Open Peer Review on Qeios

In the doing of science, what is the place for naturalistic philosophy? Implications for the teaching of science

David Turnbull[1], Ross Barnard[2]

1 The University of Queensland
2 University of Queensland

Funding: No specific funding was received for this work.

Potential competing interests: No potential competing interests to declare.

Abstract

It has been argued that naturalistic philosophy is nothing like science, and that science and naturalistic philosophy are methodologically distinct. This claim has been grounded in the view that science is entirely methodologically experimental; it is to do with testing hypotheses, *a posteriori*. Philosophy is methodologically argumentative, testing the validity of arguments, *a priori*. If *doing* science is only about doing experiments, it seems to follow, quite logically, that there is no place for naturalistic philosophy in *doing* science. We do not take the view that doing science and doing experiments are equivalent, but rather, that there is far more to the scientific project than experimentation. We suggest that scholars should consider the views of eminent scientists who we consider might be taken as examples of doing naturalistic philosophy *from within science*. We propose theoretical physicists Richard Feynman and Werner Heisenberg as examples, as well as discuss relevant contributions of physicist Niels Bohr, philosopher Ludwig Wittgenstein and political theorist Hannah Arendt. We argue that *both* the *a priori* and *a posteriori* have a vital role in the doing of science.This more complete view of what constitutes the *doing of science* has implications for the teaching of science, and calls for an emphasis on the conjectural and creative aspects as well as the purely methodological.

Introduction

Until the 1830s, people like Darwin were known as *natural philosophers*. A categorical schism had its origin in 1833 with the coining, by William Whewell, of the name “scientist” to describe members of the British Association for the Advancement of Science. Thenceforth, the task of scientists changed from the systematic elucidation of an underlying divine plan, to the solving of a secular puzzle (Henig, 2001). The debate surrounding this ostensible schism has persisted, metamorphosed, and reemerged in various guises and contexts since that time.

In her article *Naturalism’s maxims and its methods. Is naturalistic philosophy like science?*Carin Robinson (2018) argued that naturalistic philosophy is nothing like science; that science and naturalistic philosophy are methodologically distinct. This claim is grounded in the view that science is entirely methodologically experimental; it is to do with testing hypotheses, *a posteriori*. Philosophy is methodologically argumentative, testing the validity of arguments,*a priori*.

If *doing* science is only about doing experiments, it seems to follow, quite logically, that there is no place for naturalistic philosophy in *doing* science. Robinson's article is an attempted refutation of some recent proposals by philosophers, who maintain that naturalistic philosophy is either already like science, or *ought* to be like science.

We do not take the view that doing science and doing experiments are equivalent, but there is far more to the scientific project besides. In a recent review (anonymised, 2022) of Robinson's article, we suggested that scholars should consider the views of eminent scientists who we considered might be taken as examples of doing naturalistic philosophy *from within science*. We proposed theoretical physicists Richard Feynman (1963) and Werner Heisenberg (1959). In the present article, we include material concerning these scientists that did not appear in that review article, as well as discuss relevant contributions of physicist Niels Bohr, philosopher Ludwig Wittgenstein and political theorist Hannah Arendt.

Arendt (1958) posed a problem about the intelligibility of science from a position outside of science that still to this day requires a response from those within it. We turn Arendt's problem into a question. To what extent are the "truths" of science capable of normal expression in speech and thought? We go in search of an answer to this question through a discussion of the Bohr-Heisenberg debate concerning the meaningfulness of various concepts in science. These concepts include the principle of complementarity, a principle that Bohr proposed as an answer to the problem of intelligibility concerning the wave-particle duality in quantum physics. Bohr claimed this principle was relevant to sciences other than physics, including psychology, biology, and anthropology. The Bohr-Heisenberg debate provides an example of naturalistic philosophy as it has occurred in science in which the problem of intelligibility to which Arendt refers eventually spilled over into the political arena. The importance of this debate to the present day provides one example of the place for naturalistic philosophy in the doing of science.

In this article it is argued, first, that there is a natural affinity between naturalistic philosophy and the doing of science. Whilst science is always required for the empirical testing of hypotheses, the mandate for *doing* science has its roots in naturalistic philosophy, including moral philosophy. In general, naturalistic philosophy deals with concepts that relate to the world as expressed in natural language, as it has evolved (in English and some other European languages) from a stock of root words derived, to a considerable degree, from ancient Latin and Greek. In that sense, naturalistic philosophy occupies an intermediate position between natural language and the appropriation of that language for specific uses in science.

The argument draws upon two themes that originated first in natural language, then taken up into naturalistic philosophy, and which still have direct relevance to the doing of science. The themes are (a) time, and, (b) being. From time are drawn the concepts of *a priori* and *a posteriori.* From being is drawn the concept of *the human condition.* Taken together, these concepts concern the existential or humanistic dimension of naturalistic philosophy in doing science.

The *a priori* and the *a posteriori*

The term *a priori,* in its Latin derivation, means 'from the former'.[1] 'The former' signifies some aspect of the world which, while belonging to the past, is in a state of continuity over time with the present. This state of continuity is said to be

constitutive of the world. Philosophically speaking, we are henceforth able to discuss a specific class of statements called the *'constitutive a priori'* of natural language.

The class of *constitutive a priori* statements expressed in natural language is the bedrock of understanding upon which our current knowledge of the world through modern science is built. This bedrock forms the basic family of concepts that enable us to see the world as *our* world, that is, a world *to which we belong*. Another word for the basic family of concepts is the *ontology* that is embedded in natural language.

Science also draws on the *a posteriori*, which in its original use means 'from the latter', but which has come to mean for science, 'a kind of knowledge or justification that depends on evidence, or warrant, from sensory experience' (Moser, 1998)[2]. The *a posteriori* is both a kind of knowledge and a form of justification based on evidence. Justification for what? It cannot simply be for the claim that evidence *is* knowledge, for if that was all there is to the matter, there would be a complete circularity, whereby evidential knowledge is self-justifying. The question could still be asked: evidence for what? The evidence must be a justification, not simply for some item to count as knowledge, but for the claim that this *kind* of knowledge (i.e. *a posteriori* knowledge) *is constitutive of the world.*

The constitutive *a priori* and the constitutive *a posteriori* belong to the world in different ways. The *constitutive a priori* are the terms and concepts in natural language that bind statements about the world into a coherent whole; that render them meaningful in various ways that cannot be expressed directly in statements of science based on experimentation. Statements of principles in ethics are examples of *constitutive a priori* statements. The *constitutive a posteriori* provides the guarantee that so long as the statements that come about on the basis of evidence, continue to circulate as useful knowledge, the work of science will not be lost; that it will be available for further use in the ongoing formation of the world. On this account, there cannot, in science, be a complete disjunction between the *a priori* and the *a posteriori.* Any part of science, which relies *a posteriori* on sensory evidence, also relies on terms and concepts in natural language, for the interpretation of that evidence.

It would appear then, that there are two related forms of justification in science.

One kind of justification is that from which science draws its interpretation, the *constitutive a priori* of language that remains stable and coherent over time. Another kind of justification is the sensory experience that provides evidence, upon which new knowledge is built, termed the *a posteriori*. In this way the *a posteriori* and the *a priori* become two ways of relating to the world, each providing contrasting and yet interdependent perspectives.

The human condition

Humanistic philosophy examines the meaning of *'being in the world'*, another term for which is *'the human condition'*. Whatever is, or becomes, constitutive of the human world, not only *exists*, but *persists*. This is not to say that being in the world is impervious to change, or that the human condition persists unchanged. The human condition is not the same as 'a human nature or essence', discoverable by science (Arendt, 1958, p. 10). The idea of the human condition is based on

the continuity of what we do, with who we are, as persons, which is also to say, as mortal human beings. The *a priori* justification for such claims is as follows.

With each passing day, every human being is somewhat different to the day before; but he or she remains the same *person*. Being the same person is the only guarantee that what a person initiates doing, and what he/she finishes doing, is the same activity, continuous over time. Today I *am writing* the article I *began writing* some days ago. Tomorrow I *will write* more in the same article. Each day the article becomes slightly different. But it remains the same article. The reason is that I am the same person who initiated writing the article. I am also the same person who insists that it will one day be finished to my own satisfaction. Temporality, as a continuous process of change in which personhood persists, provides the link between the human condition as remaining stable over time, and what humans do, as constitutive of the world. Unless subject to extraordinary disqualification, that there is a continuous person who is capable of doing things that contribute to the persistence of the world, typically does not require any *a posteriori* justification from science.

The existential dimension of naturalistic philosophy in doing science

Life, as lived, provides an immediate connection with reality (a point recognised by Heisenberg, in *Physics and Philosophy*); an immediacy that extends from past to future. This immediacy, or lived reality, is human existence, pure and simple, albeit as interpreted through natural language. The terms 'existence' and 'existential' move thinking beyond the terms '*a priori*' and '*a posteriori*'.[3]

Naturalistic philosophy, in its existential dimension of being rooted in natural language, is deeply involved with the formation and interpretation of concepts and language of science, and has a role in their justification.

First, there is an existential dimension that is embedded in natural language *in general* which is shared with science that renders science intelligible. This *in general* existential dimension of natural language is already part of the scientific endeavour, insofar as natural language enables humans to express a sense of wonder, to ask questions and make assertions that relate to the natural world. One of the roles of naturalistic philosophy is in making this existential dimension explicit.

Second, there is a specific existential concept of 'the good'. This naturalistic *moral* concept is part of the ultimate justification for doing science. The contribution this concept makes to scientific justification is that the knowledge science produces *ought to be* a benefit to humanity and to the world. This existential dimension is contained in the maxim that Plato attributed to Socrates, that the good must be *good for something* (of value to human beings), to even qualify as good.[4]

These two levels of affinity place naturalistic philosophy in connection with the occupations where *doing* science occurs. Hence there must be an occupational connection between doing naturalistic philosophy and doing science. The occupation cannot be solitary or merely subjective. It requires dialogue, and such dialogue requires a 'third space', one that is neither purely scientific nor purely philosophical (Barnard & Turnbull, 2006). The doing of naturalistic philosophy in

science depends on, and is given by, the relationship between natural and scientific language. Such a relationship indicates that doing naturalistic philosophy includes investigating the logic of scientific language, interpreting the results of experiments in terms that are accessible to a wider public, and developing new concepts to provide tools for the doing of experimental work.

In the following sections, we apply the themes introduced in the previous section to various topics that originate in the overlap (the fuzzy boundary) between naturalistic philosophy and science.

Feynman, Heisenberg and Wittgenstein

We commence our discussion by drawing attention to the close affinity between Feynman's naturalist philosophical approach (in Vol.1 of his *Lectures on Physics*) and Ludwig Wittgenstein's (1922) *Tractatus Logico-Philosophicus.* As Wittgenstein (1922) argues in his own naturalistic philosophical account of science,

> *2.1 We make to ourselves pictures of facts. 2.11 The picture presents the facts in logical space, the existence and non-existence of atomic facts. 2.12 The picture is a model of reality. (Quote italicised, as are all direct quotes in what follows.)*

Similarly, Feynman outlines, *a priori,* the basic assumptions that comprise the world-picture of physics. As a method of enabling an understanding, piece by piece, of this total world-picture, Feynman draws numerous little pictures, for instance of atoms jiggling side-by-side in an enclosed space under different conditions.

Both Wittgenstein and Feynman are examples of doing positivist naturalistic philosophy. Wittgenstein was a philosopher and Feynman a physicist. That naturalistic philosophy in the first part of the 20th century influenced science, and *vice versa*, seems abundantly clear from the historical record, captured in innumerable articles and books about members of the Vienna school, as well as Popper, Quine, Dewey, and others. This seems to suggest that rather than a strict or solid line demarcating naturalistic philosophy and science, there is instead porosity, evidenced by numerous channels of communication.

In the works by Wittgenstein and Feynman cited above, there is an assumed correspondence between a picture in science as a model of reality, and reality itself. Each picture, in combination with others, aggregates to a total world-picture. This is not quite the same as a worldview. A world-picture (in science) is about the aggregation of facts. A worldview is about the perspective a viewer takes.

As Feynman postulates, in expanding the world-picture of physics to include biology,

> ***Everything is made of atoms***. *That is the key hypothesis. The most important hypothesis in all of biology, for example,* ***is that everything that animals do, atoms do.****In other words,* ***there is nothing that living things do that cannot be understood from the point of view that they are made of atoms according to the laws of***

> ***physics.*** *(Feynman, 1963, Vol 1, 1-8. Boldface to capture Feynman's italicised emphasis.)*

The statement, 'everything that animals do, atoms do' is a violation of the intelligibility of natural language. Animals can do an enormous range of things, including run, bound, leap, climb, swim and fly. Atoms can do none of those things. In making this statement, Feynman is asking the students in his *Lectures on Physics* to take leave of their senses, and to take *the point of view* of physics. Without even noticing it, or at least not drawing attention to it, Feynman has jumped from physics into metaphysics. This feature of positivism, that it fails its own requirement of strict empiricism, is the key to understanding the debates that occurred in relation to quantum physics involving such eminent physicists as Einstein, Schrödinger, Pauli, Heisenberg and Bohr.

Heisenberg brings into question the relation of the basic propositions of physics (especially quantum physics) with reality. In that sense, Heisenberg moves the doing of naturalistic philosophy in science beyond positivism. Heisenberg states,

> *Quantum theory does not allow a completely objective description of nature. In biology it may be important for a complete understanding that the questions are asked by the species man which itself belongs to the genus of living organisms, in other words, that we already know what life is even before we have defined it scientifically. (Heisenberg, 1959, pp. 94,95)*[5]

Here Heisenberg argues that biology poses its questions from the perspective of a living organism. Since humans are already living, *we already know what life is even before we have defined it scientifically*. I refer to this postulate as an example of an *a priori* of human existence (an existential *a priori*); or more simply, an existential. Heisenberg goes on to state,

> *Furthermore, one of the most important features of the development and analysis of modern physics is the experience that the concepts of natural language, vaguely defined as they are, seem to be more stable in the expansion of knowledge than the precise terms of scientific language, derived as an idealization from only limited groups of phenomena. This is in fact not surprising since the concepts of natural language are formed by the immediate connections with reality;... But through this process of idealization and precise definition the immediate connection with reality is lost. (Heisenberg, 1959, p.188)*

The realisation that *the concepts of natural language are formed by the immediate connections with reality* goes hand-in-hand with Heisenberg's other realisation that in the theoretical *idealisation and precise definition* that underpins scientific methodology, *the immediate connection with reality is lost.* Only human beings immersed in natural language are capable of immediately and directly connecting with reality. There is, from Heisenberg, a suggestion of a difference between having a direct connection with reality in natural languages and (at best) having an indirect connection with reality through science.

I see the difference between Feynman (in *Lectures on Physics Vol. 1*) and Heisenberg (in *Physics and Philosophy*) as

both having an affinity with Wittgenstein, but of two different sorts. The former is with the Wittgenstein of the *Tractatus*; the latter with the later work of Wittgenstein, in books such as *Philosophical Investigations,* where that philosopher introduces concepts such as *family resemblances, language games* and *forms of life*. In moving from one kind of affinity to the other, there is not so much a movement between two world-pictures, but a movement from an approach in which the world is modelled using pictures, to natural language in which an entirely *univocal* worldview is neither given, nor is it giveable. What natural language enables is an enormous variety of worldviews, none of which are complete in themselves, even though people of various ideological persuasions do have an affinity with one worldview over others. Having a worldview requires taking a perspective. A perspective is a connection with reality from one direction, not a complete grasp of reality from all directions at once. Natural language poses the problem of *plurivocity*; a problem that is not able to be overcome by insisting on *univocity* in the *a posteriori* of scientific research.

Hannah Arendt, the human condition, and existential consequences of doing science

At this juncture, we will examine, more closely, some of the existential consequences of the fuzzy boundary between physics and philosophy. These consequences are revealed in the difference between taking either an *a priori* or *a posteriori* axiomatic perspective in science and having an immediate connection with reality. One of the most important consequences is that in a world dominated by modern science and the proliferation of technologies, there has been the loss of a sense of reality among the wider population (perhaps even among scientists themselves). Hannah Arendt referred to this phenomenon as *world alienation.* Arendt, in the Preface to *The Human Condition* (1958) noted that the question of the direction of how we wish to use our new scientific and technical knowledge, '*is a political question of the first order and therefore can hardly be left to the decision of professional scientists or professional politicians.*' (Arendt, 1958, p.3) The kind of politics that Arendt had in mind was *engaged* politics. Of concern to Arendt was the possibility of changes to the human condition through the agency of science.

Writing about the cutting of ties with the natural condition into which humans in previous eras had been born, and the creation of a completely artificial world for instance through space travel, and widespread automation, she states,

> *While such possibilities still may lie in a distant future, the first boomerang effects of science's great triumphs have made themselves felt in a crisis within the natural sciences themselves. The trouble concerns the fact that the "truths" of the modern scientific worldview, though they can be demonstrated in mathematical formulas and proved technologically, will no longer lend themselves to normal expression in speech and thought. The moment these "truths" are spoken of conceptually and coherently, the resulting statements will be "not perhaps as meaningless as a 'triangular circle' but much more so than a 'winged lion' " (Erwin Schrödinger) (Arendt, ibid)*

She goes on to say, '*But it could be that we, who are earth-bound creatures and have begun to act as if we are dwellers of the universe, will forever be unable to understand, that is, to think and speak about the things we are nevertheless able to do.*' (Arendt, *ibid*)

Of course, if Arendt is right, and we are unable to think and speak about what we are able to do, then that spells disaster for *engaged* politics. '(*W) e would indeed become the helpless slaves, not so much of our machines as of our know-how, thoughtless creatures at the mercy of every gadget which is technically possible, no matter how murderous it is.*' (Arendt, *ibid*)

Such political considerations were, on occasions, at the centre of discussion between the people who were at the forefront of the new quantum physics, (see Lanouette and Silard, 1992), however, here we will focus on their discussions centred on the problem of reconciling quantum physics with classical physics; in particular, the vexed issue of what became to be known as the wave-particle duality. The complexities of this issue created deep divisions within what was otherwise a cordial and friendly discussion between physicists who deeply admired each others' theoretical work. Abraham Pais (1991), in his fine scholarly treatment of those times (primarily from the mid-1920s to the mid-1950s), draws attention to the tensions between Werner Heisenberg and Niels Bohr in particular.

The Bohr-Heisenberg debate

The "new physics" was based on the impossibility of finding *a precise* simultaneous determination of both the position and velocity of an electron in its orbit around the nucleus of an atom. Added to this was the problem that when examined using different experimental conditions, the electron was observed to behave either as a wave or as a particle. What then is the correct description: a wave or a particle? Or just certain aspects of an electron that appear as a wave or particle? These problems represent two different types of uncertainty. There was no disagreement between Heisenberg and Bohr concerning the first type of uncertainty. The disagreement was a philosophical one over the second type of uncertainty, amounting to what interpretation could be given to electrons appearing in two different forms under different experimental conditions. In classical physics, the answer had to be an either/or. It could not be both.

Classical physics, however, had a problem. It assumed that an observer (including instruments used in the observation) and the observed object are wholly distinct entities. Such an assumption no longer holds with regard to experiments in the subatomic realm.[6] The problem for quantum physics is that the terms 'particle' and 'wave' receive their definition from classical physics. Heisenberg was prepared to sacrifice everything that classical physics upheld in order to produce a quantum mechanical mathematical description of the subatomic "world". However, as Bohr argued, such a description is impossible, and such a world is impossible, because the results of experiments still need to be described in terms of macroscopically observable properties.

Both Heisenberg and Bohr agreed that a complete objective description using quantum mechanics is impossible. Heisenberg thought that the loss of such a description opened the door for subjectivity in experimental situations. To give some background to the problem:

> *In 1925 Heisenberg had discovered matrix mechanics by adopting the particle picture. In 1926, Schrödinger had discovered his version of quantum mechanics by starting from the wave picture.... The mathematical equivalence*

> *of the Heisenberg and the Schrödinger picture... (had not led)... to any improved understanding of the wave-particle duality. (Pais, p. 301)*

It was only at that time that the two descriptions gradually came to be regarded as a paradox. "Subjectivity" in this context meant that Heisenberg was prepared to privilege his own ideas. Speaking of what Schrödinger had proposed (Schrödinger, 1926), or what people on Schrödinger's 'side' might add to quantum mechanics, Heisenberg wrote,

> *'I expected it would probably be wrong... That was my idea. Of course, this conviction came from the fact that we now have a mathematical scheme which is consistent, it can either be wrong or right, but if it's right then anything added to it must be wrong because it is closed in on itself.' (Heisenberg, in Pais, p. 303).*

Bohr thought that the terms 'wave' and 'particle' needed to be retained as parts of an overall description, without the need for introducing "subjective" considerations. As Pais describes the dispute,[7] Heisenberg and Bohr were talking right past each other, with great distress on both sides.

In order to resolve the problem that is inherited from classical physics, Bohr introduced the idea of complementarity. The way he first tried to get around the difficulty was to interpret 'wave' and 'particle' as referring to different ways in which an electron is (observed to behave or manifests) under different experimental conditions. In 1928 Bohr considered that they offer '*complementary pictures of the phenomena*' (Bohr, quoted in Pais, p. 315). A *picture* of a phenomenon as depicting a kind of behaviour, however, still indicates a distinction between the thing and the way it behaves. However Bohr's understanding, even of the term 'phenomena', continued to evolve.

The dispute between Heisenberg and Bohr seems to have been based on an interpretation of the state of quantum physics at that time as being either subjective or objective (or a mixture of both). Heisenberg thought that words such as 'wave' and 'particle' indicate a subjective preference for using the language of classical physics to describe quantum phenomena. Bohr's final response to Heisenberg (in 1938) has a great deal to do with his philosophical rethinking of the meaning of the word 'phenomenon'.[8] It goes as follows

> *Phrases often found in the physical literature, as 'disturbance of the phenomena by observation' or 'creation of physical attributes of objects by measurements' represent a use of words like 'phenomena' and 'observation' as well as 'attribute' and 'measurement' which is hardly compatible with common usage and practical definition and, therefore, is apt to cause confusion. As a more appropriate way of expression, one may strongly advocate limitation of the word 'phenomenon' to refer exclusively to observations contained under specified circumstances, including an account of the whole experiment. (Bohr, quoted in Pais, pp. 432, 433).*

It is this definition of 'phenomenon' that indicates Bohr's final claim that 'wave' and 'particle' are part of an overall description of *different* phenomena observed under *different* experimental conditions. He is no longer saying that a phenomenon is the way electrons, photons, and other subatomic entities *behave*. In Bohr's view, the phenomenon *is* the

experiment as a whole (entailing the entanglement of the measuring device and the object of interest); it is all of what happens and is revealed in the *doing* of the experiment. The emphasis shifts from *being* (concerning the existence of entities) to *doing (i.e. measuring the changes in a system)* Insofar as these are philosophical shifts in thinking about what the *scientists* are doing (c.f. Arendt, 1958, p. 5) the Bohr and Heisenberg debate provides an example of scientists *doing* naturalistic philosophy.

However, neither science nor naturalistic philosophy could not, and has not so far, been able to resolve the issues at the core of a debate that raged more broadly amongst physicists at that time. One of these was Albert Einstein. Pais writes, in summary of Einstein's view of the matter,

> *Having explained Bohr's concept of phenomenon, I can now state Einstein's objections to quantum physics in one brief phrase: Bohr's usage of '**phenomenon**' was unacceptable to Einstein. In contrast to the view that the notion of phenomenon **irrevocably** includes the specifics of the conditions of experimental observation, Einstein held that one should seek for a deeper-lying theoretical framework which permits the description of phenomena independently of these conditions. This is what he meant by the term '**objective reality**'... It was his almost solitary conviction that quantum mechanics is logically consistent, but that it is an incomplete manifestation of an underlying theory in which an objectively real description is possible - a position he maintained until his death. (Pais, p. 433. Boldface added to capture Pais' italicised emphasis)*

What is interesting from a *political* perspective is that Einstein's objection placed Heisenberg and Bohr in the same camp, irrespective of the differences between the latter two scientists. The theories of neither Heisenberg nor Bohr fulfilled Einstein's criterion of the need for a *complete* objectively real description. Bohr's rethinking of *'phenomenon'* whilst drawing from natural language, also gives it an entirely *experimentalist* meaning, serving his own theoretical viewpoint. Einstein's critical view captures a sentiment that is readily shared by many who take a view of reality based on natural language, including many naturalistic philosophers (as well as political theorists such as Arendt). *Some justification is needed for changing the meaning of words derived from natural language. And if they are changed, how will they be understood by a wider public?* Heisenberg's eventual response to the call for a completely objective description may well receive its existential justification from the need to put quantum physics in terms that are available to a philosophically literate public.

In *Physics and Philosophy* Heisenberg (1959) took the liberty of coining the phrase '*Copenhagen interpretation of quantum physics*' in which his views and those of Bohr were conjoined. Whilst there is credibility to Howard's (2004) claim the Copenhagen interpretation is a myth devised by Heisenberg, and one that served the agendas of others (including Feyerabend, Kuhn, and Popper), one first needs to define '*myth*' with greater precision than did Howard. The term can either be pejorative (as seems the case with Howard's article). It can also be understood in a constructive sense, that of enabling an *appropriate* (to its audience) understanding of an inherently complex situation. It is quite evident that in *Physics and Philosophy* (chapter 3) Heisenberg was appealing to a wider audience than physicists themselves. It is also plausible that Heisenberg himself saw the affinities between his own theory and that of Bohr as much greater than their

points of disagreement.

Conclusion

The preceding discussion of a small fraction of Feynman's, Heisenberg's and Bohr's contributions to naturalistic philosophy, points in the direction of a fruitful line of inquiry. Would the "truths" of science to which Arendt referred as being beyond thought and speech continue to be such a problem (as they were for Arendt in 1958) if the place of naturalistic philosophy in the doing of science was more fully recognised and accepted?

First, what of these "truths"? How far-reaching are they? Science, in the process of conducting experiments, has to be able to decide which of the following words fit the occasion: *confirmed or disconfirmed; verified or falsified; true or false.* Without such words science is useless. There is no *a priori* to these words, taken individually. There is no confirmation, verification, or truth, apart from their instances. The only *a priori* that such words possess, is language itself, in which words like true and false appear and disappear into a whole variety of language games (Wittgenstein). In the "language game" of science, those words do not fit any occasion until the results are in. This is the meaning of the *a posteriori* of science. So we should be able to say that the truths of science only extend as far as the experimental situation in which they occur.

Next, we turn to the meaning of 'phenomena' as Bohr proposed. If a phenomenon is *the entire experimental situation*, then who sets the boundaries of experiments? Surely the people carrying out experiments should be considered to be part of the experimental situation. But, in many instances, there is still a disjunction between the doing of science and people whose sense of reality derives from an immediate connection with the world. And is this still not a problem that requires continual addressing from the side of naturalistic philosophy?

On these comments hangs an answer to the one question that is the title of this article: In the doing of science, what is the place for naturalistic philosophy? Two possibilities are available.

The first is that naturalistic philosophy is already an accepted (albeit, taken for granted) part of science as illustrated by the previous discussion of the Bohr-Heisenberg debate, and there is nothing left to do, except reiterate, render explicit, or explain the concepts to students, colleagues, and the wider public.

The second is to engage in a 'third space' dialogue somewhere in-between, or in the sometimes-blurry overlap of, the *a priori* and the *a posteriori* - the existential situation - where new questions can be posed, hypotheses proposed and the results interpreted and debated in a multipartite dialogue. Such questions occur whenever science ventures into a different territory and where fresh horizons of inquiry are opened up through conceptual innovation.

What is clear is that a more complete view of what constitutes the *doing of science* has implications for the teaching of science; suggesting that at least some emphasis is required on the conjectural and creative aspects of science, as well as the purely methodological. Even within the consideration of method, there is room for more sophistication, through discussion and demonstration of the entanglement between the observer and the observed, a phenomenon discussed

above in the context of quantum physics, but demonstrable to students in much more easily understood and accessible settings, like field observation of wildlife.

Footnotes

[1] Merriam-Webster. (n.d.). *A priori.* In Merriam-Webster.com dictionary. Retrieved January 1, 2023, from https://www.merriam-webster.com/dictionary/a%20priori

[2] Moser, P. (1998). *A posteriori.* In The Routledge Encyclopedia of Philosophy. Taylor and Francis. Retrieved 30 Dec. 2022, from https://www.rep.routledge.com/articles/thematic/a-posteriori/v-1. doi:10.4324/9780415249126-P002-1

[3] Although they remain useful as tools used in justification

[4] See, *Plato's Republic.* For Plato, the ultimate form of the good resides in the realm of ideas, so Plato might be considered the founder of two forms of moral philosophy: existential and metaphysical. Here we only consider moral philosophy insofar as it falls within the scope of the existential.

[5] Heisenberg, W. (1959). Physics and Philosophy. The revolution in modern science. George Allen & Unwin

[6] Neither should it hold when considering the role of humans in observing and altering the environment

[7] See Chapter 14, section (c), Prelude to complementarity. The Bohr-Heisenberg dialog.

[8] See chapter 19 'We are suspended in language'.

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