Physics 419: Lecture 6: Determinism, Causality, and Knowledge (Gettier Examples)
Feb. 11, 2021

1 Themes

- Redux on Newton's space-time

- What is Knowledge?

- Critique of Newton: Is Newtonian Mechanics Deterministic?

- Causation

2 Space and Time Redux

Galilean Invariance: Two frames in uniform motion relative to one another exhibit identical physics. A ship moving at constant velocity in quiet waters and someone on shore experience the same laws of physics.

Newton: Newton is in a quite odd position. He constructed a theory of mechanics, planetary motion and a complete system for all that was observed at the time. The problem was that he did not like the result. He found that all the motion was relative. To specify that anything was moving, one has to pick a frame that is fixed. This introduced a weird human perspective into equations that should tell us the truth. To fix this, Newton invented Newton's mechanics. For Newton absolute space and time exist. They have reality independent of sensation. Space and time are the arena within which objects move and events take place. (substantivalism) For Newton (and Leibniz and everyone else at the time), the two-train example discussed in class posed a serious problem. Relative to one another, the trains are both accelerating. However, only in one does one feel non-inertial forces. The only way out, for Newton is that non-inertial motion is absolute motion relative to an unmovable frame, that is absolute space. That is, there is a change of velocity which is absolute not relative to some arbitrary material reference frame. Absolute space is not just a container. It enters into a causal relation with the stuff in it, that is, material objects. The search for an effect of this sort was an important enterprise during the middle of the 20th century in the form of the search for the space-filling aether.

Leibniz: In contrast, for Leibniz space and time are merely mathematical devices which are convenient for describing the relationships among objects. (relationism) Leibniz implies there should be no such effects of absolute space should exist.

You should think about relationism vs substantivilism in terms of the realist/instrumentalist debate. The view that time and space are just constructs that are defined entirely from relationships is in stark contrast to the substantivilist account in which space and time are objective entitites. You should think about the discussion regarding Caesar's death. Is all the temporality of this event simply summed up by saying that it occurred before Regan was president? Relationists say yes; substantivilists say no.

Mach: In the 19th century, Mach tried to solve Leibniz' problem by appealing to the matter in the universe as a whole (the distant stars) as the source of the preferred frame. Perhaps there is some unknown effect (a long range force of some kind) by which acceleration with respect to this matter becomes observable. In this case, absolute acceleration is contingent, not necessary. More later.

Kant: Space and time are fundamental organizing principles in the mind and hence never get explained. In some sense, he takes them as brute facts of nature that always belie explanation. We musst take them for granted. Note the similarity with Kant's take on causation. Is this sort of argumentation helpful?

Some unstated assumptions of Newton's physics

Some features are invariant as one changes point of view. These features are not relative, and may be considered objective.

In addition to absolute space, there is, independently, absolute time. Time intervals between events are independent of who measures them. (Invariant) The geometry of space is Euclidean and is independent of any reference to time. For Newton these were not empirical issues. The answers were assumed. However, Euclidean geometry is not a logical necessity. In particular, Euclid's fifth postulate ("Through a given point there is exactly one line parallel to another line.") always bothered the Greeks, because it required the notion of extending lines to infinity. (If you replace the standard assumptions of Euclid's plane geometry with ones where there's an additional point for each set of parallel lines, and the set of all such points also forms a line, you get something with the same logical consistency as Euclid, but with no parallel lines at all. It's what we now call projective geometry.)

Consequently, local geometrical measurements can't be reliably extrapolated to infer a universal geometry. This was not fully appreciated until the 19th century (Gauss, Riemann, et al.)

Some further questions to ponder:

If geometry describes space, not the objects in space, how can you test it?

Is there anything more to space than a mathematical framework?

Is there a medium which transmits gravitation? (Newton was very uncomfortable with his action-at-distance gravity.) Newton thought gravity was communicated instantaneously.

Could that medium provide the "stuff" of absolute space/ How?

Another issue

Two questions that are not answered by Newtonian physics:

How is inertia explained? That is, why do objects continue to move?

3   Newton on Method

Newton's four rules of reasoning in natural philosophy: (Principia, Book III)

- Simplicity: "We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances."

- Induction: "The qualities of bodies ... which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever." To what extent can induction be justified? To what extent do discoveries made by induction represent "reality"?

- Uniformity: "To the same natural effects we must, as far as possible, assign the same causes." This is more or less a combination of simplicity and induction.

- Empiricism: "In experimental philosophy we are to look upon propositions collected by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur, by which they may either be made more accurate, or liable to exceptions."

Newton saw himself as an empiricist. "I do not entertain hypotheses," means that he does not want to spend time on ideas that are not rooted in observation. E.g., it is fruitless to speculate on the "true nature" of things.

Whatever is not deduced from the phenomena is to be called an hypothesis; and hypotheses, whether metaphysical or physical, whether of occult quantities or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena and afterwards rendered general by induction. (Principia, book II)

At least that was Newton's self-image. In practice, he spent more time on theological speculations and alchemy than on physics, and within physics his theory of light (particles undergoing alternating fits of easy and hard refractability) was exactly the sort of speculation he claimed to eschew. His assertions about true space and true time were essentially assumptions not specifically based on observations.

4   Is Justified True Belief Knowledge?

Critique of Justified True Belief: Any theory of the physical rests on some kind of knowledge claim. The question arises: What is knowledge? Plato formulated conditions that must hold for belief in a certain proposition to properly constitute knowledge. In essence S knows that P if and only if 1) P is true, 2) S believes that P is true and 3) S is justified in believing that P is true. In the companion reading to this lecture, E. Gettier showed that this formulation, though perfectly intuitive, is flawed. We will discuss the two types of Gettier examples in class. As a result of the Gettier examples, it is unclear what condition has to be added to justified true belief for the knowledge claim to be valid.

5   Newton's Influence

Suppose one knew the force laws (i.e., how to calculate F in a given situation). Then if one knew the motions of all objects at any moment, one would, in principle, know the entire past and future. In Newtonian physics, events are inevitable.

"Let us imagine an Intelligence who would know at a given instant of time all ... forces .... and positions .... and that this Intelligence would be capable of ... mathematical analysis. ... Nothing would be uncertain. ....The past and the future would be present to its eyes". (Laplace)

But Laplace acknowledged

"Geometry provides a weak outline of this Intelligence.... man will remain infinitely far removed from it". (Laplace)

If conditions were different, the laws would give the hypothetical "Intelligence" a way to calculate what the results would then be. So a definition of causation that starts "if things had been different, then... " would be meaningful. This is closely related to Lewis's counterfactual formulation.

Newtonian determinism fed into a Deistic religious stance: The "intelligence" could be treated as God, perhaps as one somehow involved in the initial setting of a clockwork universe, but not as one intervening to disrupt the inevitable lawful workings of the machine.

The stunning successes of physics (especially for astronomy) led to attempts to adopt its principles in other fields. Some of these confused the type of principles that described how things are with the type of rules that it would be good for societies to adopt.

Chemistry and biology: mechanistic, causal theories were sought, and, to a large extent, slowly found. Auguste Comte - Sociology. There should be some set of rules, based on generalization from observation, which describe the mysteries of why societies act the way they do. Adam Smith - Economics. The machine was supposed to work by letting a few simple principles play out, rather than by a hodge-podge of particular rules.

Many people (e.g., Thomas Jefferson) - Politics. Rather than have different rules for a myriad of different qualitative types of people (ranks of nobles, etc.) there should be some simple universal rules. (Which would not, of course, prevent the less 'massive' people from orbiting the more 'massive' ones.) Anything important should be written in a style imitating Newton imitating Euclid. "We hold these truths to be self evident"

Is the Newtonian universe deterministic in practice?

Chaotic behavior limits one's predictions to the logarithm of one's computing power. The log of 10^{100} is 100. That's why we don't know next week's weather. The solar system itself appears to be chaotic (especially Pluto's orbit). Imagine a friction-free pool table that follows simple collision rules. It is not hard to see that small initial errors grow rapidly into extreme unpredictability. A small uncertainty in the direction of a ball leads to a bigger uncertainty in its direction after a collision. The uncertainties just keep multiplying, so that you soon cannot even predict which collisions occur.

6   Cause and Effect:

HUME: Explicit in Newton's mechanics is the notion that forces cause acceleration. We would like to focus on what exactly is entailed by the notion of causality. When we say A causes B, we generally have some thing in mind of the form, "A came about as a result of B." By this rephrasing do we mean that there is a necessary relationship between A and B. That is, once A happens, then B must obtain. Let's entertain, for the moment, that there is a necessary relationship between A and B. By necessary, I mean that B does not happen by accident. Given A, B cannot fail to occur. We become aware of causal relationships by experience. That is, we know that when a que ball hits the 8 ball, the 8-ball will move and we know that certain viruses cause colds. How from our experience can we determine that two states of affairs are necessarily related. Three prequisites are needed here: 1) universality–that is, there is no effect for which there is no cause, 2)

uniformity–the future will resemble the past, and 3) we can by experience know which states of affairs are impossible. If all three are granted, then necessity follows trivially. However, note that there is no way of establishing universality from experience. The same thing is true for uniformity. How are we to know that the laws of nature will not change tomorrow. In addition, the third point can never be verified by experience because experience can only tell us what is the case. This is essentially Hume's argument against necessity in causation. On the Humean account, we can only interpret causation as a conjoining of events. That is, one event follows another. But all bets are off in terms of inferring any type of connection between the events. We see the que ball and the 8-ball subsequently move. This is all we see. Hume argues that the idea of causality is something extra which we have no grounds to believe in. A slightly different version of this viewpoint is due to the Humean empiricists. Here they argue that there is some necessity entailed but only what is entailed by the laws of motion. That is, the causation is only as necessary as are the laws of motion. Since the laws of nature could conceivably have been different, or are at best conditionally true, the motion of the 8-ball upon being struck by the que ball is conditionally necessary. Unconditionally necessary truths are equalities in mathematics, for example, 1+0=1. Also falling into the category of necessary truths are claims based on definitions. For example, bachelors are unmarried men; hence, all unmarried men are bachelors. Such statements are tautologies.

KANT: Kant countered the Humean account and argued for a necessary connection between cause and effect. Kant argued that while we are aware of causal relations by experience, cause and effect can be necessarily related. Here's how this works. Kant argued that planted deep in the human psyche is the notion of causation. That is, we have no sensible way of organizing information about the world without the sense that some sort of causal order exists between events. For Kant the deterministic dictum that every event in the natural order is the effect of some cause is a necessary truth because it is the presupposition of any experience of the objective world. Hence, Kant grants Hume that causal necessity cannot be established by experience. Its just that Kant eschews that a new type of proposition exists, synthetic a priori propositions, which are establishable solely by reason. Such propositions are necessarily true as they are not grounded necessarily in human experience. For example, Kant would put the necesisty of causal relations in the same class of proposition as he would that the sum of the interior angles in a triangle is 180 degrees. While both are established from experience, they are not solely based on experience as they are inextricable from any sensible description of the world. That is, we cannot conceive of a world in which they are not true. Hence, they must be necessary.

COUNTERFACTUALS AND DETERMINISM: Kant never offered a clear argument as to why we conceive of the world in terms of cause and effect and a necessary link between them. We consider now the counterfactual formulation of causation. What if by A causes B, we simply mean that if A did not occur then B would not have either. The statement, "if A did not occur then B would not have occured either" is a counterfactual conditional. A counterfactual is simply a statement that could be true in some possible world. However, in the world where the proposition is false, it is counter to fact and hence a counterfactual. As long as we can conceive of a possible world in which the counterfactual obtains, then in the world we live in, we can safely assert that things could have been otherwise. All that is necessary is that there is no logical contradiction that arises were the counterfactual to be true. For example, $1+0=1$ is true in all possible worlds. This identity has transworld invariance. However, that it rained on Monday the 12th of January need not have occurred in all possible worlds. Consider A being the announcement of the Tet offensive which began Jan. 30, 1968 and B being a riot. The counterfactual "if the Tet offensive were not announced, then the riot would not have occurred," is certainly true in some possible world. That is, we can imagine another world with the same laws as ours but in which the Tet offensive did not take place. If this were the case , then it is conceivable that the riot would not have occurred. Likewise we can also conceive of a world in which the Tet offensive were announced and the riot did not occur. What if everyone were daft or everyone were in favour of the Vietnam war? For there to be a strict 1-1 correspondence between cause and effect on the possible world account, we need to impose the constraint that all other things are equal. That is, the announcement of the Tet offensive would always yield a riot if people were the way they are in this possible world. Hence, had the Tet offensive not been announced, then the (specific) riot would not have occured. The counterfactual interdependency between cause and effect is the essence of this view. This view is particularly attractive because it offers a way out of the determinism problem. In the world in which we did x, we could not have but done x. But certainly there is no transworld invariance associated with our doing x. All we mean by freely choosing x is that we could have done otherwise– that is, there is a possible world in which we did not do x. As long as there is no logical necessity associated with the doing of x, then not doing x is a possibility in some possible world. More on this next class.