Scientific Method, Empiricism, and Sunspots

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Slides available via the "Blog" section of my website
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- Last week you've seen Prof. Crowther talk about how to think for yourself and introduce the course.
- By way of introducing myself, I just wanted to add my own opinion about why I think this course is so interesting.
- A bunch of my work involves the philosophy of science and mathematics (among some other things).
- When I started as an undergraduate, I had a vision: Reduce everything to some clearly understood theory, that expresses the "eternal truths" of the universe.
- (The hubris!)

- Unfortunately as I spent more time doing philosophy, I came to believe that things are more subtle.
- A key theme: By looking at our intellectual ancestors, we can see that very often they were on to something but only had partial understanding.
- We are the intellectual ancestors of future generations.
- We know that there are deep problems in many different areas.
- What about your own fields?

- Not everyone wants to be a philosopher, but I'm hoping that the tools from philosophy can be useful in other areas.
- Whilst working within a framework is an important skill, so is critically analysing and assessing those frameworks.
- Many of you are embarking on your journey into whatever field you choose to end up in, and I'm hoping that as well as working within particular frameworks, you also want to make them better.
- This is a pretty universal problem, applicable in science, mathematics, computing, politics, business...life in general!
- Whilst I'll be giving the background needed for you to do well in your exams, I'll be giving some of my own (opinionated!) takes too.
- I invite you to think critically about what I say, and start to form your own views about how we should navigate the world.

Enough about my views (for now). Plan for today:

Introduction

Empiricism and Rationalism

Sunspots, Galileo, and Scheiner

Webs of belief

Conclusions

Let's start with some things you (we) know.

- You're now sat in a lecture hall.
- This chalk is white.
- 5 times 6 is 30.
- Yesterday you had X for breakfast.
- The sun is much larger than the earth.

- There appear to be different sources for this knowledge.
- You can reflect on your own experience for the lecture hall.
- You can see the chalk.
- You either know (by rote) or can work out by repeated addition that $5 \times 6 = 30$.
- You use your memory to remember what you had for breakfast yesterday.
- Unless you've got a lot of expertise in astrophysics, you probably accept that the sun is larger than the earth based on testimony.

- Throughout the latter half of the second millennium, a key question concerned the following two views.

Rationalism

A rationalist view is one that promotes the role of reason in knowledge acquisition.

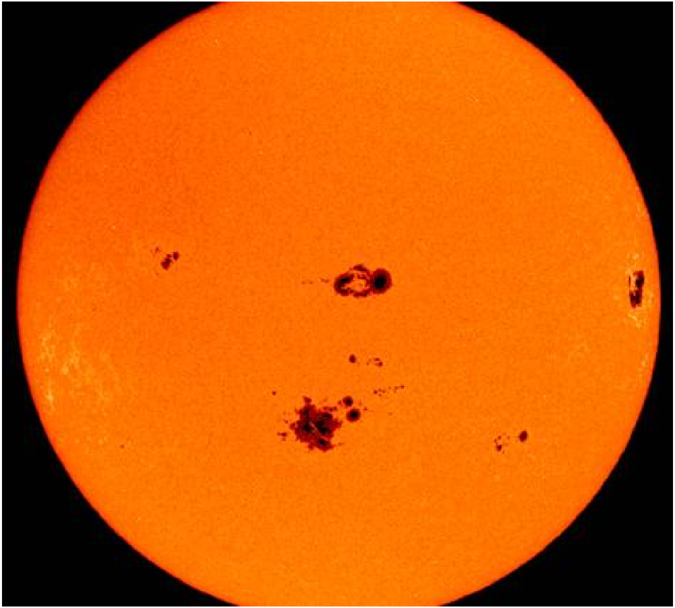
Empiricism

An empiricist view is one that promotes the role of sense experience in knowledge acquisition.

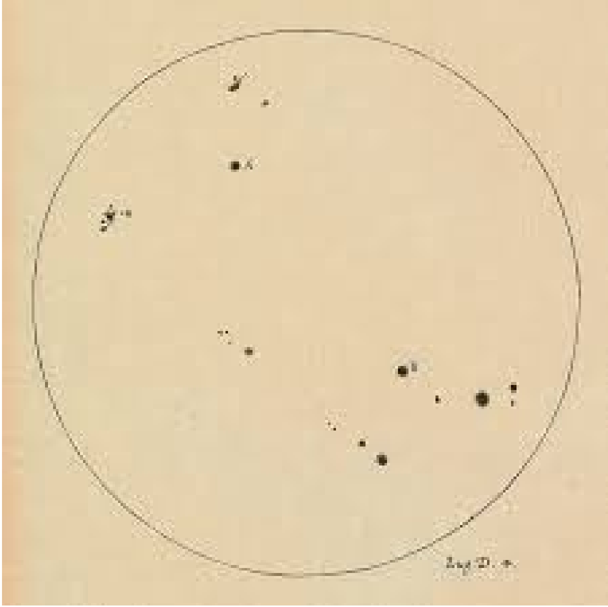
- These can be relative to domain (e.g. I might be a rationalist about math or morality, but an empiricist about colour perception).
- These can have varying strengths e.g. knowledge about math is entirely founded on reason vs. mostly founded on reason.

- Strong forms of **Rationalism** tend to do well with respect to logic and mathematics, but have tricky problems with accounting for knowledge that seems to come direct from the senses (cf. Descartes rationalism).
- Strong forms of **Empiricism** do well with respect to knowledge that comes from the senses, but then have difficulties with logical/mathematical knowledge ($5 \times 6 = 30$ doesn't seem to rely on observation).

- A common theme: Often strong views like these have complementary virtues/vices.
- It's more usual nowadays to think that any reasonable epistemology (i.e. the study of knowledge and belief) takes something from both.
- We make observations about the world and use our reason to systematise these observations into a theory.
- A given theory can **accommodate** data (systematise what we already know) and make **predictions** that can then be tested.
- This **scientific method** is a crowning human achievement, enabling (a) a better understanding, but also (b) much of the amazing technology we see around us today.



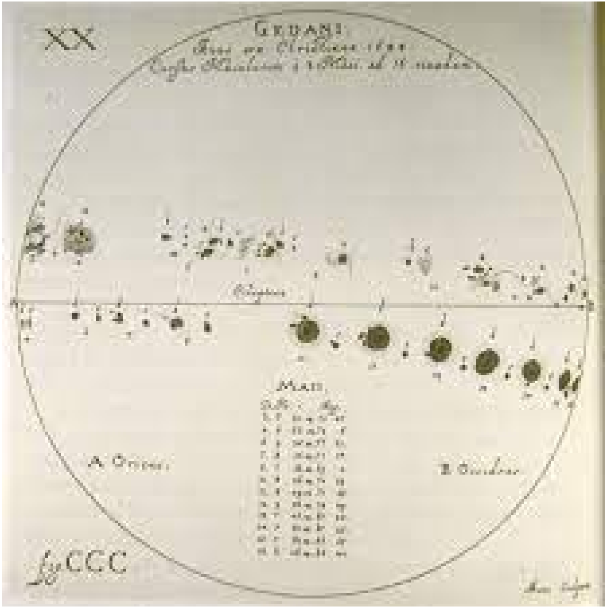
- The invention of the telescope in the 1600s led to a greater ability to make empirical observations.
- In particular, it was observed that there appeared to be dark patches on images taken of the sun.



- This presented an issue for the (standard at the time) geocentrism (i.e. where the earth is at the centre of the solar system) as opposed to our modern-day heliocentrism.
- On that view the sun was a perfect celestial body in the firmament around the earth (no spots).
- **Note:** This isn't a central part of geocentrism, it was rather part of the theory as an entire package.
- How to account for this?

This debate played out with the political figure Mark Welser mediating between Christoph Scheiner (1573ish-1650), a Jesuit priest, astronomer, and mathematician, and Galileo Galilei (1564-1642):

- **Option 1.** (Scheiner) The observation of sunspots is caused by an occlusion of the sun by some other objects
- **Option 2.** (Galileo) The sunspots are on the surface of the sun.
- In the text for this week you can see Galileo making his case (using a combination of reason and observation), the solar spots move faster across the centre of the sun, and slower around the edges.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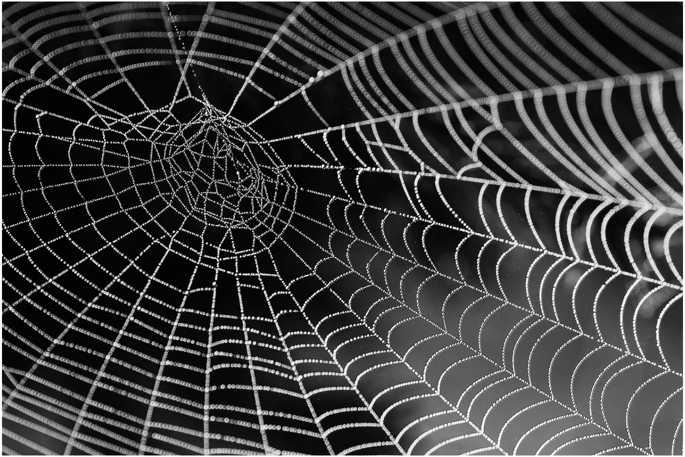
- The response on behalf of Scheiner was to come up with new ideas about motion, and new kinds of object that can vary their speed.
- **Note:** After Scheiner's modification, both are then consistent with the data!
- But Scheiner's theory is very ad hoc—the necessary assumption to get it to work is just written in.
- This uses the notion of a theoretical virtue (don't have ad hoc assumptions written in!).
- **Foreshadowing.** What other kinds of theoretical virtue are there?
- In the end, political considerations carried the day—Galileo's theory was not widely accepted in his lifetime.

There's a number of aspects of scientific development highlighted by this exchange.

1. What is available to us for empirical observation is dependent upon our intellectual and technological context (in this case, the invention of the telescope).
2. Via observation and systematising this knowledge, an entire way of seeing the world can be **overturned** (in this case geocentrism and the associated solar perfection).
3. There are **multiple considerations at play**, observation is essential, but so is mathematics and reasoning about what kinds of theory are better than others.
4. These issues with our worldview being doubtable contrasts with the more 'exotic' philosophical cases like Descartes' demon—this concerns observation of the physical world.
5. At the time, **political considerations** were important to theory acceptance.



- I now want to suggest one way of thinking about some of these issues to do with theory revision.
- **Note:** This is now going beyond what you'll be examined on!
- Let's start by noting that there's lots of examples where observations conflict with currently accepted theory.
- The revisions made can vary in successfulness.

Uranus/Neptune. In the 17th century Isaac Newton formulated his laws of motion. In 1821 a shift in the perihelion (point at which an orbiting body is closest to the sun) in Uranus was observed. This suggested that Uranus was being pulled around gravitationally by another large body. The existence of a planet was conjectured and in 1846, Neptune was discovered.

Mercury/Vulkan. A similar phenomenon was noticed in 1859 with Mercury's orbit. The search went underway for a new planet, Vulkan. In the end, no such planet exists (the change in orbit was later explained by relativity).

Faster-than-light neutrinos. In 2011 the OPERA experiment reported neutrinos travelling faster than the speed of light. It turned out to be the result of experimental error: A fiber optic cable was attached improperly and a clock oscillator was ticking too fast. Very few people thought that FTL neutrinos were real.

- What is going on here?
- Sometimes we are lead by evidence to error (especially when an inference worked before, as with Uranus/Neptune and Mercury/Vulkan).
- Sometimes we just know (everyone was pretty clear that faster-than-light neutrinos were a result of experimental error).
- In 'Two Dogmas of Empiricism', W.V.O. Quine argued that beliefs are always in principle revisable.
- But some are closer to the centre of our web of belief than others.
- When we encounter a anomaly, we try and incorporate it doing minimal violence to our web of belief (prioritise what's at the centre as much as possible).

- This suggests that Scheiner wasn't being stupid or irrational—his Jesuit faith and associated geocentrism was close to the centre of his web of belief.
- Similar remarks about Mercury/Vulkan, Newtonian theory was central at this time.
- But in time, things in the centre can be pushed towards the edge (e.g. if anomalies build up).
- But it's always possible to incorporate evidence (e.g. everyone was hallucinating when they saw the sunspots!).

- The question is what kind of theory do we get out?
- **Question:** What things are at the centre of your web of belief.
- **Question.** What about within your respective fields?
- **Question.** Can you envisage this changing?
- **Question.** Can you imagine yourself within other belief systems?

This session we've seen:

- The distinction between empiricism and rationalism.
- The fact that both empirical and rationalist considerations are important (without serious further argument).
- The example of sunspots indicates that there's multiple routes to be taken when evaluating evidence (observations on their own don't do squat).
- This all suggests that evaluating evidence is hard, and that we should pay attention to disagreements about framework as well as disagreements about observations.