Observation and Theory-ladenness

In the philosophy of science, observations are said to be "theory-laden" when they are affected by the theoretical presuppositions held by the investigator. The thesis of theory-ladenness is most strongly associated with the late 1950s and early 1960s work of N.R. Hanson, T.S. Kuhn, and P. Feyerabend, and was probably first put forth (at least implicitly) by P. Duhem about 50 years earlier. Although often run together, at least two forms of theory-ladenness should be kept separate: (i) the *meaning* of observational terms is partially determined by theoretical presuppositions; (ii) the theories held by the investigator, at a very basic cognitive level, impinge on the perceptions of the investigator. The former may be referred to as *semantic* and the latter as *perceptual* theory-ladenness. The thesis of theory-ladenness, if true, has troublesome consequences for theory-testing. If there are no theory-neutral observations, then this raises doubts about whether empirical tests can truly decide between competing theories. So, if theories partially determine the meaning of observation terms, two investigators holding incompatible theories will mean different things when they use the same observational vocabulary, and, if theories partially determine 'what we see', two investigators holding incompatible theories will see the objects relevant for discriminating between their theories differently.

A thesis that also goes under the heading of theory-ladenness may be (more appropriately) referred to *theory-dependence of instruments*, on which much discussion has focused on: the investigator's confidence in the truthfulness of the results obtained with certain instruments depends on her having sound theories of how these instruments work. Such theories are also referred to as 'background' theories. The theory-dependence of instruments is particularly problematic when the background theories are the very theories that the investigator seeks to test, for in those scenarios the testing procedure is rendered circular.

Theory-ladenness should not be confused with certain other ideas. Theory-ladenness does not imply that our perceptions are *fully* determined by our theories; it does not imply that we see '*whatever* we want to see'. No philosopher of science of some standing has defended such an extreme position. We cannot see flying pigs even if we had theories that told us that there were such things. On the other hand theory-ladenness does not simply amount to perceptions being *interpreted* differently by different people. Nor is theory-ladenness the mere theoretical *guidance* of empirical inquiries, i.e., the decision to perform certain experiments rather than others or to investigate a certain aspect of the world. Both of these ideas are platitudes and philosophically not particularly interesting. A grey area is the phenomenon of negative theoretical bias, i.e. the idea that empirical results not amenable to certain theoretical presuppositions are (wilfully or subconsciously) ignored by the investigator. Clearly, also in cases of theoretical bias theoretical presuppositions impinge on the data in ways that are comparable to the thesis of theory-ladenness. Yet negative theoretical bias is normally taken to be easily revealed through various control mechanisms in scientific practice (e.g. peer-review). Since theoretical bias as a form of theory-ladenness has received rather little attention by philosophers of science, it will not be discussed here.

Semantic theory-ladenness

One of the best known examples for semantic theory-ladenness concerns the (observational) term 'mass' which has a different meaning in Newtonian physics than it does in Einstein's theory of relativity. Whereas in the former theory, mass is a constant, in the latter it depends on the velocity of the object in question.

Or take the term ‘planet’. In the Ptolemaic system the (observational) term ‘planet’ referred to a class of astronomical objects that included the Sun and the moon but not Earth. In contrast, in the Copernican system the term ‘planet’ included Earth but neither the Sun nor the moon. Kuhn used examples like these to argue for his (perhaps most) controversial idea of the incommensurability of paradigms. Kuhn’s view has been rejected by many philosophers on the grounds that he employs a particular theory of reference (descriptivism/holism) that most philosophers take to be inadequate. Still, largely due to Kuhn, Hanson, and Feyerabend the vast majority of philosophers have accepted that there are hardly any observational terms relevant to scientific practice that are not theory-laden. Indeed, this was one of the major reasons that led to the demise of logical positivism/empiricism, which had postulated a strict distinction between observational and theoretical vocabulary, whereby any theoretical terms had to be relatable to observational terms in order for the former to be deemed meaningful. Modern day empiricists such as B. van Fraassen, however, do accept semantic theory-ladenness, the vagueness of the observation/theoretical distinction, and that theoretical terms are meaningful without being relatable to observational terms, but do insist on scepticism about the unobservable referents of theoretical terms (such as ‘electron’).

Perceptual theory-ladenness

An instructive example for perceptual theory-ladenness is a psychological experiment, famously used by T.S. Kuhn in his *Structure of Scientific Revolutions*. In this experiment the subjects were presented with a set of playing cards (one-by-one) which contained ‘anomalous’ cards, such as the black four of hearts. Interestingly, with a sufficiently short amount of exposure, the subjects perceptually assimilated the anomalous playing cards to the normal ones, i.e., they would report a black four of spades when being presented with a black four of hearts. Apparently their belief that playing cards fall into certain categories ‘primed’ their perceptual system accordingly. Other examples illustrating the second form of theory-ladenness include ‘Gestalt figures’ like the duck/rabbit or the Necker Cube, which are drawings that can be perceived in two different ways without the object of perception changing. These examples are of course merely illustrative. An example from scientific practice allegedly exhibiting Gestalt-like features, given by Hanson and Kuhn, is the difference between a Copernican, i.e., a believer in the sun-centred-universe, and a Ptolemaian, i.e., a believer in the earth-centred-universe, seeing different things when looking at a sun-set. Whereas the Ptolemaican sees the sun falling behind the horizon (because in her view, the sun is moving, not the earth), the Copernican sees a fixed sun and a rising horizon. Likewise, an Aristotelian, who believes that all objects have the natural tendency to fall to the earth, sees the “constrained” fall of an object when watching a pendulum, whereas a Galilean, having developed an early form of the concept of inertia, sees damped inertial motion.

A straightforward criticism that can be levelled against those latter examples in particular is that they are based on a confusion between ‘seeing’ and ‘seeing *that*’, i.e. a propositional attitude that requires judgment. Van Fraassen in his influential *The Scientific Image* illustrates this point with an aboriginal tribe seeing a tennis ball for the first time: although they do, as we would, see the tennis ball (i.e. a yellow fluffy thing that bounces) they don’t see *that* this is a tennis ball, for this would require some basic familiarity with the game of tennis, immersion in Western culture, etc. Likewise, Lavoisier and Priestly, as much as Aristotle and Galileo, both do see the same objects but make different (theoretically informed) judgments about them. However there are examples where this interpretation seems less plausible. A native speaker of Chinese, for instance, just *hears* (without needing to interpret or consciously judge) meaningful utterances when hearing Chinese rather than just awkward sounds, as a speaker without any knowledge of the Chinese language would. In examples like these, theory-laden observation has a character of immediacy and inevitability that is not reflected by the 'seeing' vs. 'seeing that' distinction.

Another related critique of perceptual theory-ladenness was given by J. Fodor in the 1980s. Based on examples such as the Müller-Lyer illusion, in which two lines of equal length appear to be of different length, Fodor argued that perceptions are *cognitively impenetrable*. That is, even if we are made aware of the two lines being of equal length, we still perceive them as being of unequal length. Fodor's attack on perceptual theory-ladenness has been taken up by others in more recent works. Two things should be noted about Fodor's defense. First, appeal to examples such as the Müller-Lyer illusion can only show that *some* perceptions are cognitively impenetrable. Second, as indicated above, defenders of perceptual theory-ladenness do not claim that all of our perceptual experience is subject to cognitive penetration. If that were so, it would indeed be possible that we see what we wish to see. Again, no philosopher of science has defended such a view. On the contrary, the Kuhnian account of science, for instance, presupposes that there are observations that *resist* theoretical assimilation ('anomalies').

Still another influential way of countering perceptual theory-ladenness was made by J. Bogen and J. Woodward (also in the 1980s). Bogen and Woodward advance the view that scientific theories explain and predict unobservable phenomena rather than observable data. Phenomena are inferred from data (usually by statistical methods). But if this is so neither phenomena nor data can be theory-laden: phenomena are not perceptually theory-laden because they are unobservable, and data are not theory-laden because they do not form the basis against which we test theories. Bogen and Woodward's simplest example for an unobservable phenomenon is the melting point of lead, at 327.5°C, which is inferred from individual data points, none of which might exhibit this exact value. A more advanced example for a phenomenon is the weak neutral current, which was inferred from bubble chamber pictures (the data). The Glashow-Salam-Weinberg model explains and predicts the neutral current, but not the bubble chamber pictures.

Theory-dependence of instruments

P. Feyerabend, in his *Against Method*, pointed out that Galileo, when gathering telescopic observations in support of the sun-centred universe in the early 17th century, had no knowledge of the working of the telescope. Amongst other things, Feyerabend reasons that Galileo would have needed such a theory to provide good grounds to convince his sceptical contemporaries of the truth of heliocentrism. Pointing the telescope to terrestrial objects in order to demonstrate its magnifying effect would not have sufficed since his contemporaries thought that the physics on earth was completely different form the physics of the heavens. In fact, Feyerabend accuses Galileo of circular reasoning: in order for Galileo's telescopic observations to be acceptable evidence for his contemporaries, Galileo had to show the inadequacy of the Aristotelian "two-physics" world picture. But in order to show this, he relied on his telescopic observations, which, again, presupposed that the physics on earth and the physics of the heavens were the same.

Several strategies have been proposed to counter the alleged theory-dependence of instruments leading to the circularity of testing procedures. Some philosophers have accepted the theory-dependence of instruments and have demanded that the tested theory be *independent* from the theories that are presupposed when instruments are used (P. Kosso). Others have simply denied that one needs knowledge of how an instrument works in order to *use* that instrument in such a way that it produces reliable data. I.

Hacking's *Representing and Intervening* has been influential in this respect. He points out that observations made with microscopes in the 19th century were trusted despite no accurate theory of the microscope being available. Hacking also argues that the observations made by biologists when using microscopes are not undermined by the fact that biologists regularly know rather little of the physics that underlies these microscopes. And yet *someone* knows about it. But even if reliability of experimental results depended on background theories, Hacking argues, scientists have a powerful strategy for addressing this problem. This is Hacking's famous 'argument from coincidence', which is also known as the 'robustness' argument. It says that it would be a preposterous coincidence if the observations made with *several* instruments each presupposing *different* background theories were to converge and the observations were not reliable. Hacking's example is the presence of red blood platelets in the same locations (of a grid) when viewed with the optical and the electron microscope. The robustness argument has been complemented with various other 'epistemological strategies' in the work of A. Franklin. Still other philosophers have not been convinced that theory-dependence of instruments of the circular variety should be taken seriously. H. Chang in his *Inventing Temperature* considers the example of establishing that mercury expands uniformly with a raise in temperature in the production of reliable thermometers in the 19th century. In order to do this, one had to plot volume of mercury vs. temperature. But for that one of course needs a reliable thermometer which was what scientists had set out to discover in the first place. But Chang argues that this kind of circularity is innocuous: even if the theory assumed when using a particular instrument is the same as the one at stake, the actual experimental result is still contingent. In other words, the reliance on assumptions which we wish to establish when using a certain instrument does not imply that results gained with those instruments are guaranteed to be of a particular form.

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See also

Empiricism, Relativism in Scientific Theories, Kuhn on Scientific Revolutions and Incommensurability, Holism (Philosophy of Language)

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