Poincaré, Jules Henri (1854-1913)

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Biography

Jules Henri Poincaré was born in 1854 in Nancy, France to mother Eugénie, who had interests in mathematics, and father Léon, who was a professor of medicine. During his childhood he suffered from diphtheria, which left him with a temporary paralysis of the larynx and legs, during which time he invented a sign language to communicate. He went to school between 1862 and 1872 where he showed great aptitude for science and mathematics as well as philosophy. He studied mathematics at Ecole Polytecnique from 1873 to 1875 and continued his studies in engineering at the Mining School in Caen while also receiving a doctorate in mathematics from the University of Paris in 1879 for his work on partial differential equations. In 1886 he took the chair in mathematics in the Faculty of Science in Paris.

His contribution to mathematics started during his graduate studies, with him quickly gaining an international reputation for his innovative work on complex function theory, complex differential equations, automorphic functions, real differential equations and a new way of thinking about celestial mechanics, creation of the subject of algebraic topology, algebraic geometry and Lie's theorem of transformation groups. Beyond mathematics, he also gained an impressive reputation as a leading expert in electricity, magnetism and optics, and wrote seminal work on the special theory of relativity. He was actively engaged with the public as well as his scientific peers and was passionate about communicating scientific and philosophical ideas to the wider public.

Science and convention

Poincaré's work on non-Euclidean geometry invited the reconsideration of the status of geometry and his introduction to conventionalism, a thesis he is perhaps most known for in philosophy. His conventionalism, however, is a matter of much debate, and the arguments he mastered from 1902, when his *Science and Hypothesis* was published, until his later essays, significantly refine. Starting with his argument for the empirical equivalence of Euclidean and non-Euclidean geometries, advanced in *Science and Hypothesis*, Poincaré argues that modifications in the physical laws can make it possible to describe our experience as taking place within a Euclidean or non-Euclidean space. While at the time his contemporary Pierre Duhem was also developing his argument for the underdetermination of theory by evidence, in this chapter Poincaré shows how the problem of equivalent descriptions can take concrete place in practice, with geometry now being underdetermined by experience. This very fact led Poincaré to conclude that geometry cannot be empirical. But how does he arrive at the idea that geometry is conventional? Poincaré accepted much of Immanuel Kant's epistemology, and his categorization of geometry as synthetic a priori knowledge. With the problem of geometric underdetermination, he arrives at the idea that geometry is not empirical, but he also rejects the idea that geometry can be synthetic a priori, since Euclidean geometry is not uniquely imposed upon us by reason. We can conceive of the negation of the fifth axiom of Euclidean geometry and have constructed consistent geometries based on its negation; these facts entail that geometry must have a different epistemic status. In light of this, since geometry no longer fits within the Kantian framework, Poincaré introduces the epistemic category of convention.

In a later chapter of *Science and Hypothesis* Poincaré discusses the laws of motion in Newtonian mechanics, and deems them also to be conventional. This fact made many of his contemporaries, such as Abel Rey and Édouard le Roy, to deem his broader philosophical stance towards scientific theories as conventionalist, a thesis attributed to him by many contemporary scholars as well. But Poincaré certainly did not intend for his argument to be taken to apply to empirical science in general; rather it was more narrowly focused and sophisticated. His argument for the conventionality of Newton's laws of motion was motivated by the fact that the truth of these laws could not be established either a priori or a posteriori. The important point he made is that these laws are conventional and serve to define the central concepts of Newtonian mechanics, opening the door to the much discussed account of constitutive principles in science later advocated by philosophers such as Hans Reichenbach, Arthur Pap and advanced in the contemporary literature by Michael Friedman and David Stump.

In his second philosophical book, *The Value of Science*, published in 1905, Poincaré further develops his ideas on the status of arithmetic, geometry and experimental science, and defends scientific knowledge against the generalised conventionalism with which he was associated after the publication of *Science and Hypothesis*. The chapters 'Is Science Artificial' and 'Science and Reality' are particularly targeting the assumptions of his contemporaries, especially Édouard Le Roy, who interpreted his conventionalist arguments to generalise to science as a whole. Poincaré makes clear that he localises the conventionalist thesis to certain hypotheses only – geometry and Newtonian mechanics – rather than seeing conventionalism as a generalised stance towards scientific theories.

Theory transitions

In 1900 Poincaré gave a public talk at the International Congress of Physics in Paris entitled 'The Relation Between Experimental Physics and Mathematical Physics', to appear later as the chapter 'The Theories of Modern Physics' in *Science and Hypothesis*. In this talk he argues against the widely debated pessimistic take on scientific progress, the argument from 'the bankruptcy of science'. While acknowledging that much theoretical change indeed occurs in theory transitions, he motivates a more optimistic stance towards science by arguing that every theory contributes to scientific progress and not all of a past theory is lost when it is replaced by a new theory. Rather, some of the theoretical components, the 'structure' of the theory, is retained, while much of the speculative components of a theory are revised and lost. A famous example concerned the change from Fresnel to Maxwell that saw the mathematical structure of the theory carry over in the theory transition, but the same did not occur at the level of the unobservable entities, with the ether being abandoned. Poincaré's argument has received much attention, with John Worrall (1989) interpreting it as a form of selective scientific realism, which he calls 'structural realism'.

Poincaré was also interested in the philosophical debate on time measurement, stemming from practical work on determination of longitude and his and scientific interest in electromagnetic and optical phenomena. He introduced the idea of relative motion and the rejection of Newtonian absolute time by recognising that the measurement of duration or simultaneity involves the introduction of convention. Many have been fascinated about the relationship between Poincaré and Einstein and how much the special theory of relativity was conceived by the former. His 1906 lectures *On the Limits of the Law of Newton* engages with the laws of relativity. While his discovery of the Lorentz group made the ether irrelevant, Poincaré's search for dynamical solution to the observed Lorentz contractions and dilations prevented him from going as far as Einstein into the theory of relativity.

The atomic hypothesis

Perhaps one of the most surprising turns in Poincaré's philosophy concerns his attitude towards the atomic hypothesis. His distrust towards atomism was originally due to scientific and philosophical objections. Poincaré classified the atomic hypothesis as 'indifferent', arguing that atomism can at best be admitted as a fictional device that aids our thinking, but cannot be construed as an empirical hypothesis and that we cannot infer the real existence of atoms. He also compared the atom to the ether, the existence of which he did not commit to and claimed it will be abandoned by future theories. Such scepticism towards the atomic hypothesis was not uncommon, with other contemporary scientists, such as Ernst Mach, Pierre Duhem and Wilhelm Ostwald dismissing the theory as a metaphysical speculation. Yet, in 1912 Poincare delivered a lecture at the French Society of Physics, following Jean Perrin's talk on Brownian motion, in which he accepted Perrin's results and famously stated that the atom of the chemist had become reality, arguing that one could claim atoms have been made observable since they have been made countable. This turn in Poincaré's thinking has caused a rather intense debate among his interpreters, with some claiming Poincaré became a scientific realist. The argument Poincaré advanced however, can be seen as more consistent with his previous commitments, by taking it as an argument for the acceptance of the atomic theory as a theory supported by the evidence. His original distinction between indifferent, conventional and empirical hypotheses gives us context to understand the level at which Poincaré changed his mind. Poincaré took the evidence provided by Perrin to shift the classification of the atomic hypothesis: he made it from metaphysical and indifferent, to empirical and testable, with its quantities now being empirically determinate. He also raises the question, just like Perrin did in his presentation, as to which 'atom' we are accepting: the metaphysical, physical or chemical? While admitting the empirical evidence that has become available in favour of the atomic hypothesis, Poincaré claims that this is certainly not the indivisible atom physicists have been aiming to find since antiquity and this new atom brings a whole lot of new problems and mysteries, echoing the pessimistic argument he had previously developed.

Science and aesthetics

Contemporary philosophers of science have recently become invested in studying the relationship between science and aesthetics. Similarities in the notion of representation in art and in science have given rise to fruitful discussions as to how theoretical constructs reflect or represent nature, and the notion of beauty in science and its role in practice has also motivated a lot of debates, as well as the notion of creativity and imagination in scientific discovery. While not always explicitly acknowledged in these debates, Poincaré certainly engaged with the notion of beauty in science, with the question of whether an aesthetically pleasing theory is more likely to be true, and tried to articulate his own theory of creativity in the context of mathematical discovery. In *Science and Hypothesis* Poincaré asks what role aesthetic values such as simplicity and unity play in science: are they guiding us to the employment of useful theories or are they guiding us to the truth? He offers an interesting account for aesthetic values, taking simplicity and scope or unity to be a guide in scientific theorising. Preference for a simple theory that accounts for the largest number of facts is a regulative ideal guiding the development and choice of theories. He is, however, careful to clarify the epistemic role of such values, claiming that we should not infer the simplicity or unity of the world from the simplicity and unity of our theories. Later in *The Value of Science*, Poincaré's account receives further elaboration, showing the depth of his argument. Addressing now a different problem, that of accounting for the value of science, Poincaré claims that scientists are motivated to discover beauty in nature. This search for beauty, the simplicity and unity of nature, provides the value of science and motivates scientists. It is here that we can start to see a reductivist approach to beauty – in terms of simplicity and unity – and some Kantian threads in his account. Poincaré claims that it is us that impose beauty on the world, that our aesthetic requirements guide our investigations and our intellect works together with our aesthetic sensibility. Later in *Science and Method* he draws an analogy between the scientist and the artist, claiming that the scientist selects the facts that would best satisfy the requirement of the aesthetic as the painter chooses those features of a person that would make the portrait most lively. Poincaré's account of beauty has only recently received a detailed analysis but his contribution to this topic in philosophy is unquestionable, offering insightful new ways to think about aesthetic judgement in science.

Mathematics and creativity

Poincaré's discoveries in mathematics certainly made him reflect on the nature of scientific discovery and creativity, leading him to develop an insightful account of creativity, showing again his innovative philosophical thinking. Creativity has been subject to substantial philosophical work. It is important because we attribute value to works of art and scientific discoveries and often we are interested not only in the properties that the work might possess, but also in the process by which it was brought about. We value originals, not forgeries. We care about credit attribution and the original discoveries, rather than replications. In his chapter 'Mathematical Discovery' from *Science and Method*, Poincaré takes creativity to be the identification of unsuspected relations among known facts. What is particularly fascinating is his exploration of the creative process, which he divides into four phases: preparation; incubation; insight; and revision. Preparation is the process during which the subject consciously studies the problem at hand. During incubation, the subject's mind freely explores possibilities without being conscious about it; he calls it 'the unconscious machine', and comes up with 'sudden illuminations'. Next, the mind explores the tenability of the ideas, followed by critical conscious reflection after the inspiration in order for the ideas to be evaluated and verified. This account critically differs from the standard inspirationalist, romantic, accounts of creativity, seeing creativity as an unconscious process (often attributed to divine inspiration). Poincaré offers a more complex understanding of creativity as a product of both conscious and unconscious processes and places the aesthetic sensibility at the centre of this process as it is the aesthetic sensibility that screens which solutions of the unconscious mind satisfy its aesthetic requirements. The aesthetic sensibility acts as a "delicate sieve" which selects the theories or proofs that best suit our aesthetic requirements.

From conventionalism and structuralism, to creativity and beauty, Poincaré's contribution to philosophy is immense, and his views, while having received systematic analysis and appreciation among the philosophers of today, will certainly continue to inspire and illuminate the next generations of thinkers.

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