



LogiCCC  
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# **Formal methods in the Philosophy of Science**

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# ESF initiative: The architecture of science



*Team A: Formal methods*

# Formal philosophy of science

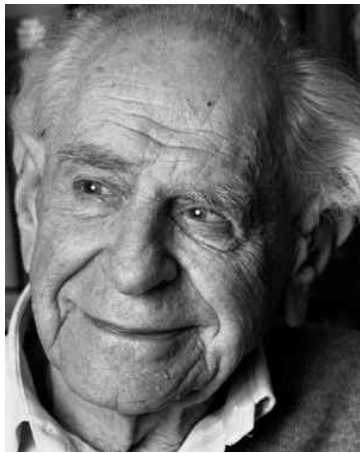
- 👉 Formal methods can clarify the practice of scientists and provide norms for good practice.
- 👉 Good-old logic is no longer the toolkit of choice for philosophers of science.
- 👉 Logic has seen major extensions and revisions in recent years.
- 👉 High time for bringing logic back to the scene.

# Outline of talk

- ❶ The demise of logical methods
- ❷ New methods: confirmation
- ❸ New methods: statistics
- ❹ New methods: uncertainty
- ❺ Logic meets philosophy, again

# ① The demise of logic

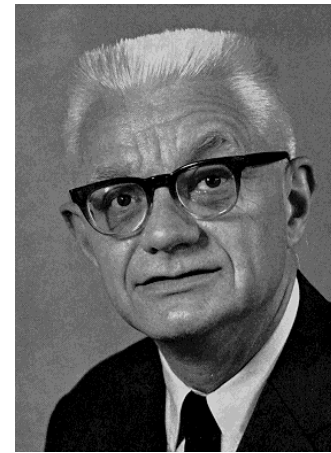
In early day philosophy of science, logical analysis played a key role, especially in confirmation theory.



*Popper*



*Carnap*



*Hempel*

1

## The poverty of syntax

The logical analysis ran into a number of paradoxes.



*grue paradox*



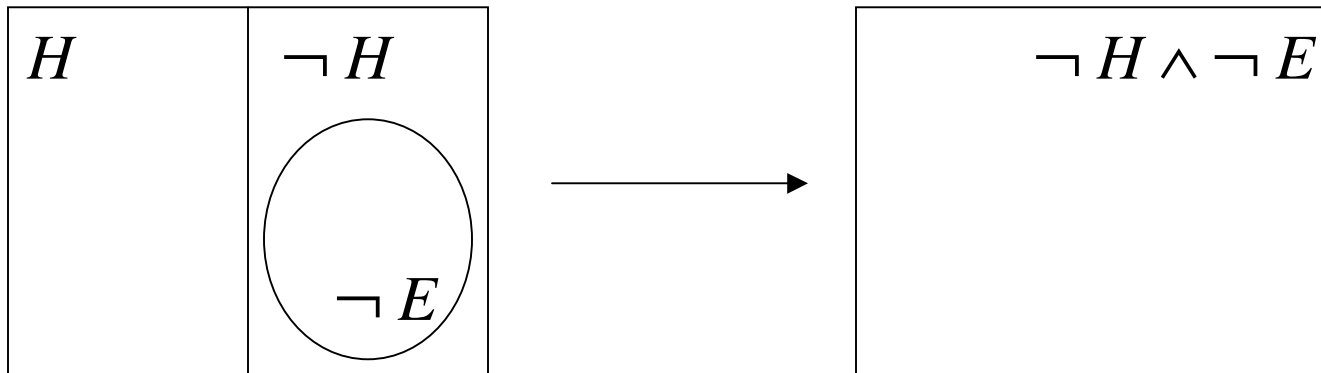
*raven paradox*

The bottom line was that traditional logic cannot cope with the complexity, or with the semantic aspects of scientific modeling.

## ② New methods: confirmation

Philosophers of science traditionally used classical deductive logic to capture confirmation.

$$H \rightarrow E, \quad \neg E \quad \therefore \neg H$$

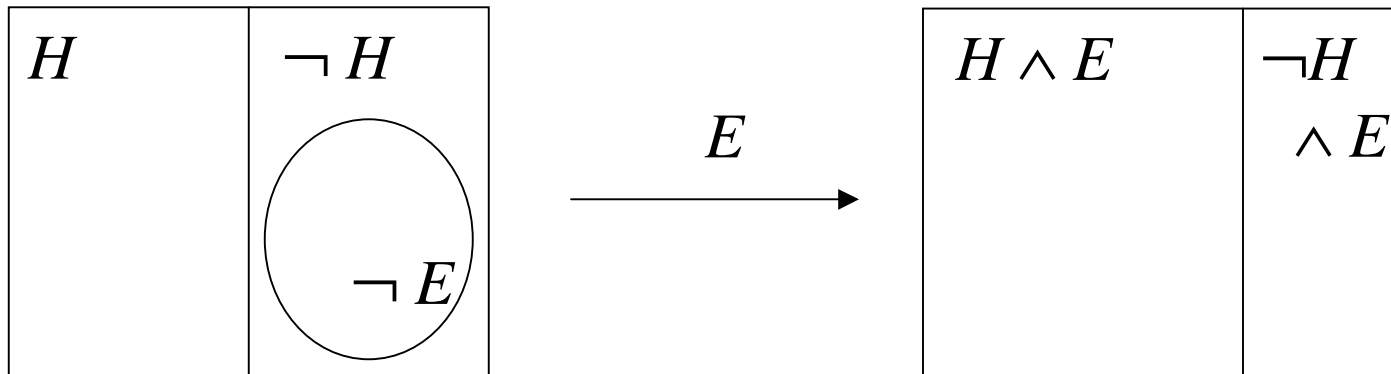


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# Bayesian confirmation

Instead of truth valuations, we can also use a probability measure over an algebra to express confirmation.



$$P(H) = P(\neg H)$$

$$P(E \mid \neg H) < P(E \mid H) = 1$$

$$P(H \mid E) > P(\neg H \mid E)$$



2

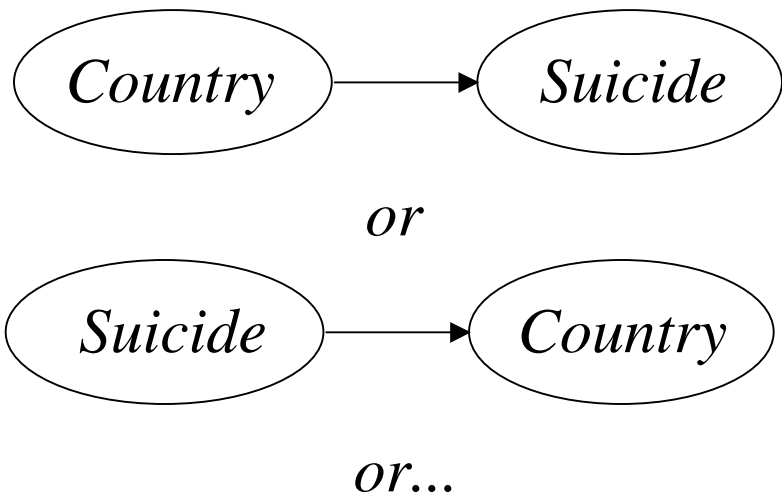
## Using new logics?

Confirmation theory can be improved in various ways:

- Scientific models often concern causal relations. Causal hypotheses invite different confirmations.
- Issues are sometimes decided by the scientific forum, by voting or by consensus formation.
- In many instances of confirmation, logical and probabilistic knowledge must be combined.

### ③ New methods: statistics

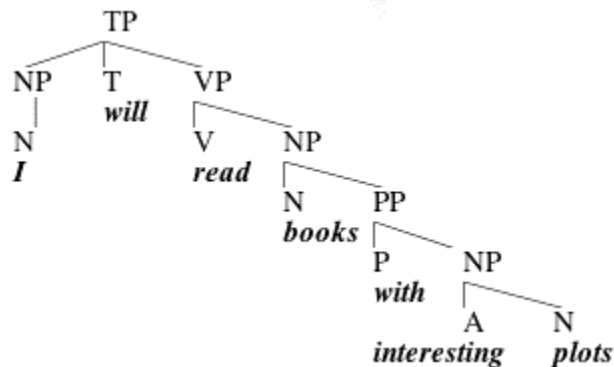
Causal networks and Bayesian methods are having increasing impact on statistics in the social sciences.



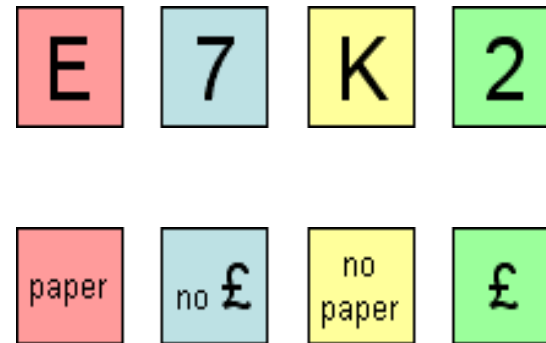
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## Integrating logic and statistics

Often we also have logical constraints on parameters and interactions in the statistical model. How can we integrate the two?



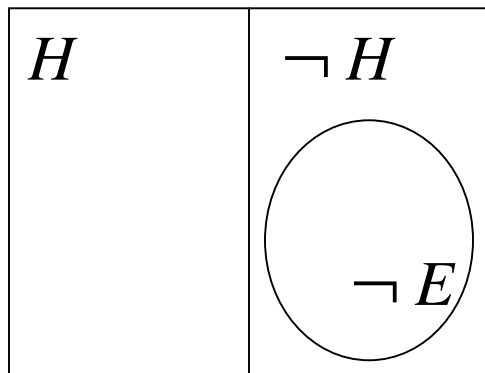
*linguistics*



*psychology*

## ④ New methods: uncertainty

Additive normed measures are not the only tool for representing epistemic uncertainty.



*uncertain evidential bearing:*

$$\frac{1}{4} < P(E \mid \neg H) < \frac{1}{2}$$

*uncertain about the evidence:*

$$P(E) > P(\neg E)$$

## Models of agents

Alternative representations of uncertainty can be used in methodology, but also in scientific modeling itself.

- The uncertainty of economic agents and psychological subjects are perhaps better represented with other measures than probability.
- Different representations of uncertainty might mesh better with new models of how agents interact, e.g., alternatives to decision and game theory.

## ⑤ Logic meets philosophy, again

- ☆ Logic can provide new tools for the philosophy of science.
- ☆ We must be careful to give priority to the sciences, not to what tools happen to be around.
- ☆ To convince scientists of new methods, we need a killer application.



# Thanks



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