Does Your Philosophy of Science Matter in Practice?

This is a more extensive overview of the contents discussed in the lecture. This assignment contains several questions for you to reflect on. Your answers to these questions aren't right or wrong – they are simply your view on this matter. Therefore, this assignment can not be graded, but feel free to use the discussion forum to exchange ideas about these topics with others, if you like.

We can broadly distinguish philosophies of science concerning ideas about truth, and how our theories relate to truth in three main categories (following Niiniluoto, 1999). First, there is the view that there is no truth, known as **anarchism**. An example of this can be found in Paul Feyerabend's 'Against Method' where he writes: Science is an essentially anarchic enterprise: theoretical anarchism is more humanitarian and more likely to encourage progress than its law-and-order alternatives" and "The only principle that does not inhibit progress is: anything goes." The second category contains **pragmatism**, in which 'truth' is replaced by some surrogate, such as social consensus. For example, Pierce writes: "The opinion which is fated to be ultimately agreed to by all who investigate, is what we mean by the truth". Rorty doubts such a final end-point of consensus can ever be reached, and suggests giving up on the concept of truth and talk about an indefinite adjustment of belief. The third category consists of approaches that believe there is who define truth as some correspondence between our statements or propositions about the world and reality, known as **correspondence theories**. In essence, these approaches adhere to a dictionary definition of truth as 'being in accord with fact or reality'. However, these approaches differ in whether they believe scientific theories have a truth value (i.e., whether theories can be true or false), and if theories have truth value, whether this is relevant for scientific practice.

Q1: What do you think? Is anarchy the best way to do science? Is there no truth, but at best an infinite updating of belief with some hope of social consensus? Or is there some real truth that we can get closer to over time?

It is possible to have different philosophies of science because success in science is not measured by whether we discover the truth. After all, how would we ever know for sure we discovered the truth? Whatever your position on truth in science, a more tangible goal for science is to make **scientific progress**. This means we do not immediately need to agree on what truth looks like, but it means we will have to define what progress in science looks like. And to have progress in science, science needs to have a goal.

Kitcher (1993, chapter 4) writes: “One theme recurs in the history of thinking about the **goals of science**: science ought to contribute to "the relief of man's estate," it should enable us to control nature—or perhaps, where we cannot control, to predict, and so adjust our behavior to an uncooperative world—it should supply the means for improving the quality and duration of human lives, and so forth.” Truth alone is not a sufficient aim for scientific progress, as Popper (1934) already noted, because then we would just limit ourselves to positing trivial theories (e.g., for psychological science the theory that ‘it depends’), or collect detailed but boring information (the temperature in the room I am now in is 19.3 degrees). Kitcher highlights two important types of progress: **conceptual progress** and **explanatory progress**. Conceptual progress comes from refining the concepts we talk about, such that we can clearly specify these concepts, and preferably reach consensus about them. Explanatory progress is improved by getting a better understanding of the causal mechanisms underlying phenomena. Scientists will probably recognize the need for both. We need to clearly define our concepts, and know how to measure them, and we often want to know how things are related, or how to manipulate things.

Q2: Think about your own research. Is it more focus on conceptual progress, or more focused on explanatory progress. What should the balance between these two goals in science be, for your own research? Are the concepts you use clearly defined and generally agreed upon? And what is the balance currently?

This distinction between conceptual progress and explanatory progress aligns roughly with a distinction about progress with respect to the entities we study, and the theories we build that explain how these entities are related, where a scientific theory is defined as a set of testable statements about the relation between observations. As noted before, philosophies of science differ in whether they believe statements about entities and theories are related to the truth, and if they are, whether this matters for how we do science. Let’s discuss four flavors of philosophies of science that differ in how much value they place in whether the way we talk about theories and entities corresponds to an objective truth.

Instrumentalism

According to instrumentalism, theories should be seen mainly as tools to solve practical problems, and not as truthful descriptions of the world. Theories are instruments that generate predictions about things we can observe. Theories often refer to unobservable entities, but these entities do not have truth or falsity, and neither do the theories.

Scientific theories should not be evaluated based on whether they correspond to the true state of the world, but based on how well they perform.

One important reason to suspend judgment about whether theories are true or false is because of underdetermination (for an explanation, see Ladyman, 2002). We often do not have enough data to distinguish different possible theories. If it really isn't possible to distinguish different theories because we would not be able to collect the required data, it is often difficult to say whether one theory is closer to the truth than another theory.

From an instrumentalist view on scientific progress, and assuming that all theories are underdetermined by data, additional criteria to evaluate theories become important, such as **simplicity**. Researchers might use approximations to make theories easier to implement, for example in computational models, based on the convictions that simpler theories provide more useful instruments, even if they are slightly less accurate about the true state of the world.

Constructive Empiricism

As opposed to instrumentalism, constructive empiricism acknowledges that theories can be true or not. However, it limits **belief in theories** only in as far as they describe observable events. Van Fraassen, one of the main proponents of constructive empiricism, suggests we can use a theory without believing it is true when it is *empirically adequate*. He says: “a theory is empirically adequate exactly if what it says about the observable things and events in the world, is true”. Constructive empiricist might decide to use a theory, but does not have to believe it is true. Theories often make statements that go beyond what we can observe, but constructive empiricists limit truth statements to observable entities. Because no truth values are ascribed to unobservable entities that are assumed to exist in the real world, this approach is grouped under ‘anti-realist’ philosophies on science.

Entity Realism

Entity realists are willing to take one step beyond constructive empiricism and acknowledge a belief in unobservable entities when a researcher can demonstrate impressive causal knowledge of an (unobservable) entity. When knowledge about an unobservable entity can be used to manipulate its behavior, or if knowledge about the entity can be used to manipulate other phenomena, one can believe that it is real. However, researchers remain skeptical about scientific theories.

Hacking (1982) writes, in a very accessible article, how: “The vast majority of experimental physicists are realists about entities without a commitment to realism about theories. The experimenter is convinced of the existence of plenty of "inferred" and "unobservable" entities. But no one in the lab believes in the literal truth of present theories about those entities. Although various properties are confidently ascribed to electrons, most of these properties can be embedded in plenty of different inconsistent theories about which the experimenter is agnostic.” Researchers can be realists about entities, but anti-realists about models.

Q3: Psychologists often talk about latent variables. Latent refers to the fact that these variables are not measured directly, but are *inferred*, typically through statistical models (for formal definitions, see Bollen, 2002). Some psychologists, such as B. F. Skinner, do not believe in the existence of latent variables. This view is more in line with constructive empiricism. On the other hand, many psychologists do believe in latent constructs, a view that is more in line with entity realism (or maybe even scientific realism, discussed below). What do you think? Do you believe latent variables are real, or do you prefer to limit statements to observable events?

Scientific Realism

We can compare the constructive empiricist view with scientific realism. For example, Niiniluoto (1999) writes that in contrast to a constructive empiricist:

“a scientific realist sees theories as attempts to reveal the true nature of reality even beyond the limits of empirical observation. A theory should be cognitively successful in the sense that the theoretical entities it postulates really exist and the lawlike descriptions of these entities are true. Thus, the basic aim of science for a realist is true information about reality. The realist of course appreciates empirical success like the empiricist. But for the realist, the truth of a theory is a precondition for the adequacy of scientific explanations.”

For scientific realists, verisimilitude, or ‘truthlikeness’ is treated as the basic epistemic utility of science. It is based on the empirical success of theories. As De Groot (1969) writes: “The criterion par excellence of true knowledge is to be found in the ability to predict the results of a testing procedure. If one knows something to be true, he is in a position to predict; where prediction is impossible, there is no knowledge.”

Q4: Think about the scientific theory that is currently most important for the work that you do and the predictions you are making. Do you think this scientific theory reveals the true nature of reality? Or do you perhaps see it more as a useful instrument that can be used to generate predictions about things we can observe?

Progress in Science

There are more similarities than differences between almost all philosophies of science. All approaches believe a goal of science is progress. Anarchists refrain from specifying what progress looks like. Feyerabend writes: “my thesis is that anarchism helps to achieve progress in any one of the senses one care to choose" – but progress is still a goal of science. For instrumentalists, the proof is in the pudding – theories are good, as long they lead to empirical progress, regardless of whether these theories are true. For a scientific realist, theories are better the closer the more verisimilitude they have, or the closer the get to an unknown truth. For all approaches (except perhaps anarchism) conceptual progress and explanatory progress are valued.

Conceptual progress is measured by increased **accuracy** in how a concept is measured, and increased **consensus** on what is measured. Progress about concerning measurement accuracy is easily demonstrated since it is mainly dependent on the amount of data that is collected, and can be quantified by the standard error of the measurement. Consensus is perhaps less easily demonstrated, but Meehl (2004) provides some suggestions, such as a theory being generally talked about as a 'fact', research and technological applications use the theory but there is no need to study it directly anymore, and the only discussions of the theory at scientific meetings are as in panels about history or celebrations of past successes. We then wait for (and arguably arbitrary) 50 years to see if there is any change, and if not, we consider the theory accepted by consensus. Although Meehl acknowledged this is a somewhat brute-force approach to epistemology, he believes philosophers of science should be less distracted by exceptions such as Newtonian physics that was overthrown after 200 years, and acknowledge this approach will probably work in practice most of the time.

Explanatory progress is mainly measured by our ability to predict **novel facts**. Whether **prediction** (showing a theoretical prediction is supported by data) should be valued more than **accommodation** (adjusting a theory to accommodate unexpected observations) is a matter of debate. Some have argued that it doesn't matter if a theory is stated before data is observed or after data is observed. Keynes writes: "The peculiar virtue of prediction or predesignation is altogether imaginary. The number of instances examined and the analogy between them are the essential points, and the question as to whether a particular hypothesis happens to be propounded before or after their examination is quite irrelevant." It seems as if Keynes dismisses practices such as pre-registration, but his statement comes with a strong caveat, namely that researchers are completely unbiased. He writes: "to approach statistical evidence without preconceptions based on general grounds, because the temptation to 'cook' the evidence will prove otherwise to be irresistible, has no logical basis and need only be considered when the impartiality of an investigator is in doubt."

Keynes' analysis of prediction versus accommodation is limited to the evidence in the data. However, Mayo (2018) convincingly argues we put more faith in predicted findings than accommodated findings because the former have passed **a severe test**. If data is used when generating a hypothesis (i.e., the hypothesis has no *use-novelty*) the hypothesis will fit the data, no matter whether the theory is true or false. It is guaranteed to match the data, because the theory was constructed with this aim. A theory that is constructed based on the data has not passed a severe test. When novel data is collected in a well-constructed experiment, a hypothesis is unlikely to pass a test (e.g., yield a significant result) if the hypothesis is false. The strength from not using the data when constructing a hypothesis comes from the fact that is has passed a more severe test, and had a higher probability to be proven wrong (but wasn't).

Does Your Philosophy of Science Matter?

Even if scientists generally agree that conceptual progress and explanatory progress are valuable, and that explanatory progress can be demonstrated by testing theoretical predictions, your philosophy of science likely influences how much you weigh the different questions researchers ask when they do scientific research. Research can be more theory driven, or more exploratory, and it seems plausible your views on which you value more is in part determined by your philosophy of science.

For example, do you perform research by pre-registering your experiments and formalizing strict theoretical predictions, and collect data to corroborate or falsify these predictions to increase the verisimilitude of the theory? Or do you largely ignore theories in your field, and aim to accurately measure relationships between variables? Developing strong theories can be useful for a scientific field, because they facilitate the organization of known phenomena, help to predict what will happen in new situations, and guide new research. Collecting reliable information about phenomena can provide the information needed to make decisions, and provides important empirical information that can be used to develop theories.

Q5: One might argue that in many research areas researchers do not spend enough effort validating measures. Research that validates measures is typically considered less exciting than the discovery of new findings, even if these new findings are discovered by using measures of questionable validity. In your own research area, is the effort spent on validating measures and testing theory in balance?

For a scientific realist a main aim is to test whether theories reflect reality. Scientific research starts with specifying a falsifiable theory. The goal of an experiment is to test the theory. If the theory passes the test, the theory gains verisimilitude, if it fails a test, it loses verisimilitude, and needs to be adjusted. If a theory repeatedly fails to make predictions (what Lakatos calls a *degenerative research line*) it is eventually abandoned. If the theory proves successful in making predictions, it becomes established knowledge.

For an entity realist like Hacking (1982), experiments provide knowledge about entities, and therefore experiments determine what we believe, not theories. He writes: "Hence, engineering, not theorizing, is the proof of scientific realism about entities." Van Fraassen similarly stresses the importance of experiments, which are crucial in establishing facts about observable phenomena. He sees a role for theory, but it is quite different of the role it plays in scientific realism. Van Fraassen writes: “Scientists aim to discover facts about the world—about the regularities in the observable part of the world. To discover these, one needs experimentation as opposed to reason and reflection. But those regularities are exceedingly subtle and complex, so experimental design is exceedingly difficult. Hence the need for the construction of theories, and for appeal to previously constructed theories to guide the experimental inquiry.”

Theory-driven versus data-driven

One might be tempted to align philosophies of science along a continuum of how strongly theory driven they are (or *confirmatory*), and how strongly data-driven they are (or *exploratory*). Indeed, Van Fraassen writes: “The phenomenology of scientific theoretical advance may indeed be exactly like the phenomenology of exploration and discovery on the Dark Continent or in the South Seas, in certain respects.” Note that exploratory data-driven research is not void of theory – but the role theories play has changed. There are two roles, according to Fraassen. First, the outcome of an experiment is *‘filling in the blanks in a developing theory’*. The second role theories play is in that, as the regularities we aim to uncover become more complex, we need theory to guide experimental design. Often a theory states there must be *something*, but it is very unclear what this something actually is.

For example, a theory might predict there are individual differences, or contextual moderators, but the scientist needs to discover which individual differences, or what contextual moderators. In this instance, the theory has many holes in it that need to be filled. As scientists fill in the blanks, there are typically new consequences that can be tested. As Fraassen writes: “This is how experimentation guides the process of theory construction, while at the same time the part of the theory that has already been constructed guides the design of the experiments that will guide the continuation”. For example, if we learn that as expected individual differences moderate an effect, and the effect is more pronounced for older compared to younger individuals, these experimental results guide theory construction. Fraassen goes as far as to say that “*experimentation is the continuation of theory construction by other means.*”

For a scientific realist experimentation has the main goal to test theories, not to construct them. Exploration is still valuable but is less prominent in scientific realism. If a theory is at the stage where it predicts something will happen, but it not specific about what this something is, it is difficult to come up with a result that would falsify that prediction (except for cases where it is plausible that nothing would happen, which might be limited to highly controlled randomized experiments). Scientific realism requires well-specified theories. When data do not support theoretical predictions, this should be consequential. It means a theory is less ‘truth-like’ than we thought before.

Q6: When a well-designed and high-powered experiment replication study does not observe the same results as an initial finding, responses might differ depending on whether a scientist is a scientific realist or a constructive empiricist. For the one, theories should reflect reality, while for the other, experimentation is the continuation of theory construction by other means. The first might consider the difficulty in replicating the original result a big problem for the original theory, while the second might believe this is simply a good reason to improve the original theory. What do you think? Are both of these views defensible? And how could scientists clarify what they think theories are for when they develop theoretical models in their articles?

Can You Pick Only One Philosophy of Science?

Ice-cream stores fare well selling cones with more than one scoop. Sure, it can get a bit messy, but sometimes choosing is just too difficult. So when it comes to philosophy of science, do you need to pick one approach and stick to it for all problems? I am not sure. Philosophers seem to implicitly suggest this (or at least they don’t typically discuss the pre-conditions to adopt their proposed philosophy of science, and seem to imply their proposal generalized across fields and problems within fields).

Some viewpoints (such as whether there is a truth or not, and if theories have some relation to truth) seem rather independent of the research context. It is still fine to change your view over time (philosophers of science themselves change their opinion over time!) but they should be somewhat stable.

Other viewpoints seem to leave more room for flexibility depending on the research you are doing. You might not believe theories in a specific field are good enough to be used as anything but crude verbal descriptions of phenomena. I teach an introduction to psychology course to students at the Eindhoven Technical University, and near the end of one term a physics student approached me after class and said: “You very often use the word ‘theory’, but many of these ‘theories’ don’t really sound like theories!”. If you have ever tried to create computational models of psychological theories you will have experienced it typically cannot be done: Theories lack sufficient detail. Furthermore, you might feel the concepts used in your research area are not specified enough to really know what we are talking about. If this is the case, you might not have the goal to test theories (or try to *explain* phenomena) but mainly want to focus on conceptual progress by improving measurement techniques or accurately estimate their effect sizes. Or you might work on more applied problems, and believe that a specific theory is just a useful instrument that guides you towards possibly interesting questions, but is not in itself something that can be tested, or that accurately describes reality.

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