The World as a Collection of Facts

Ludwig Wittgenstein (1889-1951), Bertrand Russell's one-time protégé in logic at Cambridge, may have been the closest counterpart to Aristotle as a deductive philosopher during the era when quantum mechanics was being developed, with the difference being [554, p. 357],

See the print edition of The Quantum Measurement Problem for quotation.

The ancient Greeks actually did not have a word for "fact" but could account for the inventory of things in their lives or imaginations: earth, water, fire, air, gods, angels, demons, the prime mover. In contrast, facts are relations between things or situational arrangements. Facts appear to have taken over our system of thought at about the same time that modern science developed during the 17th and 18th centuries. Instead of asking for the essence of material substances, science begins to ask how matter interacts with other matter. And Newton appears to be the first scientist to master this approach particularly with his universal theory of gravitation [554, p. 367]. However, not all scientists were up to the task, Descartes being a prime example. As we will see, the difference is between deductive and inductive reasoning. Deduction represents the approach of the most successful fundamental physical theories. This continued up to the development of quantum theory in the early 20th century with Bohr asking about the facts of a measurement and that observing the same system with different experimental arrangements can be mutually exclusive. Bohr was asking about the logic of facts and Wittgenstein attempted to address this at about the same time. Bohr later began using the term *phenomenon* to describe this [9, p. 425].

Ludwig Wittgenstein was perhaps the most influential philosopher of the 20th century though he was not in any sense a typical philosopher [555]. He inspired two important schools of thought, both of which he repudiated, i.e., logical positivism and linguistic philosophy. These influences stemmed from his early work *Tractatus Logico-Philosophicus* [556] and the posthumously published *Philosophical Investigations* [557] respectively, "the *early* and *late* Wittgenstein." Much of the focus of Wittgenstein, though approached very differently in the early and late works, dealt with the world, thought, and language and the inherent limitations in communicating aspects of these. The famous last line of the *Tractatus* is:

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Although Wittgenstein did not have a direct interest in quantum mechanics, the trajectories of his ideas ran remarkably parallel to those of Bohr's with his complementarity view of the quantum. Interestingly, the geographical points and times of Wittgenstein's early seminal work also coincidentally overlap with those of Bohr's: Manchester, Cambridge, and Como in the early 1900s. For Bohr: (1) Cambridge in 1911 with J.J. Thompson, (2) Manchester in 1911-12 with Rutherford for the atomic model, and (3) Como in 1927 for his announcement of complementarity. For

Wittgenstein: (1) Manchester in 1908-11 for doctoral studies in aeronautical engineering which morphed into an obsession with the foundations of mathematics, (2) Cambridge in 1911-13 with Russell for work on logic, and (3) Como in 1918 as a prisoner of war captured at the Italian front with the draft of the *Tractatus* in his rucksack, which he completed in captivity. Wittgenstein was the son of an industrial magnate and grew up in the Palais Wittgenstein in Vienna, with frequent visitors such as Freud and Brahms, and surrounded by a precocious but intense family (three brothers committed suicide). From his inheritance, he was perhaps the wealthiest man in Europe at one point, but one of the first steps he took was to give away this fortune to simplify his life. Wittgenstein's plans to study physics with Boltzmann were ended by Boltzmann's unexpected death in 1906. As discussed in the section *Atomism Prevails*, Boltzmann's periods of depression may have been exacerbated by the intense opposition to his ideas on statistical irreversibility and atomism. As we have also seen in *The Fall of Classicality*, Planck's discovery of the quantum required him to overcome his previous rejection of Boltzmann's ideas. Wittgenstein's subsequent studies in aeronautical engineering in Manchester piqued an intense interest in the foundations of mathematics, and he was advised by Frege to join Russell in Cambridge. Turing later attended Wittgenstein's lectures on the foundations of mathematics.

Wittgenstein attempted in the *Tractatus,* published in 1921, to decipher the possible logic of the world in terms of facts. It was adopted by the logical-positivists as their playbook, though Wittgenstein could not take their efforts seriously. It takes the form of a seventy-five-page list of hierarchically numbered propositions in austere prose, mathematical logic, and Wittgenstein's innovation of the truth-table and begins,

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During the development of quantum mechanics, Heisenberg had recalled Wolfgang Pauli saying [182, p. 206]:

> *It is part and parcel of the positivists' creed that facts must be taken for granted, sight unseen, so to speak. As far as I remember, Wittgenstein says: The world is everything that is the case. The world is the totality of facts, not of things. Now if you start from that premise, you are bound to welcome any theory representative of the case. The positivists have gathered that quantum mechanics describes atomic phenomena correctly, and so they have no cause for complaint.*
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However, as Bohr would have agreed, the constraints of formal logic are not subtle enough to encompass the quantum mechanics of measurement occurring under various experimental arrangements. Wittgenstein reportedly was first put off from the logical basis of his *Tractatus* while arguing with his friend, the Italian economist Piero Sraffa,

that a proposition and that which it describes must have the same logical form. Sraffa made a Neapolitan gesture of contempt, brushing up underneath his chin, and asked,

> *What's the logical form of that?*
> *Ludwig Wittgenstein, A Memoir by N. Malcolm (1975),*
> *By permission of Oxford University Press.*

Wittgenstein said that his discussions with Sraffa made him feel like a tree from which all branches had been cut [558, p. 15] and, like a true deductive reasoner, abruptly set out on a new path. This eventually led to *The Philosophical Investigations* and its exploration of facts through the meaning of concepts and activities within a multiplicity of what Wittgenstein called *language games*, by traveling with the word's uses through a complicated network of similarities, overlapping and criss-crossing. [557] In his survey of Bohr's contributions to the foundations of quantum theory, philosopher Edward MacKinnon summarizes [435, p. 115],

> *In his earlier conceptual analyses Bohr had focused on the proper way of extending classical concepts to, and restricting their usage in, quantum domains. His later work forced him to come to grips with the problem of how any concept has meaning. Though he never developed a systematic theory, he anticipated some of the key features later developed in Wittgenstein's Philosophical Investigations. The meaning of a word is determined by its usage in language, not by the objects it can or may denote. Bohr's analysis clarified the possible meanings of "particle" and "wave" within the contexts of experimental sources of information of atomic systems. Bohr also extended this approach to such higher order terms as "observe", "objective", "real", and "exist", analyzing the conditions of the possibility of unambiguous communication of information.*
> Reprinted by permission of Edward MacKinnon.

For Bohr, philosophical problems were about the general conditions for the communication of facts [559]:

> *What is it that we human beings ultimately depend on? We depend on our words. We are suspended in language. Our task is to communicate experience and ideas to others. We must strive continually to extend the scope of our description, but in such a way that our messages do not thereby lose their objective or unambiguous character.*
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> *There is no quantum world. There is only an abstract quantum physical description. It is wrong to think that the task of physics is to find out how nature is. Physics concerns what we can say about*

nature.

The Philosophy of Niels Bohr, A. Petersen, Bulletin of the Atomic Scientists 19 (7), 8 (1963), Taylor & Francis, reprinted by permission of Taylor & Francis Ltd. http://www.informaworld.com