Lecture 2: Philosophy of Science

What is this thing called science?

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07 October 2021

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Philosophy of Science

The title of this course is "Psychology as a Science".

- But what is this thing called "Science"?
- Is it a special way of learning about the world?
- And if it is then what makes it special?

The common-sense view of science

The common-sense view might go something like this:

> Science is special because it is knowledge based on facts

Science is often contrasted with other forms of knowledge that might be

- based on authority (e.g., celebrities, religious and political leaders)
- revelation (e.g., personal religious or spiritual experiences)
- superstition (e.g., "knowledge of the ancients")

But this raises two questions:

1. If science is based on facts, then where do "facts" come from?
2. And how is knowledge then derived from these facts

Where do facts come from?

The common-sense view of science was formalised by two schools of thought: The *empiricists* and the *positivists*

Together they held a view that went something like this:

> *Knowledge should be derived from the facts of experience*

We can break this idea down:

1. Careful and unbiased observers can directly access facts through the senses/observation.

2. Facts come before and are independent of, theories.

3. Facts form a firm and reliable base for scientific knowledge.

But is this true?

Facts through the senses

A simple story of a how the senses work is that there are some external physical causes (light, sound waves etc.) that produce some physical changes in our sense organs (e.g., our eyes) that are then registered by the brain.

This account implies direct and unmediated access to the world through our senses. But is this actually the case?

- This image could be seen as an old woman or a young woman. Some of you might see one and not the other while some might see both and switch between them.
- The physical causes (the light hitting our eyes) is more-or-less the same for everyone, but you might "see" different things

Observation is not "theory-free"

The previous example is just a toy example, but it reveals a larger point:

Two scientists might "observe" something different even when looking at the same thing.
In some fields, being able to make "observations" actually requires training.

1. Training in how to observe stuff through a microscope
2. Training in how to distinguish different kinds of behaviour
3. Training in how to read an x-ray etc

So a simple claim that observations are "unbiased" or "straightforwardly given by the senses" seems to be false.

But what do we even mean by "facts"?

When we think of a "fact" there are two things we could mean

1. "Fact" could refer to some external state of the world
2. Or statements about those external states

The fact that this university is in East Sussex could refer to this actual university and its actual being in East Sussex

or it could refer to the statement: "This university is in East Sussex."

When we talk about "facts" as the basis for science, we're talking about these statements.

We'll call this type of fact an "observation statement."

Do facts come before theories?

Think of a child learning the word apple:

> They might initially imitate the word "apple" when shown an apple by their parent.
>
> Next, they might use the word "apple" when pointing to apples
>
> But then one day they might see a tennis ball and say "apple". The parent would then correct them, and show them that a tennis ball isn't an apple because you can't, for example, bite into it like an apple
>
> By the time the child can make accurate "observation statements" about the presence of apples they might already know a lot about the properties of apples (have an extensive "theory of apples")

The same goes for scientists; formulating observation statements might require substantial background knowledge or a conceptual framework to place them in.

So observation statements aren't completely independent of theory

Not just facts, but relevant facts

Let's say that we've been able to acquire some facts. Will any old facts do?

Let's take a simple example:

> You observe that grass grows longer among the cowpats in a field.
>
> - You think this is because the dung traps moisture that helps the grass grow.
> - Your friend thinks this is because the dung acts as a fertiliser

Observations alone can't distinguish these. To tell which is correct you need to intervene on the situation.

For example, grind up the dung so that it still fertilises the ground or use something else to trap the moisture.

Intervening, for example, through experiment allows you to tell what the *relevant facts* of your observation are

Active observation and intervention

By intervening on the system, we can tell which facts are relevant

But *scientific theories* may play a part in helping to determine what is and isn't relevant

> Example from the history of *cognitive psychology*
>
> In certain kinds of reading tasks psychologists thought it was relevant that people made errors, but they didn't think the exact nature of the errors was relevant.
>
> But after certain kinds of theories were developed (ones based on neural network models) they came to realise that the particular kinds of errors (e.g., if people swapped letters between words) was relevant.

In short, observations can't be completely divorced from theories.

And experiments will presume the truth of certain theories (e.g., brain imaging experiments assume the validity of certain theories about brain function).

"Objectivity"

> Fact's don't care about your feelings
>
> — *Guy on the internet*

The idea that science is objective in a *simple sense* of "objectivity" is misleading.

Your conceptual framework, and theoretical assumptions, and even your knowledge and training can play a part in *what kinds of observations* you can make or *what types of observation statements you can formulate*

"Objectivity" doesn't mean observations free from theoretical assumptions ("the view from nowhere")

"Objectivity" is more complex

"Objectivity" does mean

- Publicly and independently verifiable methods
- Recognising theoretical assumptions
- Theory/data that are open to revision and improvement
- Free from avoidable forms of bias (confounds, cherry picking data, experimenter bias)

It is also objective in the sense that despite all this, when you make the observations either the behaviour will happen or it won't, the detector will flash or it won't etc. *Your theory can't make things happen*.

Deriving theories from facts

The second part of the common-sense view of science is that scientific knowledge is derived from facts.

Usually this idea of derived means something like logically derived. We might sum up the view like this:

> Science = Facts + Logic
>
> — *Guy on the internet*

To understand what it might mean to logically derive scientific knowledge we need to know a bit about logic

Deductive logic

A deductive argument is called valid if the conclusions follow from the premises.

Example 1

1. All research methods lectures are boring
2. This is a research methods lecture
3. (Therefore) this lecture is boring

In this example, if we accept that (1) and (2) are true, then we have to accept (3) as true. We cannot accept (1) and (2) as true and then deny that (3) is true because we would be contradicting ourselves.

Example 2

1. Most research methods lectures are boring
2. This is a research methods lecture
3. (Therefore) this lecture is boring

In our new example, we can accept (1) and (2) as true without accepting (3) as true. That is, (3) does not necessarily follow from (1) and (2). It might just be a case of a research methods lecture that isn't boring.

Deduction was only concerned with whether (3) follows from (1) and (2). Not concerned with determining whether (1) and (2) are true or false. The argument assumes that (1) and (2) *are* true, but it doesn't establish truth

False but valid

Example 3

1. All pigs can fly
2. Percy is a pig
3. (Therefore) Percy can fly.

The conclusion is valid. However, it is also false because (1) is false.

It is valid because if we accept (1) and (2) we can have to accept (3)

logic only tells us what follows from what. If there is truth in our premises, then there is truth in our conclusions.

If our premises are false, then our conclusions will also be false.

Deductive logic is truth-preserving, but it can't tell us what is true and what is false. And the conclusion is just a *re-statement of the information contained in the premises*

So deductive logic can't create new knowledge. What can you do instead?

We need a way to go from particular observations to generalizations (this process is called induction)

Induction

We need a way to construct arguments of the following form:

Premises

1. Emily the swan is white
2. Kevin the swan is white
3. ... the swan is white

Conclusion

All swans are white

But the problem with arguments like this is that *all the premises may be true and yet the conclusion can be false*

Maybe we just haven't observed the one swan that isn't white?

Collecting observations

But surely there are good and bad inductive arguments?

- More observations better than fewer observations—*but how many is enough?*
- Observations in many different contexts—*but what makes a context different and what makes differences relevant?*
  - Different contexts should be novel in some sense
  - That is, it should not just be trivial changes
- No contradicting observations—*but what about probabilistic phenomena*?

Clear and simple rules aren't easy to come by.

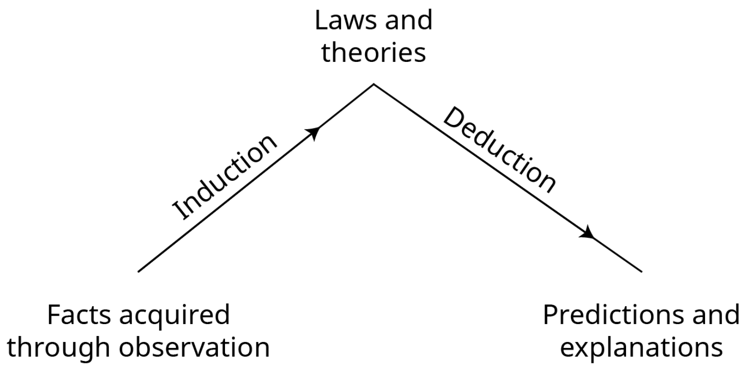
But the bigger problem is induction can never establish truth.

So how do we ever prove anything for certain in science. The short answer is, we don't.

We can never be certain of truth.

Using induction and deduction

Instead of just collecting *confirmations* we can employ induction and deduction



- Collect observations and use induction to come up with general laws and theories from particular observations
- Use deduction to figure out what logically follows from these general laws and theories

This approach nicely captures the idea of testability

Our theories should make predictions about what we expect to find and we can test these predictions with more observations

Deduction and knowing what is false

The philosopher *Karl Popper* also saw trouble with relying on induction. He wanted to put science on a firmer logical footing.

To do this, he proposed that while scientists can't use deduction to figure out what is true, they can use deduction to figure out what is false

He suggested that a key quality of scientific theories is that they should be falsifiable.

Theories can come into existence through any means (wild speculation, guesses, dreams, or whatever), but once a theory has been proposed it has to be rigorously and ruthlessly tested

Falsification of theories

Confirmation

Premise: A swan that was white was spotted in London at time t

Conclusion: All swans are white.

Conclusion might be true or false, but it doesn't logically follow from the premise

Falsification

Premise: A swan, which was not white, was spotted in Australia at time t.

Conclusion: Not all swans are white.

Conclusion logically follows from the premise, so if the premise is true the conclusion is true.

We can't prove the claim "*all swans are white*", but we can reject it.

Degrees of falsifiability

Good theories are *falsifiable*, better theories are *more falsifiable*

Three theories:

1. Mars moves in an elliptical orbit
2. Mars and Venus move in elliptical orbits
3. Planets move in elliptical orbits

Of these three theories, (1) is the least falsifiable and (3) is the most falsifiable. Why? For theory (1) only an observation of Mars could falsify it. But for theory (3), an observation Mars, Venus, Saturn, Neptune, or any other yet undiscovered planet would falsify it.

Bad theories are ones that can seemingly accommodate any observation

If two outcomes are possible and the theory can explain outcome one and outcome two then this is bad. What would be evidence against the theory?

Good theories are broad in their *applicability* but precise in their *predictions*

Encountering a falsifier

What happens when you make an observation that falsifies a theory?

That is, you observe something that contradicts the theory you're testing. What do you do?

Your options:

- You could *abandon the theory*
  - But what about *probabilistic theories*?
  - And what about *auxiliary assumptions*?
- You could *modify or amend the theory*
  - But are their *better* ways and *worse* ways to do this?

Probabilistic theories

Theories in psychology tend to be probabilistic. They make claims about how things are on average, not claims about how things are in every case.[1]

Much of what we do with statistics is figuring out how to test and specify probabilistic claims. For example:

- What does it mean for things to be different on average
- How many cases do you have to observe before you have evidence for a probabilistic claim
- How many cases do you have to observe before you have evidence against a probabilistic claim (that you might previously have believed)

But putting that aside, a single contradictory observation can't falsify a probabilistic claim because we will sometimes expect contradictions with probabilistic claims.

[1] A probabilistic claim might say something like *on average* "men are taller than women", but of course there are shorter men and taller women.

Abandoning the theory

Putting aside the probabilistic nature of claims (or assuming you've seen enough contradictory examples), should these contradictory observations lead you to abandon the theory?

Any experiment is not testing one theory in isolation but also relies on a range of auxiliary assumptions and other support theories.

For example, an experiment on memory using brain imaging is also making assumptions about the truth of theories related to physics and brain functioning, besides testing the theory about memory).

The Duhem-Quine problem

It may be the case that what is actually at fault is one of these auxiliary assumptions and not your theory. Telling which part of the interconnected web of theories is at fault can be tricky. Philosophers call this the *Duhem-Quine problem*.

Popper didn't have a good answer on how to figure out where to lay the blame for an *apparent* falsification.

Popper also didn't think that theories should be abandoned *too quickly*.

He suggested some *dogmatism*, because at the start scientists might still be figuring out the details, and therefore they might just need to make some *tweaks* and modify their theories.

Revising and amending theories

But if we decide to amend a theory, then how do we do this?

Theory: All bread is nourishing

Observation: Bread eaten in a French village in 1951 was not nourishing[1]

Ad-hoc modification

All bread expect bread eaten in a French village in 1951 is nourishing

Modification has fewer tests: Original theory can be tested by eating any bread. Modified theory can be tested by eating any bread except that particular bread.

Acceptable modification

All bread except bread made with flour containing ergot fungus is nourishing

Modification leads to new tests: 1) Test the bread for the presence of fungus; 2) Cultivate fungus and make bread with it and test whether it nourishes; 3) Analyse fungus for poisons.

[1] https://en.wikipedia.org/wiki/1951_Pont-Saint-Esprit_mass_poisoning

Problems with Popper's falsificationism

Popper's focus on falsifying theories leads to a couple of problems:

1. It can be difficult to figure out when to abandon theories and when to amend theories.
    - Are all parts of the theoretical web of the same status?
2. It can difficult to compare two theories to see which is "better"
    - For example, if you have Theory A and Theory B and neither has been falsified, which is the better theory? The one with *more confirming observations*? But then won't trivial theories will always win?

The philosopher *Imre Lakatos* developed his idea of research programmes[1] as a reaction to these two problems.

[1] A *similar* idea was developed by the philosopher *Thomas Kuhn*, but *Kuhn* used the term paradigms for his idea.

Research programmes

One key aspect of *Lakatos's* idea of research programmes is that not all parts of a science are on par

- Some laws or principles are so fundamental they might be considered a defining part of the science.
- Other parts might be more peripheral

Lakatos called these fundamental parts the hard core and the more peripheral parts the protective belt

He suggested that the hard core is resistant to *falsification*, so when an apparent falsifier is observed the blame is placed on theories in the protective belt

Research programmes are defined by what is in their hard core

Hard cores and protective belts

What is in the hard core and what is in the protective belt might not always be explicit, but these might be some examples:

- In Cognitive Science the hard core might include the theory that mind/brain is a *particular kind of computational system* and the protective belt might include specific theories about how memory works

- In the biomedical view of mental illness the hard core might include the theory that mental illness can be explained biochemically and the protective belt might include the dopamine theory of schizophrenia

When apparent falsifications occur the protective belt is up for revision but the hard core stays intact. Falsifying the hard core amounts to abandoning the *research programme* (more on this later)

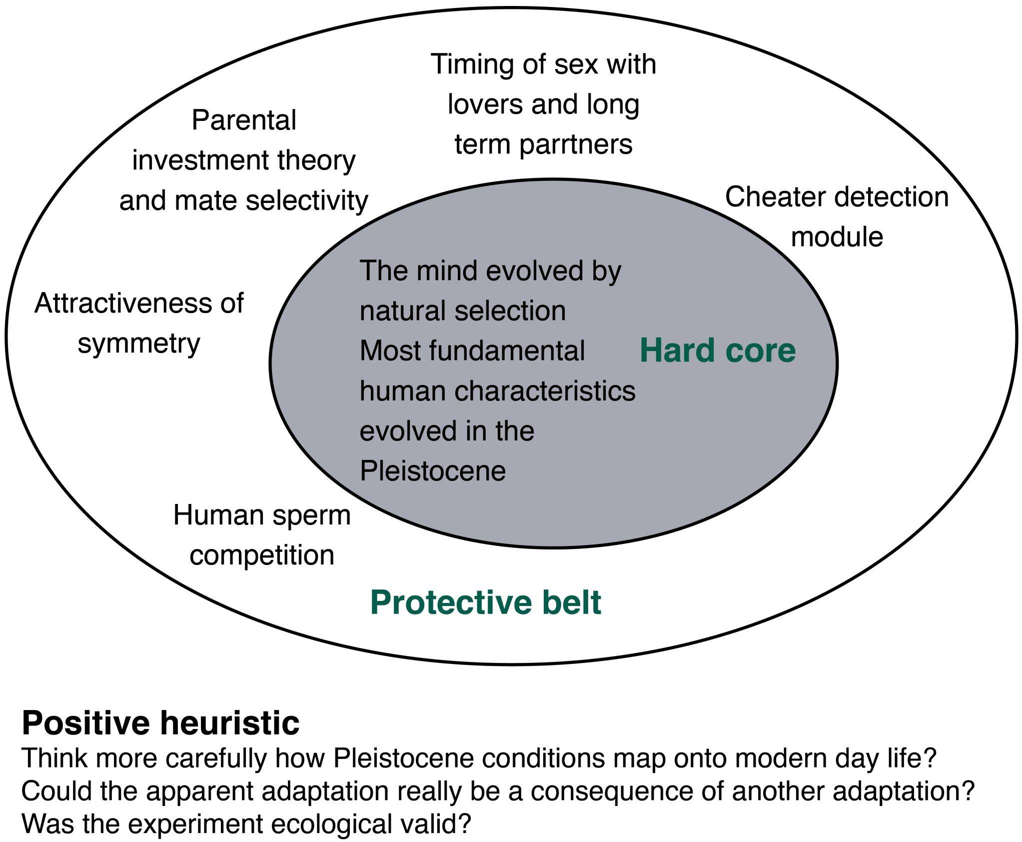
Working within a research programme

On *Latakos's* view, scientists work within a research programme.

He split guidelines for working within a research programme into a negative and positive heuristic, specifying what scientists shouldn't do but also what they should do

- The *negative heuristic* includes things like not abandoning the hard core
- The *positive heuristic* is harder to specify exactly, but it includes suggestions on how to supplement the protective belt to develop the research programme further
    - That is, it should specify a programme of research
    - The research programme should identify problems to solve

Example of a research programme



Example of a research programme from Dienes (2008)

Progressive / degenerating programmes

Lakatos was also interested in comparing research programmes, something that is difficult to do on a *strictly* falsificationist account.

He divided research programmes into those that are progressive and those that are degenerating

- Progressive research programmes are coherent (i.e., have minimal contradictions)
    - And progressive research programmes make novel predictions that follow naturally from theories that are part of the programmes
    - These predictions are then confirmed by experiments
- Degenerating research programmes are those that have faced so many falsifications that they have been modified to the point of being incoherent.
    - At this point, it's no longer sustainable to carry on modifying the protective belt, and instead, the hard core must be abandoned

Moving from one programme to another

When the hard core is abandoned then scientists move from one research programme into a new one.

Some examples of this in psychology might include:

1. The move from psychological behaviourism to cognitive science
2. From classical cognitive science to embodied cognitive science
3. From connectionism to deep neural networks
4. From sociobiology to evolutionary psychology

But again, what is and isn't a research programme isn't always clear, because often the hard core and the protective belt are left *implicit* and not made *explicit*

However, I think it's valuable to keep these distinctions in mind as you move through your university career.

Any Questions?

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