There is No Such Thing as Statistical Explanation (of individual outcomes by probability ascriptions)

1. Introduction

Definition of statistical explanation (SE): a putative explanation in which the occurrence of an individual outcome (or their collection) is explained by the ascription of a probability *p* to the outcome/collection (p between 0 and 1).

Schema,

(1) Events of kind K have probability p of occurring.

(2) e is an event of kind K.

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(3) e occurs.

(1)-(2), if true, explains (3).

Example:

(1) All radium atoms have a probability p of decay within time interval dt.

(2) a is a radium atom

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(3) a decayed within time interval dt.

A division in the literature: in order to be a successful explanation, must the probability p be “high”?

Elitist: Yes

Egalitarian: No, low values for p also explain (e.g., Clatterbuck 2020)

Other versions:

1. SEs that assign high probabilities provide *better* explanations (e.g., Strevens 2002)
2. In order to be a successful explanation, a SE must render e *more probable than* some or all alternative outcomes (see Sober 2020)
3. In order to be a successful explanation, a SE must cite a factor that *increases* the probability of e substantially wrt some baseline

Woodward will argue that there are no such things as SE (understood as the schema) of *any* form. Instead, probabilistic theories (such as quantum mechanics) are explanatory, but they explain *the probabilities of outcomes*, rather than the occurrences of individual outcomes themselves.

A weird quote: “quantum mechanics explains the probabilities of radioactive decay and similar phenomena by assigning these a probability but not individual decay events. Information about the composition of a coin and the circumstances of its tossing can explain why it has probability p of landing heads (see Keller, 1986, also Engel, 1992 for the case of a fair coin) but this fact about probability does not explain why the coin lands heads on a particular toss, and this is so whether p is high or low.” Similarly, frequencies are not explained.

[C: is there any differences between individual outcomes and frequencies?]

2. Motivation

1. Criteria for successful explanation: provide grounds for expecting that an explanandum will obtain? show the extent to which an explanandum is expectable? Or, as Woodward himself thinks, exhibit dependency relations between explanans and explanandum and successfully answering of what-if-things-had-been-different questions? The most natural understanding of the last view will lead to rejection of SE, or Woodward will argue so.

Can the same explanatory factor E explain both the explanandum M and the alternative explanandum not M? (discussed in Salmon 1984). W: NO.

2. Is there anything in scientific practice that requires the supposition of SE? Do we need a notion of SE to evaluate the explanatory power of various statistical theories? W: NO.

[deterministic vs indeterministic explanation]

3. IBE: use IBE-like assumptions to argue for SE.

EX→ EV: if h is the best explanation for e, then e is evidence for h. (2.3.1a)

EV→ EX: if e is evidence for h, then h is the best explanation for e. (2.3.1b)

(IBE): suppose that if h were true it would provide the best explanation of e (comparatively), where e is known to known to obtain. Then we may infer h is true/well-confirmed/supported by e.

Coin example: E=700 heads in 1000 tosses is evidence for H=0.7 bias toward heads. From EV, we get to EX (even if Pr(E|H) is small). If frequencies can be explained with a low probability, why can't individual outcomes? Favor egalitarianism.

[Does Woodward understand IBE adequately?]

Pro-elitist: one toss. E1=heads is evidence for H, while E2=tails is evidence against H. From EV, w get to EX, H explains E1. Given the EX→ EV link, H does not explain E2.

Woodward: both EX→EV and EV-EX are mistaken, as well as the general IBE thought.

1) Classical statistics and Bayesian treatment of evidential support need not be understood as tying evidence to explanations.

2) Whether the probabilities ascribed by a hypothesis are high or low does not matter in itself for the acceptability of that theory. All that matters is whether those probabilities are objectively correct. Such assessments of correctness do not require assumptions about the extent of SE.

4. Although some accounts of explanations fit well with IBE (such as DN explanation and HD confirmation, or likelihood as a measure of evidential support and also of explanatory power), the account of explanation as the exhibition of dependency relations does not. Here, providing evidence for the truth of a candidate explanation is subject to different requirements from showing that those assumptions if correct would successfully explain (i.e., its potential explanatoriness).

Another consideration: evidential support is discriminatory, but potential explanatoriness is not. Also, we can have evidential support without explanation (mathematical laws, the readings of several thermometers in relation to the reliability of my thermometer)

[Yifan's complain: explanation constraints confirmation in meaningful ways. Example: our observations does not confirm the grue hypothesis, because the grue hypothesis does not constitute a good explanation for our observations]

5. Distinctions among forms of explanation:

SE understood as above vs. singular causal explanations in which the outcome explained has probability of occurrence less than 1, given the cited cause.

Example: Jones' paresis E is explained by his untreated syphilis S but in which only a minority of those with S develop E. This is not an example of SE, because the explanatory factor is a cause that operates probabilistically, not a probability in itself.

3. More Background Assumptions

1. If there is such a thing as SE, the probabilities must be "objective" and "physical".
2. the objective probabilities obey the usual axioms of probabilities theory. Probabilities cannot be identified with frequencies, but information about frequencies can be evidence for claims about probabilities.
3. Woodward will not ascribe to these objective probabilities some features ascribed to "chance". This is because he wants to reject SE, while several recent accounts have built into the notion of chance the role of "explaining" outcomes/frequencies.

An interesting footnote:

[9] To my mind, this is roughly like saying that we postulate the existence of the natural numbers in order to explain facts about the size of flocks of sheep, that we postulate the real numbers to explain facts about scalar quantities like mass, the existence of vectors to explain facts about electromagnetic fields and so on. Probabilities, real numbers, vectors and so on are parts of a general mathematical technology that we have available in formulating scientific theories but we don't postulate their existence to explain things in the way that, e.g., Pauli postulated the existence of the neutrino to save energy conservation in beta decay.

Another footnote, on the distinctiveness of causal claims and probabilistic claims:

> For Pearl (and for me) causal notions should be understood in terms of responses to interventions-- this is not something that can be defined in terms of statistical relationships.

4. If one believes in SE, can outcomes be explained when they have probability 0? [I THINK THEY SHOULD SAY YES]
5. Assume that objective probabilities be ascribed to systems that are deterministic at some level of analysis, such as coin tosses, roulette wheels and so on. (This is W's own view too)

6. The role of probability: describes the relationship between the explanans and the explanandum, or is itself an explanatory factor (power? propensities? Quasi-causal)?
7. An account of explanation should be judged not only by whether it fit our judgments about particular cases, but it should also make it clear why the discovery of explanations is a valuable goal in science.

4. Some examples and their consequences

Describe a quantum mechanics example.

EX2: the explanandum is the probability that a particle of mass *m* with kinetic energy *E* will penetrate a square potential barrier of width $2a$. The potential is V(x) within the barrier and 0 outside of it. The explanans includes the Schrodinger equation (as a law) and information about the potential barrier and the kinetic energy of particle as initial and boundary conditions. Solving the Schrodinger equation for this system, leads, after considerable calculation, to an explicit expression for the approximate probability of transmission through the barrier in terms of E, V and L.

This explanations meets the w-criterion:

The explanans identifies conditions such that variations or changes in those conditions would have led to a change in the explanandum. For example, the derivation enables us to see how the probability of barrier penetration would have been different had the the potential been different or had the the kinetic energy of the particle been different.

A more general description of the w-criterion: the explanandum is a claim that some variable E takes a particular value-e. Then satisfaction of the w-condition criterion requires that there be a set of true counterfactuals connecting variations in the value of E with variations in the variables cited in the explanans X. In other words, the requirement is that there be true counterfactuals of the form:

(**W**) If X had been different in such and such a way, (e.g., X= x1 rather than x2) the value of E would have been different.

OUR OWN DISCUSSION:

Distinguish between:

1) C causes E.

2) C is deterministic cause of E iff an intervention on C will change the value of E.

3) C is probabilistic cause of E iff an intervention on C will change the pd of E.

Example 1:

smoking causes lung cancer

smoking causes **the probability of lung cancer**.

Further distinction:

1. C is a probabilistic cause of E.

2. C is a (deterministic) cause of the probability of E.

1) If C were been ~c than c, then e would not occur.

2) If C were been ~c than c, then the probability distribution of E would been different.

3) If the probability distribution of E would been different, then e would not occur.

Example 2 (Yichen):

The cause variable: the energy of the quantum state of the particle

The effect variable: the probability distribution of the position of a given particle

(Weixin: do type level causes satisfy the w-criterion? Example: if C (the number of cigarettes consumed by US people daily) had been c1 rather than c2, then the value of E (the occurrence of lung cancer within 50 years by Jones) would have been e1 rather than e2.

By contrast, SEs do not satisfy the w-condition or cite dependency relations. R= Some radium atom a has a probability p of decaying in some time interval is not information about what the occurence of the decay depends on or what made a difference to the decay. R does convey information about a pattern in the behavior of radium atoms and perhaps invites us to see the decay of atom a as an “instance” of that pattern, but this is different from identifying a factor which made a difference for whether the decay occurred or on which the decay depends.

In particular, there are no true counterfactuals of either of the following forms :
4.1 If the probability of decay had been different from p, decay would not have occurred.
4.2 If the probability of decay had been different from p, decay would have occurred.

Because even a very high value for p does not ensure that decay will occur and even a very low value for p does not ensure that decay will not occur.

On the dependency account of explanation, we can explain why sth is possible by identifying conditions that make a difference for whether it is possible. But here the explanandum is the fact that sth is possible, rather than the occurrence of the outcome. And the idea that the fact that sth is possible (because it has a non-zero probability, under a non-standard interpretation of probability) explains why that thing occurs is problematic and endorsed by no one.

What if you think SEs work by providing information about what the explananda depend on? For example, you might interpret probabilities as quasi-causal entities/powers/forces that contribute to the occurrence of the outcomes to which they are attached. However, the problem remains that what varies with different values of p are the degrees of probabilification, rather than the target explanandum E.

In general, W thinks we should conclude that there is a real difficulty with fitting explanations of SE schema into an overall framework of explanation as exhibiting dependency relations.

5. Singular causal explanations

Scriven 1959, Jones has paresis e and this condition is caused by untreated syphilis s.

It has seemed to many that 1) This shows that there must be such a thing as statistical explanation of individual outcomes. 2) This shows that SEs need not conform to a high probability requirement.

The explanation is:

(5.1) Jones' untreated syphilis caused his paresis.

In W's view, 5.1 is a genuine explanation in a dependency account, because assuming the only cause of paresis is untreated syphilis, the following counterfactual is true:

(5.2) "If Jones had not suffered from untreated syphilis, he would not have developed paresis."

(5.2) does convey information about the conditions under which the explanandum phenomenon would have been different. So the w-condition requirement is satisfied.

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Note also that (5.1) has a straightforward interventionist explanation. But the notion of **intervening directly on a probability** (a probability distribution) does not have a straightforward interpretation. Of course one can change other variables, such as treating his syphilis, but this is not an intervention directly on p. [I DISAGREE WITH THIS]. Moreover, even if dir**ect interventions on probabilities** are possible, most of those interventions would not change individual outcomes in any s**ystemat**ic way. [ALSO DISAGREE].

6. Are Non-dependency accounts of explanation defensible?

If SE does not fit well with a dependency framework, why not just understand them in terms of some alternative frameworks? Perhaps SEs are a *sui generis* form of explanation.

Unconvincing for several reasons:

1. if there are a number of acceptable theories of explanation with different different and inconsistent implications for the evaluation of various examples, as the pluralist maintains, this threatens to undermine any principled basis for the assessment of the explanatory credentials of different hypotheses, which we've been assuming is one of the goals of an account of explanation.

Particularly pressing for supporters of IBE.

2. The kind of pluralism threatens to trivialize the whole discussion around SE. Presumably it is not satisfactory to merely stipulate that such and such counts as an explanation and then "argue" that SEs are explanatory in virtue of satisfying this condition, but how exactly is this to be avoided under strong forms of pluralism?