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 $H$: $P_{\text{old}}(H)$
  - evidence $E$ is relevant for $H$: $P_{\text{old}}(H) \cap P_{\text{new}}(H)$
  - Bayesian updating: $P_{\text{new}}(H) = P_{\text{old}}(H|E)$
The Basic Model

\[ P(\text{HYP}) = h \]

\[ P(\text{CON}|\text{HYP}) = p \]
\[ P(\text{CON}|\neg\text{HYP}) = q \]

\[ P(\text{REP}|\text{CON},\text{REL}) = 1 \]
\[ P(\text{REP}|\neg\text{CON},\text{REL}) = 0 \]
\[ P(\text{REP}|\text{CON},\neg\text{REL}) = a \]
\[ P(\text{REP}|\neg\text{CON},\neg\text{REL}) = a \]

\[ P(\text{REL}) = \rho \]
$P^*(\text{HYP})$

$P(\text{CON}) = .52$

\(a = .9\) \(a = .52\) \(a = .2\)
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
  \[ P = P'(\text{HYP}|\text{REP}_1, \text{REP}_2) - P(\text{HYP}|\text{REP}_1, \text{REP}_2) \]
• After some algebra, one obtains:
  \[ P > 0 \text{ iff } 1 - 2(1 - a)(1 - b) > 0 \]
\[ \Delta P > 0 \]

\[ \Delta P < 0 \]
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.