Probability

PHI 152 Scientific Reasoning (Eliot)

Our last two readings ended with probability—oppositely!

Hempel (208)

“Far from generating a hypothesis that accounts for given empirical findings, such rules will presuppose that both the empirical data forming the “premises” of the “inductive argument” are *given*. The rules of induction would then state criteria for the soundness of the argument. According to some theories of induction, the rules would determine the strength of the support that the data lend the hypothesis, and they might express such support in terms of probabilities.”

Popper

“According to my view, the corroborability of theory … stand[s] in inverse ratio to its logical probability” (269)

Where did the idea of probability come from?

We normally invoke “probability” when we’re dealing with chance.

Many cultures — are there notable exceptions? — have understood the world apart from us as entirely governed by partially-hidden powers or wills. [gods, God, deities, spirits, laws of nature]

This doesn’t leave much room for chance, nor probability as we understand it. So, how did we get “probability”?

Example of early "probability": Aquinas

Aquinas[1] on justification

The first of these is the attaining of science by demonstration, which belongs to 'physics' (if physics be understood to comprise all demonstrative sciences). The second method is to arrive at an opinion through probable premises, and this belongs to 'dialectics.' The third method is to employ conjectures in order to induce a certain suspicion, or to persuade somewhat, and this belongs to 'rhetoric.'

[1] Thomas Aquinas (1225–1274) was a philosopher and Dominican friar

How can you learn about will?

Paracelsus[2] (1493–1541)

[Nature] indicates the age of a stag by the ends of his antlers and it indicates the influence of the stars by their names. Thus she made liverwort and kidneywort with leaves in the shape of the parts she can cure. [...] Do not the leaves of the thistle prickle like needles? Thanks to this sign the art of magic discovered that there is no better herb against internal prickling.

[2] born Philippus Aureolus Theophrastus Bombastus von Hohenheim

But what if nature's not telling?


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What makes a “chance setup” fair?

Chance setups have trials and outcomes:

trial
the selection of a member from a population

[tosses, spins, draws, samples]

outcome
one of a definite set of possible results of a trial

- coins: heads/tails
- dice: 1,2,3,4,5,6
- roulette wheel: 38 segments

Let’s define “bias” in terms of “chance setup”

“A chance setup is **unbiased** if and only if the relative frequency in the long run of each outcome is equal to that of any other.” (25)

You can define “bias” *mutatis mutandis*.

(But what do “relative frequency” and “long run” mean?)

But lack of bias is not all there is to fairness!

Why?

But lack of bias is not all there is to fairness!

Why?

> *Lack of bias in the system does **not** guarantee that a chance setup is fair. We need more than that. The idea of a fair tossing device seems to involve there being **no regularity** in the outcomes. Or they should be **random**. Randomness is a very hard idea. Outcomes from a chance setup are random (we think) if outcomes are not **influenced** by the outcomes of previous trials. (25)*

We need independence. Trials are **independent** if and only if the probabilities of the outcomes of a trial are not influenced by the outcomes of previous trials. (26)

What's independence?

Independence can be conceptualized as involving:

randomness no influence from previous trials

no regularity no memory of previous trials

complexity impossibility of a gambling system

Fairness, again

So, a chance setup is **fair** if and only if:

- It is **unbiased**, and
- outcomes are **independent** of each other.

So, three ways of being unfair

- biased and independent
- unbiased and dependent
- biased and dependent

The gambler's fallacy

1. This a fair chance setup.
2. One outcome has just happened repeatedly.
3. So, I should expect a different outcome next.

The conclusion follows from the premises only if outcomes from the setup are not independent. But premise 1 says outcomes *are* independent. (Invalid.)

propositions	true or false (for logic)
events	occur or don't occur (for statistics)

Logical notation

disjunction

$A \vee B$ = A or B or both; "inclusive or"

conjunction

$A \& B$ = A and B

negation

$\sim A$ = it is not the case that A or "not A"

Set notation

These are not exactly the same concepts, but related:

union

$A \cup B$ = the union of sets A and B

intersection

$A \cap B$ = the intersection of sets A and B

complement

A' = the complement of a set A

$Pr(A)$ or $P(A)$ is the probability of A.

N can be an expression in proposition language or event language.

Probabilities lie between 0 and 1, inclusive

For any A, ($0 \leq Pr(A) \leq 1$)

A basic strategy for probability thinking is:

1. create simple and artificial models using probability expressions
2. compare the models to real situations
3. explore whether differences between model and real situations are due to
    - problems in the model, or
    - drawing wrong conclusions from the model.