Lecture 3

Applications in Philosophy of Science

Motivation

- General goal: Make Bayesianism more realistic.
- Two observations about the practice of science

  1. Instruments are only partially reliable.

  2. Scientific theories are more complicated than textbook Bayesianism makes us think.
- Specific goals:

  1. Model confirmation with partially reliable instruments.

  2. Develop a Bayesian account of what a scientific theory is.

Overview

I. Lecture 1: Bayesian Networks
   1. Probability Theory
   2. Bayesian Networks
   3. Modeling Partially Reliable Information Sources

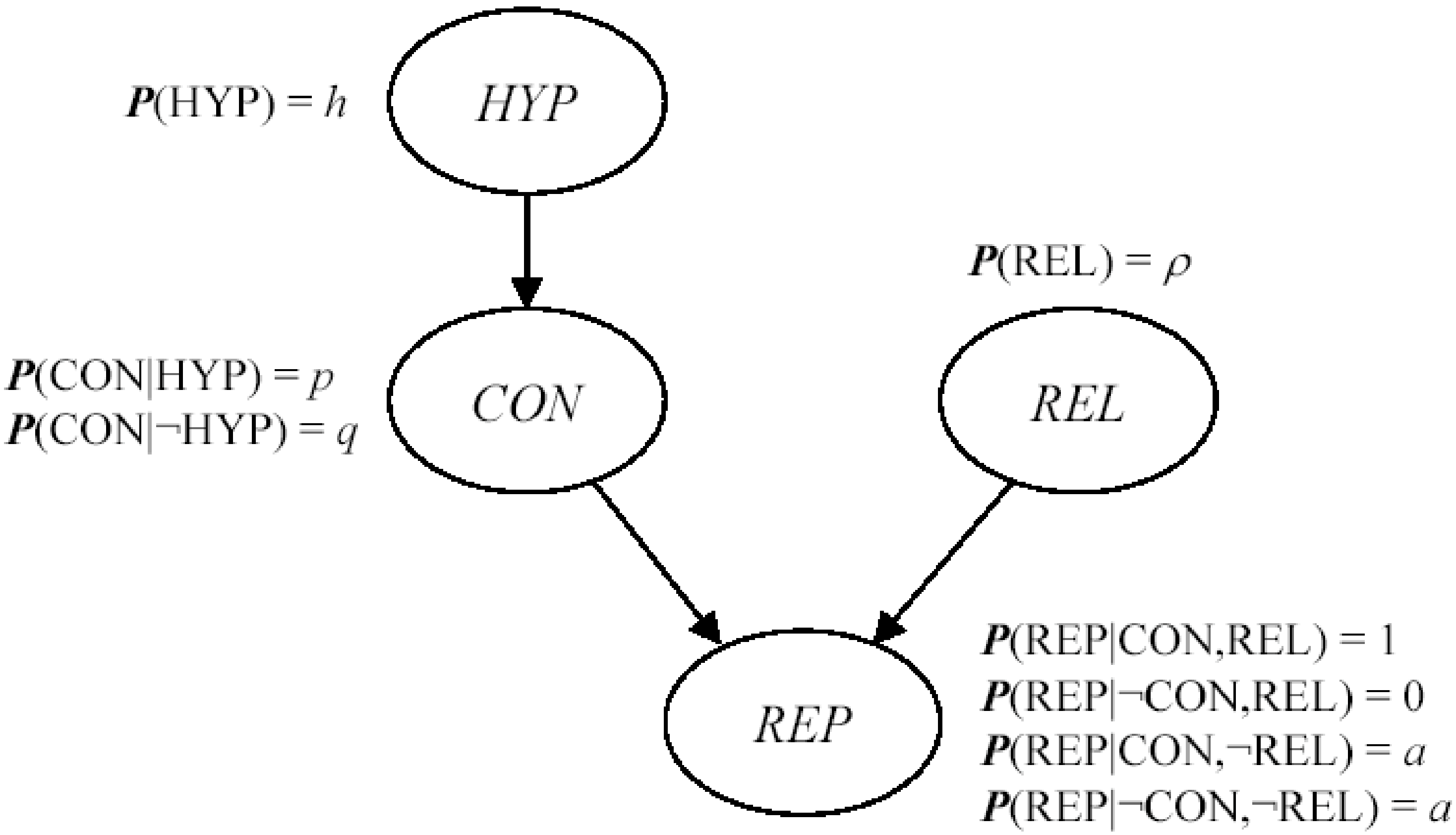
II. Lecture 2: Applications in Epistemology
   1. Is Coherence Truth-Conducive?
   2. How Can one Measure the Coherence of an Information Set?
   3. Open Problems

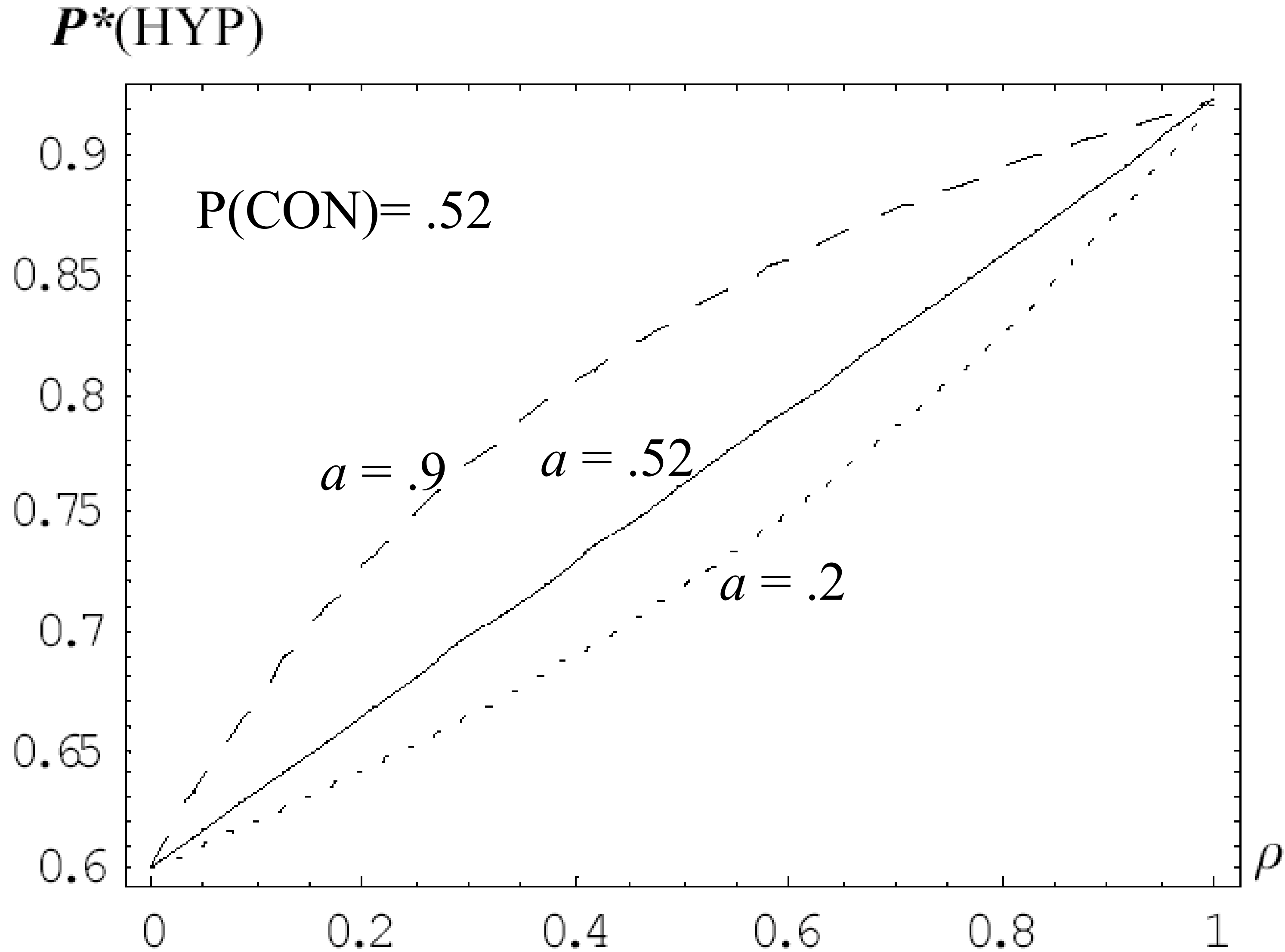
III. Lecture 3: Applications in Philosophy of Science
   1. Does the Variety-of-Evidence Thesis Hold?
   2. What Is a Scientific Theory?
   3. Open Problems

1. Does the Variety-of-Evidence Thesis Hold?

- Bayesian confirmation theory
  - test a hypothesis H
  - start with a prior probability of H: $P_{old}(H)$
  - evidence E is relevant for H: $P_{old}(H)$ □ $P_{new}(H)$
  - Bayesian updating: $P_{new}(H) = P_{old}(H|E)$

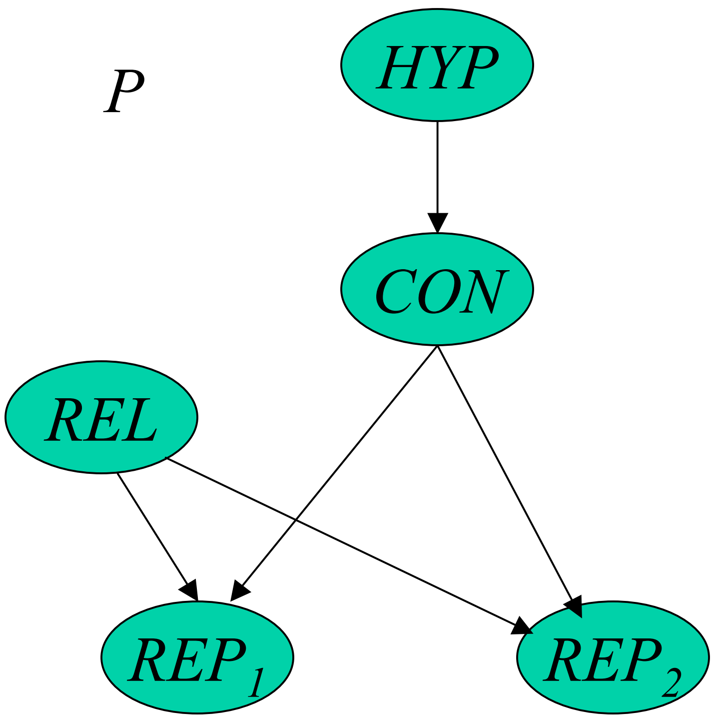
The Basic Model

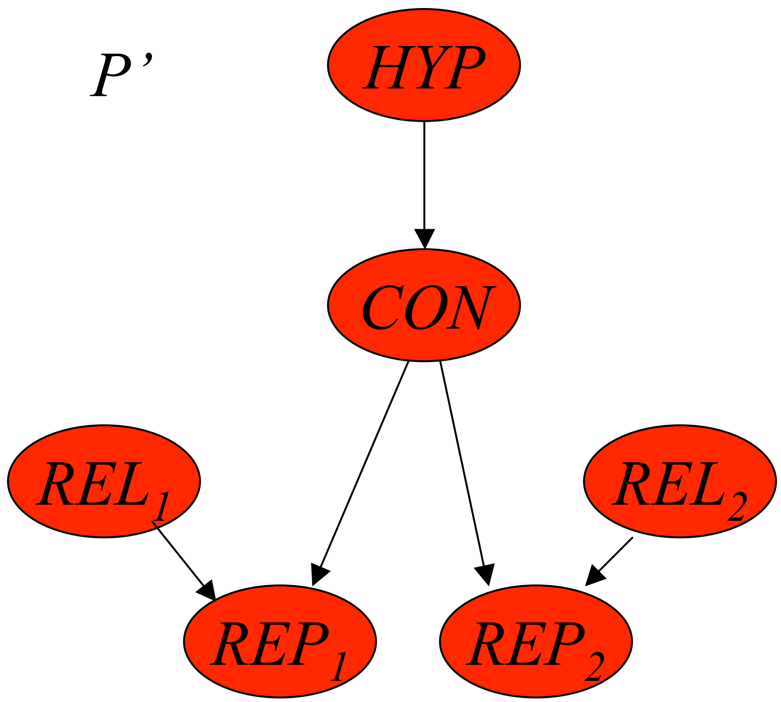




P*(HYP)
0.9
0.85
0.8
0.75
0.7
0.65
0.6
P(CON)= .52
a = .9
a = .52
a = .2
0
0.2
0.4
0.6
0.8
1
ρ

Single vs. Multiple Instruments



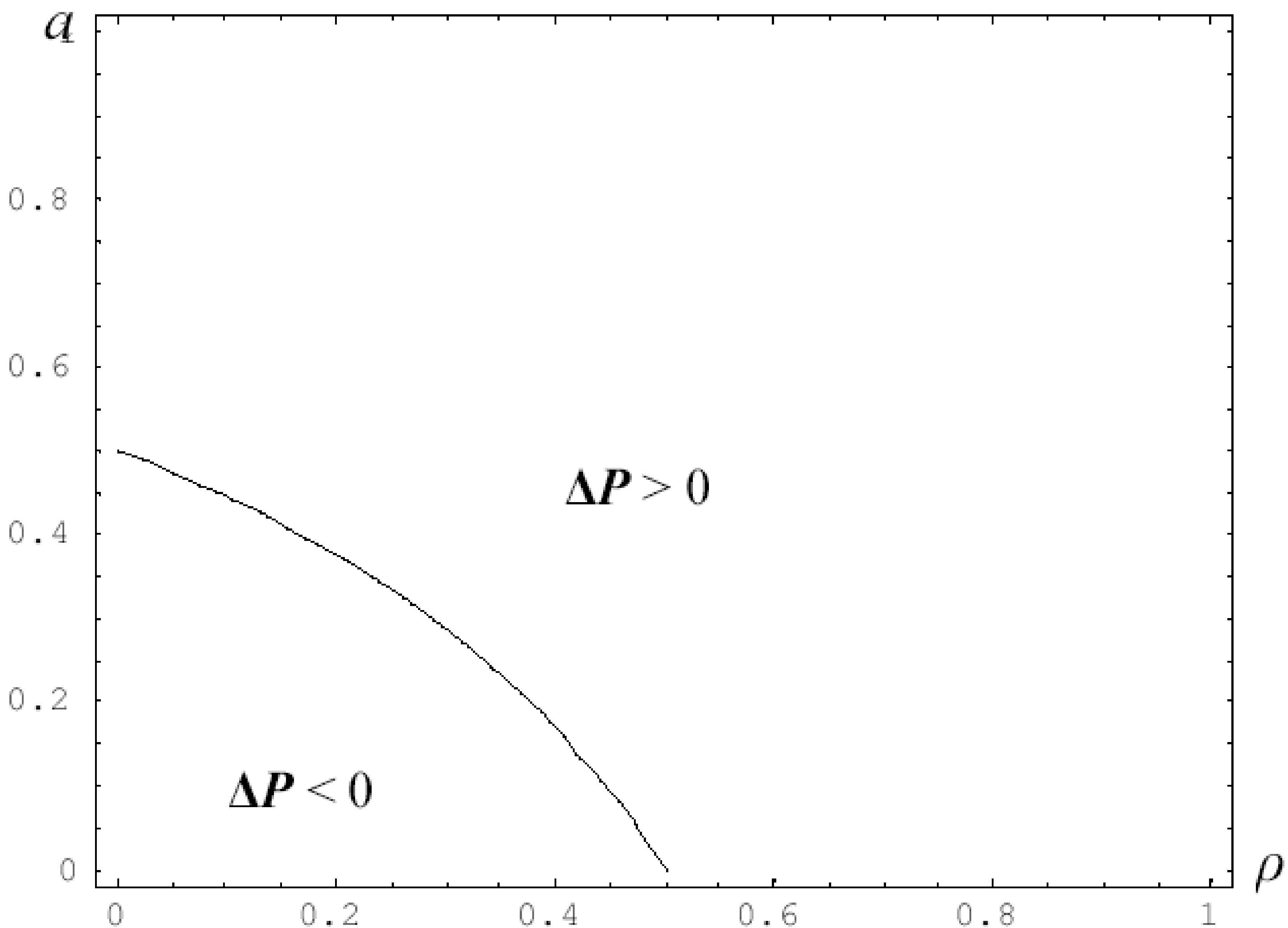


The Relative Strength of Confirmation

- Use the theory of Bayesian Networks to calculate the posterior probability for both cases!
- To find out which procedure is better, calculate the difference

  $\Delta P = P'(\mathrm{HYP}|\mathrm{REP}_1, \mathrm{REP}_2) - P(\mathrm{HYP}|\mathrm{REP}_1, \mathrm{REP}_2)$
- After some algebra, one obtains:

  $\Delta P > 0$ iff $1 - 2(1 - a)(1 - \alpha) > 0$



a
0.8
0.6
0.4
0.2
0
ΔP > 0
ΔP < 0
0
0.2
0.4
0.6
0.8
1
ρ

Interpretation

There are two conflicting considerations:

1. Independent test results from two instruments yield stronger confirmation than dependent test results from a single instrument.
2. Coherent test results obtained from a single instrument increase our confidence in the reliability of the instrument which increases the degree of confirmation of the hypothesis.

The *Variety-of-Evidence Thesis* Challenged

Under certain conditions, test results from a single test instrument provide greater confirmation than test results from multiple independent instruments.

2. What is a Scientific Theory?

- Textbook Bayesianism has no account of what a scientific theory is. That is a shortcoming.

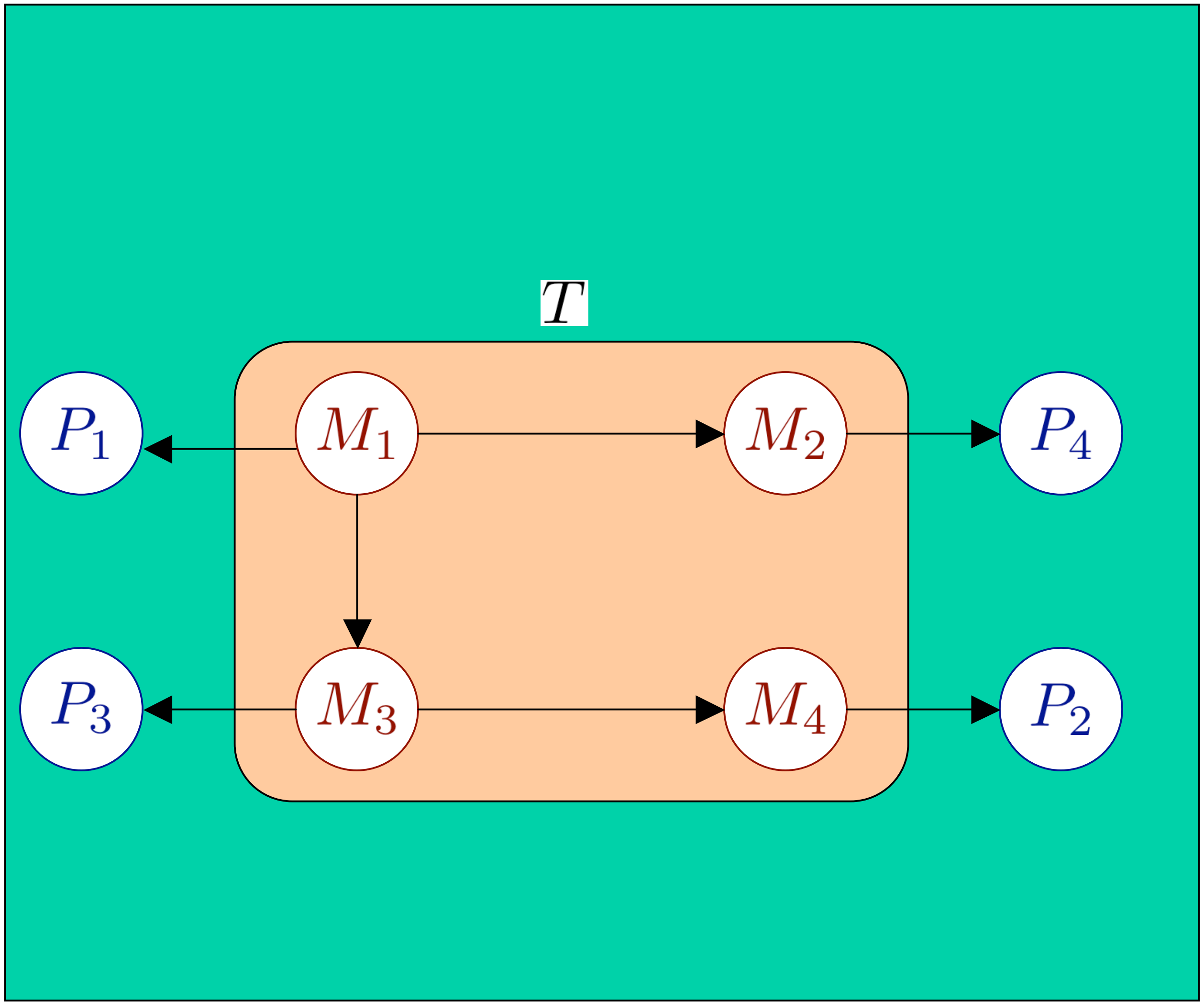
Formal Characterizations of Theories

- Syntactic view:
  - linguistic entities
  - sets of assumptions (and their consequences)
- Semantic view:
  - non-linguistic entities
  - realizations of an abstract formalism
- Probabilistic view:
  - theories are sets of models, and models are sets of interrelated of propositions

The Probabilistic View

- Theories are networks of interrelated models.
- Models (M_i) are conjunctions of propositions that account for a specific phenomenon P_i. One model for each phenomenon.
- There is a joint probability distribution over all propositional variables M_i, P_i.
- From this, the posterior probability of the theory (given the phenomena) can be obtained.

Representing Theories by Bayesian Networks



Taking Stock

- We used a Bayesian Network model to make plausible that the variety-of-evidence thesis is not sacrosanct.
- We provided an account of what a scientific theory is.

3. Open Problems

1. The Duhem-Quine Thesis: dependent auxillaries
2. Scientific theory choice

   - Which role does coherence play here? (Kuhn‘s internal consistency, cf. Salmon)

   - Can other criteria of theory choice be ‚Bayesianized‘?
3. Intertheory Relations

   - Come up with a general account of intertheory relations
4. Probabilistic explanations

Methodological Conclusions

- There are examples where probabilistic modeling can be used in philosophy.
- Models are always preliminary, they can be improved in various ways.
- Philosophers should be more open for new methods which can be imported from the sciences (methodological pluralism).

The Methodology (in a Nutshell)

1. **Problem Specification**: Formulate a philosophical problem in ordinary language.
2. **Model Construction**: Choose a modeling framework and make modeling assumptions which suit the problem at hand.
3. **Translation**: Translate the problem into a question which can be posed within the mathematical model.
4. **Deduction**: Obtain an answer to this question by deduction within the model.
5. **Back-Translation**: Translate this answer back in ordinary language.
6. **Interpretation**: Give a *model-independent* explanation of the results of the model.