the consequences of exogenous interventions, regularities are enough for passive prediction.
- Causal inference: inferring the causal structure from (observational or experimental) data



Example: Causal Discovery as a Game

Eberhardt, F. (2008) Journal of Machine Learning Research 1

- The problem: How to select the optimal experiments?
- Intervention = randomized controlled trial
- Causal discovery as a (zero-sum) game between players *Scientist* and *Nature*.
  - Scientist's strategies: what (passive) observations or RCTs to perform and when to make a guess about the structure
  - Nature's strategies: select the true structure



Example: Causal Discovery as a Game

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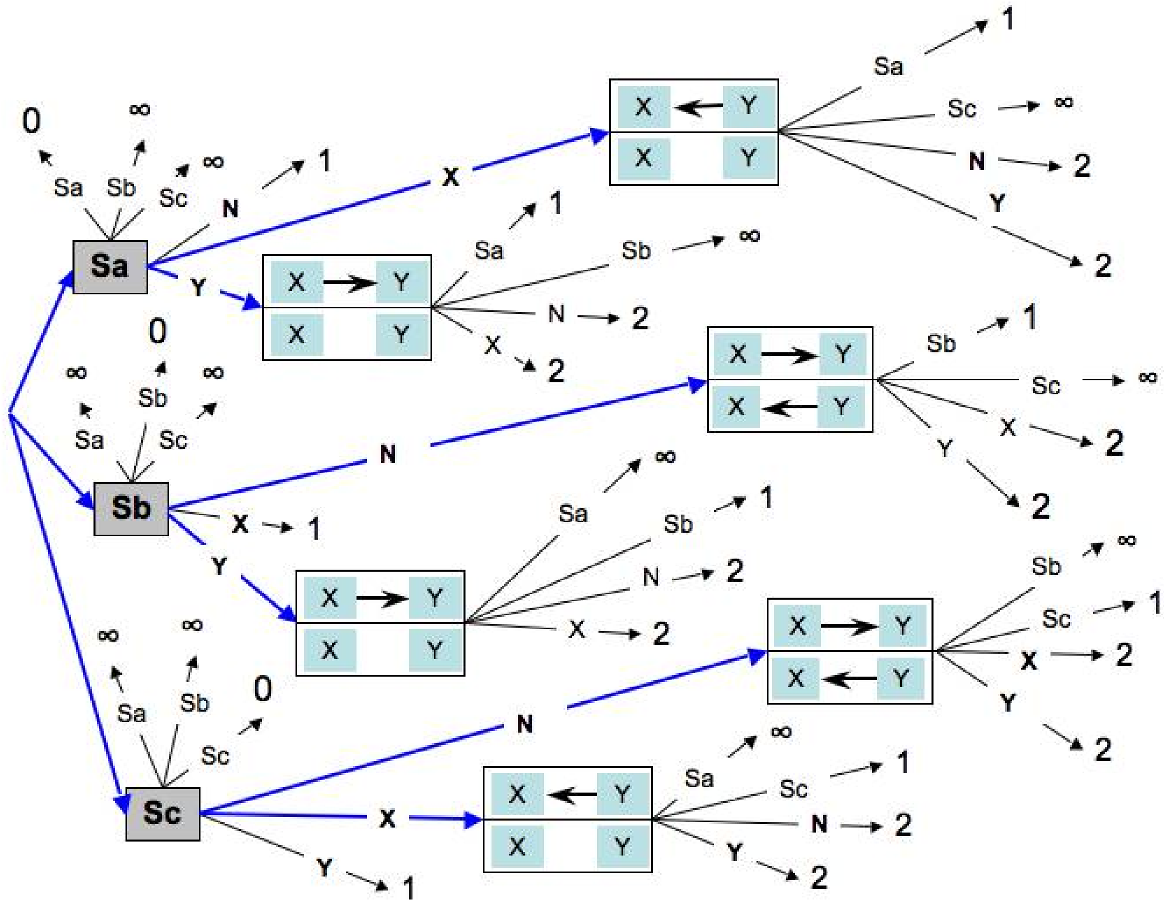
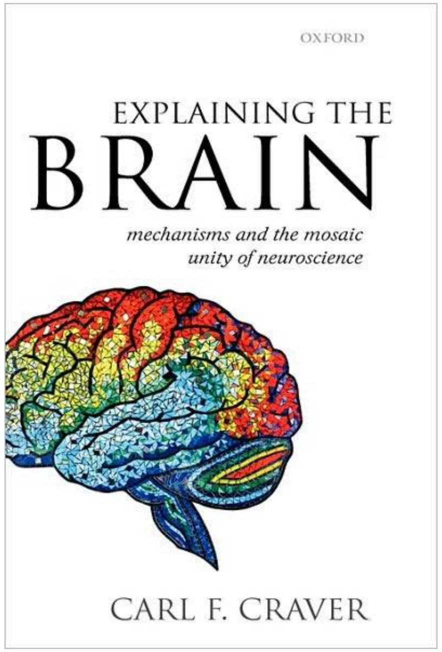
- Sa := X Y; Sb := X → Y and Sc := X ← Y:



From laws of nature to mechanisms

- Traditional nomothetic picture: sciences aim at uncovering universal, exceptionless regularities.
- Mechanism: a structure performing a function in virtue of its component parts, component operations, and their organization. The orchestrated functioning of the mechanism is responsible for one or more phenomena.
- Causation and explanation: explanatory relationships not ”natural laws”, but *invariances* realized by mechanisms
- Confirmation and evidence: from inductive logics to causal discovery algorithms, reductivist heuristics and mechanistic extrapolation
- Conceptualizing the unity of science: not deduction of special laws from more fundamental laws (classical reduction), but relating *levels of mechanisms*

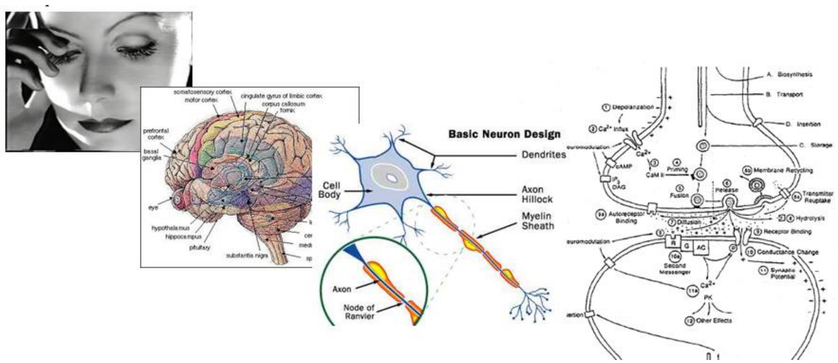
Mechanistic explanation



- Carl Craver: Explaining the Brain
  - Explanations describe mechanisms
  - Explanations are multi-level
  - Levels of mechanism
    - Levels are local, behaviour → mechanism → components
  - Intra-level, as well as inter-level integration of fields
    - research not always bottom-up or top-down
    - Evidential relevance as constraining the space of *plausible mechanisms*
    - Manilpulability as the criterion of explanatory relevance
    - *Mechanisms schemas* as the blueprint for the integration of scientific knowledge

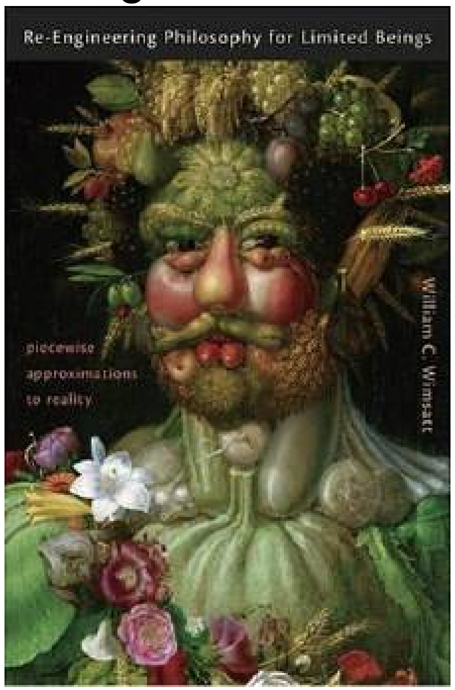
Mechanistic research programmes and reuctionistic heuristics

- Opening black boxes according to the heuristics of *functional decomposition and localization* (Bechtel and Richardson 2000)
  – phenomena that the system of interest exhibits are identified
  – phenomenon of interest is *functionally decomposed*
  – the system is *structurally decomposed*
  – *localization* of the component operations to appropriate structural component parts



Mechanistic research programmes and reuctionistic heuristics

- William Wimsatt: The point of "reductionism": make simplifying hypotheses in order to learn about the organization by finding out why simple hypotheses *fail*.
- Reductionistic biases:
  - Localization fallacies in conceptualization, modeling and testing
  - Functional localization fallacies
  - Interface determinism
  - ...



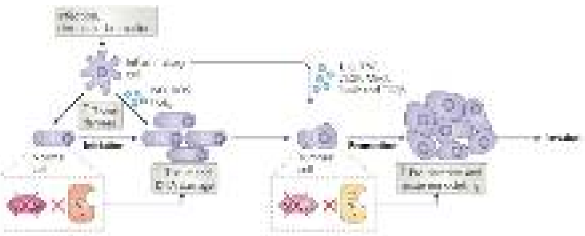
Emergence as a failure of aggregativity

- William Wimsatt: a property of a system is *aggregative with respect to* a decomposition to its parts and their properties, when its invariant with respect to
  - *Intersubstitution:* rearranging parts or interchanging parts with (relevantly) equivalent ones
  - *Size scaling:* addition or substraction of parts
  - *Decomposition and reaggregation:* decomposition and reaggregation of parts
  - *Linearity:* there are no cooperative or inhibitory interactions between the parts
- *Don't ask whether it is emergent, but how it is emergent!*
  - most things outside fundamental physics (properties subject to conservation laws) are emergent
  - learning about organization by exploring the limits of aggregation

Example: mechanistic extrapolation

Steel, Daniel (2008): Across the Boundaries: Extrapolation in Biology and Social Science, OUP

- The problem: *the extrapolator's circle:* how is it possible to establish the similarity of the model and target without already knowing what one wants to extrapolate?
- How to reduce the number of required comparisons:
  - background knowledge according to which causally relevant disanalogies are likely to be found at some stages of the mechanism and not others.
  - comparisons of model and target mechanisms will be more efficient if they focus on mechanism activities and components that are *downstream in the sense of being more direct causes of the outcome* → *"distinctive markers"*

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Literature

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