



Heisenbergian explanation and Husserlian evidence: ontological significance in idealized language

Kevin Mager¹

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Abstract

In contemporary philosophy of science many theories of explanation are rooted in positivist or post-positivists accounts of explanation. This paper attempts to ground a phenomenological account of scientific explanation by using the works of Werner Heisenberg and Patrick Heelan. To explain something for Heisenberg is to describe what can be intersubjectively observed and conceptualized in an adequate language. However, this needs to be qualified, as not any adequate account will do. While Heisenberg thinks that Kant is right to think that a priori concepts are the conditions which make science, and thus explanation, possible, he also believes pure a priori concepts have a limited range of applicability. Neils Bohr shared this belief with Heisenberg, but thinks human thought can go no further. However, Heisenberg never gave up on the idea that we could create new concepts that act as a priori grounds for quantum entities. To go beyond Heisenberg, I believe that we should look to Husserl's account of *Evidenz* and the material a priori to help us think about a phenomenological account of explanation.

Keyword Philosophy of science · Explanation · Phenomenology · Quantum physics · Heisenberg · Heelan · Husserl

Explanation, throughout the history of modern science, has been posed as a problem.¹ Explaining and understanding “why” something happens is always an interpretation, and many view this process as subjective, metaphysical mythos when

¹ de Regt, Henk W. “Understanding and Scientific Explanation” in *Scientific Understanding: Philosophical Perspectives*, edited by Henk W. Regt, Sabina Leonelli, and Kai Eigner, (Pittsburg: University of Pittsburgh Press, 2009), 1. “Schrödinger then observes that philosophers from Hume to Mach to the positivists have not given positive answers to these questions. On the contrary, they have argued that scientific theories are merely economical descriptions of observable facts, which do not supply explanations. This view, which was endorsed by most of Schrödinger’s physicist colleagues.”

✉ Kevin Mager
kevinemager@gmail.com

¹ Loyola University-Chicago, Chicago, USA

compared to systematic accounts of observations which, rigorously yet humbly, seek only to tell us the patterns of nature. Indeed, even if we grant that there are “successful” explanations, we always explain misunderstood phenomena in terms of new and equally misunderstood phenomena.² This problem of explanation reemerged with new life in the early decades of the twentieth century and had a profound impact on the physicists who were exploring the new and bizarre quantum world. Werner Heisenberg, in particular, wrestled with this problem as he struggled to make sense of the mechanics he was developing.³ Heisenberg, well versed in the philosophical tradition, walked a taut line as he traversed the space between positivism, Kantianism, as well as phenomenology, and developed the rough sketch of a view that I am terming *critical explanation*.⁴ Just as critical philosophy is philosophy which first takes into account the limitations of reason, critical explanation is explanation that takes into account the limitations of scientific understanding.⁵ This paper will develop this account of explanation and suggest some implications for this account. I will rely heavily on Patrick Heelan’s work with Heisenberg and on Heisenberg’s own philosophical works.

I take Heisenberg’s use of the term explanation to be significantly different than how the concept is used in contemporary literature, so we must begin with an overview of the literature to show the difference. Of course, most theories of explanation will assume that an explanation is an answer to a “why” question, but how one thinks we ought to answer these questions can be markedly different. It is not overly presumptuous to assume that most contemporary views on scientific understanding either stem from, or are a reaction to, positivist theories of explanation.

² Friedman, Michael, “Explanation and Scientific Understanding,” in *The Journal of Philosophy* 71, no. 1 (1974) 18. “According to this argument, science merely transfers our puzzlement from one phenomenon to another; it replaces one surprising phenomenon by another equally surprising phenomenon.”

³ Heisenberg, Werner, *Physics and Philosophy* (New York: Harper Perennial Modern Thought, 2007) 12. Heisenberg tells us in his *Physics and Philosophy* “During the months following these discussions an intensive study of all questions concerning the interpretation of quantum theory in Copenhagen finally led to a complete and, as many physicists believe, satisfactory clarification of the situation. But it was not a solution which one could easily accept. I remember discussions with Bohr which went through many hours till very late at night and ended almost in despair; and when at the end of the discussion I went alone for a walk in the neighboring park I repeated to myself again and again the question: Can nature possibly be as absurd as it seemed to us in these atomic experiments?”

⁴ Lindley, David, *Uncertainty: Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science* (New York: Random House, Inc, 2007), 70. We learn in David Lindley’s *Uncertainty* that Heisenberg was influenced by his fellow student Wolfgang Pauli whose godfather was Ernst Mach himself. Pauli proclaims that he was “baptized as ‘anti-metaphysical’.”

Heisenberg, *Physics and Philosophy*, 64. Heisenberg believes that Kant is correct in that his a priori concepts are “the necessary conditions for science,” but he “had not foreseen” that they have a “limited range of applicability.” Heelan, Patrick, *Quantum Mechanics and Objectivity: A Study of the Physical Philosophy of Werner Heisenberg*, (Dordrecht: Springer Netherlands). Heisenberg’s phenomenological influences are best understood through the work of Patrick Heelan, who, in correspondence with Heisenberg, wrote *Quantum Mechanics and Objectivity: A Study of the Physical Philosophy of Werner Heisenberg*.

⁵ Kant, Immanuel, *Critique of Pure Reason*, translated by Paul Guyer and Allen W. Wood (Cambridge: Cambridge University Press, 1998) Bxxxv. Critical philosophy is the opposite of dogmatism which is the “procedure of pure reason, without an antecedent critique of its own capacity.”

Rudolf Carnap writes in his classic *An Introduction to The Philosophy of Science*, that explanations are derived from laws, which in turn, are merely regularities that are derived from repeated observations.⁶ He says, “No explanation—that is, nothing that deserves the honorific title of ‘explanation’—can be given without referring to at least one law.”⁷ He argues that even in our most basic explanations we assume certain laws because “explanations are really laws in disguise.”⁸ To use his example, if I put my watch on the table and then came back to find that it was gone, I would look for an explanation by asking, “where is my watch?” If someone responds “Jones took it,” that explanation would only make sense if I already assumed the law “whenever someone takes a watch from the table, the watch is no longer on the table.”⁹ Carnap declares that such statements can be classified as laws and that even the most mundane explanations at least tacitly require some law. The general view of explanation that Carnap holds is that an explanation is only an explanation in reference to some accepted general truth, which we call laws. As Hempel and Oppenheim put it in their landmark paper “Studies in the Logic of Explanation,” the answer to the question “‘Why does this phenomenon happen?’ is construed as meaning ‘according to what general laws, and by virtue of what antecedent conditions does the phenomenon occur?’”¹⁰

But this is not the only way to conceive of explanation, and, in fact, this way of understanding explanation is relatively new in the context of the history of philosophy and science. Aristotle’s philosophy of knowledge (as *episteme* or *scientia*) and scientific method were the standard way across various ancient and medieval societies to think about the process by which we come to scientific explanations.¹¹ In *Posterior Analytics* Aristotle argues that explanations are tied to understanding and that we have an understanding when we can formulate a valid syllogism of essential and necessary relations. For Aristotle, principles are necessary in order to make deductions and acquire “demonstrative understanding.”¹² While an account of what Aristotle means by “principle” is not necessary for my argument here, understanding Aristotle’s notion of demonstrative knowledge, however, is necessary to understanding his theory of explanation.

⁶ Carnap, Rudolf. *An Introduction to the Philosophy of Science*, edited by Martin Gardner, 2nd ed. (New York: Basic Books, 1974).

⁷ Carnap *An Introduction to the Philosophy of Science*, 6.

⁸ *Ibid.*, 10.

⁹ *Ibid.*, 7.

¹⁰ Hempel, Carl G. and Oppenheim, Paul, “Studies in the Logic of Explanation,” *Philosophy of Science* 15. No. 2 (1948) 135–175.

¹¹ Von Fritz, Kurt, “Die ἐπιγνώμη bei Aristoteles” (München: Bayerische Akademie Der Wissenschaften, 1964). Much of the difference is grounded in the difference between Aristotelian induction [*epagoge*] and the modern enumerative or probabilistic versions of induction. For Aristotle induction was the process by which we came to the realization of principles which allowed us to formulate valid syllogism and then demonstrate an understanding of the necessary relation between terms. For a detailed account of Aristotelian *epagoge* in the context of the history of philosophy see Kurt Von Fritz’s “Die ἐπιγνώμη bei Aristoteles.”

¹² Aristotle, *Posterior Analytics*, translated by Johnathan Barnes, 2nd Edition (Oxfordshire: Clarendon Press, 1993) 99b17.

Aristotelian views of explanation and scientific understanding were not unknown to the positivists and twentieth century philosophers of science who wished to reconstruct our concepts concerning science. As Wesley C. Salmon says in *Four Decades of Scientific Understanding*, “Aristotle clearly recognized [that] not all deductive arguments can qualify as explanations. Even if one accepts the idea that explanations are deductive arguments, it is no easy matter to draw a viable distinction between those arguments that do qualify and those that do not.”¹³ To contemporary philosophers of science, Aristotle’s account relies too much on a mysterious power of perception to attain necessary principles about phenomena and on cultivating a skill to identify necessary relations.¹⁴ Much of the work done in the twentieth century has been aimed at developing a theory of explanation which can distinguish between arguments that do qualify as explanations and arguments that do not¹⁵ without relying on the idea of skill, or genius, for seeing connections in nature.¹⁶

Whether one derives an explanation from a law as Carnap, Hempel, and others think we should, or whether one arrives at an explanation by some realization of a principle or concept which “let’s one see” the necessary relations, both camps of explanation rely on essential relations. But this is a problem because, as has often

¹³ Salmon, Wesley, *Four Decades of Scientific Understanding* (Pittsburgh: University of Pittsburgh Press, 1989) 3.

¹⁴ Aristotle, *Posterior Analytics* II. 19. Here I am particularly referring to the “routing” analogy, where perception somehow is infused with a nascent principle until repeated perceptions form a full realization of the principle. Gasser-Wingate, Marc, “Aristotle on Induction and First Principles,” *Philosopher’s Imprint* 16, no. 4 (2016): 1–20. For more on this interpretation of Aristotle, see Marc Gasser-Wingate’s “Aristotle on Induction and First Principles.”

Aristotle, *Posterior Analytics*, I. 34. In this chapter Aristotle presents his conception of “Acumen” whereby one as a unique talent for quickly identifying a middle term which necessarily relates the first and third term and generates a fully valid deduction. Aristotle’s example is seeing that the earth is the necessary middle term that explains why there is a solar eclipse; because the earth blocks the light from reaching the moon.

¹⁵ Salmon, *Four Decades of Scientific Understanding*, 9. Hence why the deductive-nomological theory of explanation argues that “the event to be explained is deductively certain, given the explanatory facts (including the laws); in an I-S explanation the event to be explained has high inductive probability relative to the explanatory facts (including the laws).”

¹⁶ Mill, John Stuart, *A System of Logic, Ratiocinative and Inductive: Being a Connected View of the Principles of Evidence, Methods of Scientific Investigation* (London: Forgotten Books, 2017) 232; Whewell, William, *Theory of Scientific Method*, edited by Robert E. Butts, 2nd edition (Indianapolis: Hackett, 1989) 117; Merleau-Ponty, Maurice, *Phenomenology of Perception*, translated by Donald A. Landes (Abingdon, Routledge, 2014) 116.

Merleau-Ponty, Maurice, “Phenomenology and the Sciences of Man,” *The Primacy of Perception*, translated by James M. Edie, edited by James M. Edie (Evanston: Northwestern University Press, 1964) 68–69.

A much forgotten, yet influential, intellectual rivalry over the proper method of science took place in the 1800s between William Whewell and John Stuart Mill. Mill believed that we could establish a probabilistic observation based method of scientific reasoning whereby science was a surveying of facts. Whewell on the other hand, thought that scientific genius and special insight were an essential part of science. “No maxims can be given which inevitably lead to discovery. No precepts will elevate a man of ordinary endowments to the level of a man of genius.” Mill ultimately ‘won’ the debate, and induction and scientific method since then has been predominantly Millian to some degree. For more on this see Von Fritz, but for a quick reference see Merleau-Ponty’s *Phenomenology* where he references the famousness of Mill’s methods, and see his “Phenomenology and the Sciences of Man.”

been pointed out, we can accurately predict phenomena while erring in our explanations as to why our predictions are successful. This has caused some to view explanations as unnecessary for science. Of those views which hold that explanation is of lesser significance for science, constructive empiricism, formulated by Bas Van Fraassen in *The Scientific Image*, is among the most influential. In section four of the text, “The Limits of the Demand for Explanation,” Van Fraassen argues that any over-zealous demand for explanation causes one to hold on to unjustified metaphysical commitments that may not fit with our observations.¹⁷ Rather, explanations should take a secondary role in our sciences and we should prioritize predictions. Explanations should be regarded as useful stories that make the relations between observed phenomena intelligible. If reference to unobservable phenomena that underlies the observed phenomena is relevant for our best theories, so be it, but we ought not hold that anything unobservable is *real*. Theories are really the “construction of models that must be adequate to the phenomena, and not discovery of truth concerning the unobservable.”¹⁸ In what follows, these theories of explanation should be kept in mind as I explicate Heisenberg’s quite radically different theory of explanation.

To *explain* something for Heisenberg is to describe what can be objectively (intersubjectively) observed in an adequate language.¹⁹ That is, creatively-discovering an appropriate language to describe observations *just is* an explanation for Heisenberg.²⁰ But these claims must be qualified. Not any explanation will do, we cannot simply look for fit, nor can we simply look for coherence. David Lindley reports that when Schrödinger attempted to resolve wave-particle duality by insisting that the particle nature of the quantum object was an illusion produced by tightly gathered wave-packets, Heisenberg protested. He did not think we could resolve the ontological issues with merely a coherent account. Our explanations also need to explain direct experimental evidence, and Schrödinger’s account, while creative, did little to explain photoelectric effect or Compton scattering.²¹ The creativity that is called for in discovery must be nested in observations, and I will suggest that a phenomenological account of *Evidenz* helps us understand why.

Phenomenological *Evidenz* is transcendental in that it is the coinciding of a proposition with the experience of its truth. The experience of something as true is a necessary condition for the possibility of the judgment that a proposition is correct. Simply put, *Evidenz* is the experience of truth. Primordial consciousness,

¹⁷ Van Fraassen, Bas, *The Scientific Image* (Oxfordshire: Calendron Publishing, 1980). 23–25.

¹⁸ *Ibid.*, 5.

¹⁹ Heelan, Patrick, *The Observable: Heisenberg’s Philosophy of Quantum Mechanics* (New York: Peter Lang Publishing, 2016) 112. See Patrick Heelan’s *The Observable*. “Ontological reality...is the domain of what can be objectively (i.e. publicly or intersubjectively) observed and described.”

²⁰ This does not refer to arbitrary-subjective creation and will be clarified in following sections.

²¹ Lindley, *Uncertainty: Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science*, 127. “[Heisenberg] admired the practical utility of wave mechanics, the way it made simple calculations possible. But he didn’t like Schrodinger’s broader assertions and rose from the audience to express a few objections. If physics was to be once again entirely continuous, he asked, how was it possible to explain the photoelectric effect or Compton scattering, both of which by this time amounted to direct experimental evidence for the proposition that light came in discrete, identifiable packets?”

i.e., immediate consciousness, cannot experience the properties, essences, or movements of quantum objects, yet Heisenberg insists on observability as a necessary condition for making ontological judgments about quantum objects. This insistence can be justified if we look at the structure of *Evidenz* in relation to experiments and measurements, rather than focusing on the direct relation of consciousness with its intentional object. To explain the connection between Heisenberg and Husserlian *Evidenz*, in Sect. 1 of this paper, I compare Heisenberg's view of the implications of the Copenhagen Interpretation with that of Niels Bohr. I argue that while they both have what could be described as a Neo-Kantian approach to meaning formation in language, Bohr's more empiricist account commits him to a skepticism of ontological claims about quantum objects and events. Bohr believes that all of our concepts are grounded in either ordinary language or the idealized language of classical physics. Thus, a non-classical physics, like quantum physics, can only be described in terms of concepts that we already have at hand. Heisenberg, on the other hand, influenced by phenomenology, does not think we are stuck with the concepts we already have, because in addition to pure a priori concepts are also material a priori concepts, which are acquired accomplishments *with ontological significance*. In Sect. 2, I attempt to ground Heisenberg's position in the Husserlian conception of *Evidenz*. I suggest that even though theoretic entities are not given to "primal consciousness," our theories about them are justified if we analyze the structures of consciousness revealed through a Husserlian analysis of *Evidenz*. If our everyday language, founded in everyday experience of phenomena, requires on our part, a unifying synthesis of recollection and actuality, then this opens up a space for Heisenberg's belief that we can found a new idealized language for quantum mechanics, while still admitting that this new language will develop out of everyday language.

1 Heisenberg's Interpretation of the Copenhagen Interpretation

Heisenberg originally agreed, to some extent, with Bohr's take on the Copenhagen Interpretation. He explains the Bohrian interpretation in *Physics and Philosophy*,

[t]he Copenhagen interpretation of quantum theory starts from a paradox. Any experiment in physics, whether it refers to the phenomena of daily life or to atomic events, is to be described in the terms of classical physics. The concepts of classical physics form the language by which we describe the arrangement of our experiments and state the results. We cannot and should not replace these concepts by any others. Still, the application of these concepts is limited by the relations of uncertainty. We must keep in mind this limited range of applicability of the classical concepts while using them, but we cannot and should not try to improve them.²²

The interpretation asserts that we are limited by our concepts of classical physics, not because of particular, historically contingent, situated language, but rather

²² Heisenberg, *Physics and Philosophy*, 14.

because our language is couched in the possibilities *and limitations* of reason itself. It is a Kantian view of sorts, in that Kant was right that “a priori concepts can be the conditions for science,” but this view also asserts that Kant had erred in that he had not foreseen that at the “same time [a priori concepts] can have only a limited range of applicability.”²³ This is similar to Bohr, when he writes in *Atomic Theory*, that our ability to know is limited by our “forms of perception.”²⁴ Though this sounds Kantian, it is a more empirical Kantianism. Kant thought that space (and time) are necessary forms of intuition and that we do not derive these intuitions from experience, but that they are necessary a priori, for us to have experience at all. Famously, for Kant, our intuitions are necessary conditions for our knowing, while at the same time, he does not believe we have access to the way things are “in themselves,” but only things as they appear to us via a synthesis of what there is beyond sensation (things as they are in themselves without us) and what we bring with us (the structure of the human mind). Namely, a priori categories and a priori forms of intuition.²⁵

On a more empiricist take of the Kantian framework, which Bohr had, our “forms of perception” come from our normal, everyday experience and could not possibly be altered by something that can only be experienced in an enclosed laboratory setting.²⁶ These forms of perception serve as a kind of a priori grounding through which we can move to an idealized language. This serves as the basis for what Bohr called “complementarity.”²⁷ Our forms of perception simply are derived by the ways we experience the world, and as Patrick Heelan explains, in *Quantum Mechanics and Objectivity*, for Bohr this means that we can only speak about and describe “bodies in the strict sense,” meaning bodies as they appear to us in the forms of localizable particles or non-localisable fields.²⁸ He goes on to write,

the forms of perception “idealise” every experience and notably those of atomic phenomena by submitting them to a synthesis in which the velocity of light is represented as infinitely large and Planck’s constant is represented as vanishingly small. In other words, every experience of atomic phenomena is “idealized” *either* as a particle *or* as a wave.²⁹

Both of our concepts of “body” (either particle or field) are derived from our forms of perception. Now, if something were to appear to us as a kind of body, but does not conform to either of those conceptions (an object exhibiting wave-particle duality for example), then we can only talk about it in those ways in which it *does* conform

²³ Heisenberg, *Physics and Philosophy*, 50.

²⁴ Bohr, Neils, *Atomic Theory and the Description of Nature: Four Essays with an Introductory Survey* (Cambridge: Cambridge University Press, 2011) 55.

²⁵ Kant, *Critique of Pure Reason*, A19/B33-B73.

²⁶ Heelan, *The Observable*, 58. Heelan tells us in *The Observable* “Bohr represented a pragmatic “common sense” combination of Kantian tradition and the empiricist-inductivist tradition”.

²⁷ Heelan, *The Observable*, 63–83 and Heelan, *Quantum Mechanics and Objectivity*, 45–80.

²⁸ Heelan, *Quantum Mechanics and Objectivity*, 45.

²⁹ *Ibid.*, 46.

to our prior concepts. The result is a paradoxical description of the quantum object. According to Bohr, we have no choice but to interpret and describe the results of our quantum experiments in ordinary language terms.³⁰ We can find examples of this in contemporary quantum terms, such as “spin,” which does not denote that the quantum object is actually spinning, but the concept ‘spin’ in ordinary language is considered close enough when compared to other normal concepts, so it is the best way to describe the particle.³¹

Heelan labels Bohr’s notion of everyday language as Lo and the language of classical physics as Ln. For Bohr, Ln was always an idealization of Lo and “whatever ontological status Ln enjoyed, it borrowed it from Lo.”³² While Heisenberg first objected to Bohr’s position and believed the new mathematical formalisms could lead to a new idealized language, he was eventually convinced by Bohr that this was the best way to interpret quantum physics. However, after some time, they diverged in their understanding of the interpretation. For Heisenberg, the language of science is an idealized form of everyday language, but he had a very different conception of what grounds our language and, thus, our idealizations. He writes,

When we represent a group of connections by a closed and coherent set of concepts, axioms, definitions and laws which in turn is represented by a mathematical scheme we have in fact isolated and idealized this group of connections with the purpose of clarification. But even if complete clarity has been achieved in this way, it is not known how accurately the set of concepts describes reality. These idealizations may be called a part of the human language that has been formed from the interplay between the world and ourselves, a human response to the challenge of nature.³³

For Heisenberg, idealizations in language have a more creative grounding than for Bohr. We form idealizations through an “interplay between the world and ourselves.” This is a stark contrast from Bohr’s view. For Heisenberg, the mathematical

³⁰ We can find an example of this limitation in language in the concept of *spin*, which is directly related to Heisenberg’s solution to the anomalous Zeeman effect. Electrons produce a magnetic field while in motion. A simple version of the story is that Heisenberg, after hearing that an electron has magnetic properties even while standing still assigned the stationary energy states half values, this is the “spin” of an electron. *Spin*, then, is simply our best way of describing something that is moving while staying in a single location. (For more detail see the footnote below).

³¹ Heisenberg’s first major contribution to quantum mechanics was his quantification of Zeeman spectroscopy of an atom in a stationary state before a magnetic field is applied. When electrons move, they create a magnetic field. At the time, every state of the electron had to be assigned three integral numbers to account for its orbit. The anomalous Zeeman effect, however, created problems for this explanation. As it turns out, heavier atoms were shown to have many more states that could be explained by quantum theory at that time. Additionally, prior to entering a magnetic field, the quantum energy states were observed to divide themselves to doublets or triplets of energy states depending on if the atom had one or two electrons. This resulted in a splitting of six or eight states when the magnetic field was applied. Heisenberg noticed that current formulation captured only the difference between two states rather than the frequency of one, stationary state, which, as noted above, was also shown to have magnetic properties. To account for this, he assigned stationary states a half value (1/2, 3/2, 5/2).

³² Heelan, *The Observable*, 58.

³³ Heisenberg, *Physics and Philosophy*, 81–82.

formalism of a new scientific theory (such as quantum mechanics), would allow a new interplay and enable us to arrive at a new idealized language to talk about quantum objects.³⁴ Though, Heisenberg's view ultimately still concedes some ground to the Bohrian intuition that our concepts are in some sense fixed. While we can develop a specialized language whose concepts do not apply to Ln, we can never fully do away with it in the context of the classical world, and whatever new idealized language we come up with, it *must* have a relation to Lo. In Heisenberg's 1955–1956 Gifford Lectures he concluded that Bohr's complementarity was a path of expedience, but not a necessary path. Scientists should have "followed the paradigm of relativity."³⁵ Einstein's theory of relativity explicitly shows us that we have the creative capacity to move past our classical concepts and opt for new ones. Of course, the path is not easy, as the new concepts must both be "better in their descriptive value" and "in practical matters."

But how can this be accomplished, and are we justified in asserting that our new language and new descriptions are actually *ontologically significant* rather than mere fictions, as in, say, constructive empiricism? I propose that it would be fruitful to ground Heisenberg's account of explanation on Husserl's phenomenological account of *Evidenz* and the material a priori.

2 The Material A Priori: Evidenz and Creative Reproduction in the Imagination

While Heisenberg was deeply influenced by Neo-Kantianism, we can get a better understanding of his disagreements with Bohr if we look at how he, unlike Bohr, was influenced by phenomenology.³⁶ In a phenomenological framework there is more plasticity to our concepts because of the category of the material a priori. In his essay "Die Fakta leiten alle Eidetik" Vittorio De Palma gives an excellent explanation of the material a priori:

What we recognize a priori from things is, according to Kant, "what we put into it ourselves," on the other hand according to Husserl, what lies in the being [*Wesen*] or structure of things themselves, because the conditions of the possibility of experience are eidetic. The real categories belong to the sensible thing, not to the experiencing subject: Space and time are not forms of our sensibility, but forms of the individual objects. The "a priori conditions of possible experience" are therefore those "ontic-a priori" structures without which the world as a world of possible experience would be unthinkable and by which the method of the essential variation of universal experience and the world of experience is successful. Since the factual connections between the phenomena do not spring from the subjective forms of intuition and understanding, but from the sensually given contents, the synthetic

³⁴ Heelan, *The Observable*, 59.

³⁵ *Ibid.*, 112.

³⁶ Heelan, *The Observable*, 140. Though, the Heideggerian influence will be minimized for the purposes of this paper.

a priori belongs to the experience only insofar as it goes to the respective content of the experience. It is not experience as such that has a necessary structure, but rather the possibilities of experience that lie within it.³⁷

The addition of material a priori concepts can help us frame the disagreement between Bohr and Heisenberg. Recall from above that Bohr puts an empiricist bend on the Kantian framework. In a Bohrian framework, our conception of a body is not inherent in the mind but in the things that we experience. We then employ this concept, the concept of bodies, repeatedly as we encounter new objects in the world. This conception of a “body” will be precisely what is given in the sense-data and nothing more. On the other hand, the “material a priori” are those general categorial concepts that come from our intentional relationships to phenomena. A Heisenbergian view would agree with Bohr that experience is the grounds by which we form concepts, but suggests that experience is more rich than an empiricist would admit. In other words, within our experience is more than what an empiricists’ conception of sense-data would admit. What we need to move past Bohr’s position and towards something more Heisenbergian, is a rich account of how the experience of *Evidenz* can guide us to new concepts, which we can find in Husserl’s account of *Evidenz* and recollection in his *Formal and Transcendental Logic*.³⁸

It is important to note that for Husserl the “[c]ategory of objectivity and category of [Evidenz] are perfect correlates.”³⁹ For every objectivity, that is, everything that can be viewed objectively, there is a possible unity of possible experience with actual experience.⁴⁰ *Evidenz*, which is translated in *Formal and Transcendental Logic* as “evidence,” is not quite the same as the English “evidence.”⁴¹ *Evidenz* for

³⁷ Palma, Vittorio, “Die Fakta leiten alle Eideetik. Zu Husserls Begriff des materialen Apriori,” *Husserl Studies* 30 (2014) 195–223. My translation. “Was wir von den Dingen a priori erkennen, ist nach Kant das, was wir selbst in sie legen”, nach Husserl hingegen das, was im Wesen bzw. in der Struktur der Dinge selbst liegt, weil die Bedingungen der Möglichkeit der Erfahrung eidetisch sind (Hua XVI, 141 f.; Hua XVII, 456; Hua VII, 385). Die realen Kategorien gehören zum sinnlichen Ding, nicht zum erfahrenden Subjekt: Raum und Zeit sind nicht Formen unserer Sinnlichkeit, sondern Formen der individuellen Gegenstände (Hua XXIV, 273 f.; Ms. B IV 1/33a-b). Die “apriorischen Bedingungen möglicher Erfahrung” sind also diejenigen “ontisch-apriorische[n] Wesensstrukturen, ohne die eine Welt als Welt möglicher Erfahrung undenkbar wäre” und die durch die “Methode der Wesensvariation der universalen Erfahrung und Erfahrungswelt” zu gewinnen sind (Hua XXXII, 118). Da die sachlichen Zusammenhänge zwischen den Erscheinungen nicht den subjektiven Anschauungs- und Verstandesformen, sondern den sinnlich gegebenen Wasgehalten entspringen, gehört das synthetische Apriori nur insofern zur Erfahrung, als es zum jeweiligen Erfahrungsinhalt gehört. Eine notwendige Struktur hat nämlich nicht die Erfahrung überhaupt, sondern die in ihr liegenden Erfahrungsmöglichkeiten.”

³⁸ Husserl, Edmund, *Formal and Transcendental Logic*, translated by Dorion Cairns (The Hague: Springer Publication, 1969).

³⁹ *Ibid.*, 161.

⁴⁰ *Ibid.*, 161. “To every fundamental species of objectivities—as intentional unities maintainable throughout an intentional synthesis and, ultimately, as unities belonging to a possible ‘experience’—a fundamental species of “experience”, of [Evidenz], corresponds, and likewise a fundamental species of intentionally indicated evidential style in the possible enhancement of the perfection of the having of an objectivity itself.”

⁴¹ Ryckman, Thomas. *The Reign of Relativity: Philosophy in Physics 1915–1925* (New York: Oxford University Press, 2005) 136–142. Ryckman writes, “The obvious candidate [for translation is] *evidence*, while not quite a false cognate, wrongly suggests intersubjectively manifest proof or grounds for belief... Rather, it must be established later on, somewhat as Carnap, in §§148–149 of the *Aufbau*, constitutes an intersubjective world from the quasi-phenomenological standpoint of ‘methodological solipsism.’

Husserl is not an object which can increase confirmation about a claim, but rather it is the intentional condition which makes intersubjective agreement possible. *Evidenz* can best be described simply as an immediate experience of truth. If there was no immediate experience of the truth of an object in front of me, there would be nothing to agree about. As with many foundational Husserlian concepts, phenomenological analysis of this immediate experience elucidates the essential structures of consciousness which ground *Wissenschaft* [academic or scientific knowledge]. These essential structures of consciousness within the experience of *Evidenz* will help us to better understand Heisenberg's views about the possibility and role of explanation in science.

"Thanks to [*Evidenz*]," Husserl says, "life of consciousness has an *all-pervasive teleological structure*, a pointedness...toward discovery of correctness...and toward cancelling incorrectness." *Evidenz* can "demand" continued confirmation in the form of an agreement between reproduction, imaginative variation, memory, and experience. This does not mean, as it does for Kant, that we "put" consistency into the world; on the contrary, experience *could* appear rather inconsistent. I expect consistency because of my past synthetic unities of experience, but if something about my experience became inconsistent, such as quantum measurements, *Evidenz* would demand further appearances to explain the incorrectness of my expectation.

Before going on I want to note that Husserl should not be confused with Humeanism or other phenomenisms. Humean empiricism often leads to a radical skepticism about the possibility of explanation. One might think that because Husserl wants to derive categories from sensibility that he would draw the same skeptical conclusions as the empiricists after Hume; such as, that because necessity cannot be found in sensually given contents, we should therefore substitute talk of causality for "observed regularities." But this is not what Husserl thinks we should conclude from an analysis of sensibility. While Husserl does owe a large debt to Hume, he differs from him greatly.⁴² Husserl is not confined to Humean skepticism, in part because of his concept of material a priori.

The material a priori is the *eidos* of a contingent thing. Or, in other words, the material a priori is that which is edictally necessary for the thing to be what it is. For Hume, all knowledge comes through sense-impressions, yet sense-impressions

Footnote 41 (continued)

Neither is the English term *self-evidence* completely accurate, for it lacks the connotation of intentional achievement stemming from the coincidence of the object as intended."

⁴² See Murphy, Ronald. *Hume and Husserl: Towards Radical Subjectivism*, (Springer 1980). Additionally, Husserl himself lays out what he finds to be Hume's greatest accomplishment in *Formal and Transcendental Logic*, 256. Husserl explains, "Hume's greatness (a greatness still unrecognized in this, its most important aspect) lies in the fact that, despite all that, he was the first to grasp the universal concrete problem of transcendental philosophy. In the concreteness of purely ecological internality, as he saw, everything Objective becomes intended to (and, in favorable cases, perceived), thanks to a subjective genesis. Hume was the first to see the necessity of investigating the Objective itself as a product of its genesis from that concreteness, in order to make the legitimate being-sense of everything that exists for us intelligible through its ultimate origins. Stated more precisely: The real world and the categories of reality, which are its fundamental forms, became for him a problem in a new fashion."

alone cannot allow us to arrive at the concept of necessity which is required for the concept of causation. Kant shows us that there is a contradiction in this Humean argument. If all concepts come from experience, and if in experience there is no necessity, then how would we arrive at a concept like necessity at all? While Husserl sees this as an advancement from Hume's position, Husserl still argues in the *Crisis* that Kant is operating from the same inadequate psychology as Hume. Kant, because he shares Hume's assumption that we perceive via pure sense impressions, assumes that our notion of causation could not, as Hume argues, come from experience. It must therefore come from the structure of our minds. Both accounts would ultimately make explanation of quantum events impossible. In the Humean case, because explanations are merely regularities, and in the Kantian case, because the sensible givens in quantum experiences cannot be understood by the a priori categories of the understanding. However, Husserl holds that perception is much richer than Hume or Kant thought.⁴³ Husserl's material a priori can, in a qualified sense, be considered "a 'contingent' *Apriori*."⁴⁴ There are eidetic cognitions which are necessary a priori for the possibility of some concrete experience, but not necessary a priori for experience generally. For example, there is an *eidos* of sound that, without which, the concept of sound could not be thought. Yet, it is not necessary for experience generally that we have access to sound, e.g. that we can hear. Husserl writes, "It has in the *eidos* *sound* a materially determinate core, which goes beyond the realm of the universality of 'principles' in the most radical sense, and restricts it to the 'contingent' province of ideally possible sounds."⁴⁵ There is nothing purely a priori about a subject being able to experience sound, yet "the concepts of such matters too can be framed as *apriori* (as freed from everything empirically factual)."⁴⁶ We can determine the a priori difference between sound and other qualitative experiences, yet, "that we can experience sound" is not itself a priori necessary for experience to be possible. Thus, the a priori for sound, its material, concrete *eidos*, is not the same as the a priori concepts of pure reason, but nonetheless a kind of a priori.⁴⁷ *Evidenz* is important here because it provides the condition which makes the material a priori possible. Hence why Heisenberg's view that Kant's a priori categories have a "limited range of applicability" does not inherently prohibit us from ultimately determining an explanatory a priori of quantum objects and events. A phenomenological analysis of *Evidenz* reveals the structures of consciousness that make the material a priori possible. We first gain access to this process of *Evidenz* when we notice, through intuition, our own concrete subjectivity. With the aid of imaginative

⁴³ Husserl, Edmund. *The Crisis of European Sciences and Transcendental Phenomenology*, translated by David Carr (Northwestern University Press, 1970) 116. For more on this see Husserl's *The Crisis of European Sciences*, section 31. "Kant and The Inadequacy of the Psychology of his Day."

⁴⁴ Husserl, *Formal and Transcendental Logic*, 29.

⁴⁵ *Ibid.*

⁴⁶ *Ibid.* Husserl goes on to write, "Accordingly they too have their Apriori, which, however is contingent and not an Apriori of pure reason; or, as we may also say, introducing an old world that tended blindly in the same direction, it is not an 'innate' Apriori."

⁴⁷ *Ibid.*, 30. Here Husserl writes that there is a difference between the contingent a priori and an a priori of "pure reason" which is "*formal Apriori in the most fundamental sense.*"

variation we reveal other possibilities of other concrete subjectivities until we arrive at what is essentially necessary for subjectivity to be what it is. What it is about subjectivity that cannot be varied is what is essential for a subject to be a subject. This is a determining judgement. Then we are able to apply the same procedure to any other concrete experience, such as sound.

The process of determining the material a priori of objects of nature, as Husserl sees it, is the objective of natural science. Husserl writes,

[t]he judgement-process can progress as unitary ad infinitum; the substrate-objectivity can include infinities of single particulars within itself, as the sciences illustrate. For example, the yet-undetermined infinity of Nature lies before the judger *as a substrate for determination*, when he goes on from mere experience to his judging endeavor. And then he constitutes the determining formations, the new categorial fashionings of the substrate.⁴⁸

The judger begins from mere experience of objects which demonstrates a coherence and unity of experience. But when she directs her attention to nature she finds a substratum of all objects which is open for determination. That there is a way to unify one's mere experience to the "yet-undetermined infinity of Nature" is given to us by both the experience of *Evidenz* and the "*all-pervasive teleological structure*" mentioned above. In other words, the experience of nature as a unity and the possibility that we can make determining judgements about nature is given to us prior to the actual development of the determining concepts about the substratum of nature. Implicit in the experience of objects as unities is that there is an underlying substratum that unifies them. Nature is given to us as a unity, but we do not yet know all the parts. The undetermined substrate of nature presents itself, thanks to *Evidenz*, as *for determination*.⁴⁹ Husserl explains,

Within the proper sense-content of the judging directed to the unity of the yet-determined and to-be-determined province, the content that is being generated (and has been generated) in the judging itself, there lies the *idea of possible continuation of the determining categorial formings*—and likewise of possible consistent continuation of the aim at determining—*ad infinitum*.⁵⁰

⁴⁸ Ibid., 115–116. My italics.

⁴⁹ Kant, Immanuel. *Critique of the Power of Judgment*, translated by Paul Guyer (New York: Cambridge University Press, 2000) 5:180. Merleau-Ponty, Maurice. *Phenomenology of Perception*, translated by Donald A. Landes (New York: Routledge, 2014) lxxxii. This is reminiscent of the introduction to Kant's *Critique of the Power of Judgment*, where he says that "The reflecting power of judgment, which is under the obligation of ascending from the particular in nature to the universal, therefore requires a principle that it cannot borrow from experience, precisely because it is suppose to ground the unity of all empirical principles under equally empirical but higher principles, and is thus to ground the possibility of the systematic subordination of empirical principles under one another." Which is to say, that we must presuppose the unity of the principles of nature. Husserl, rather than presupposing, feels he has demonstrated phenomenologically, that we are justified in thinking of nature as a unity, even if we have not unified it theoretically. Indeed, Merleau-Ponty in the introduction to *Phenomenology of Perception*, says that "Husserl takes up the Critique of Judgment when he speaks of a teleology of consciousness," which, as I have said above, we know because of *Evidenz*.

⁵⁰ *Form and Transcendental Logic*, 116.

Here, it is clear that the Husserlian concept of *Evidenz* is not limited to what is given in everyday perception of objects, though, the structure of *Evidenz* necessarily arises out of everyday perception. While Husserl believes we must begin with uncovering the structure of consciousness as it is presented to us in the intuitive-givenness of ordinary objects, this belief does not imply that there is no legitimacy in advancing beyond ordinary experience. The teleological structure of our judgments is first presented to us in the intuitive givenness of perception, but so is the possibility to go beyond mere perception and uncover the substrate of nature. The intuitive givenness of *Evidenz* also gives us the teleological structure of judgments and directs us towards a unity of nature that can be understood by the conceptual determination of the substrate of nature.

This can help us make sense of Heisenberg's suggestion that knowledge is derived from an "interplay" between body, language, and world. Again, Husserl tells us that "absolutely any consciousness of anything whatever belongs a priori to an openly endless multiplicity of possible modes of consciousness."⁵¹ The multiplicity of possible modes of consciousness belongs to an imagined variation of the conditions of possibility for any given experience of phenomena. The explicit structure of this process is: 1) primordial *Evidenz*, 2) the reproducibility of primordial *Evidenz*, then 3) imagined variation of new possibilities opened up and limited by the potential possibilities of the variation of eidetic modes, or concepts for our understanding.

This opens up a space for Heisenberg's belief that we can ground a new idealized language for quantum mechanics through the interplay of body, language and world, despite maintaining that this new language will inevitably be founded on Lo (everyday language).

To explain something for Heisenberg is to describe it in an adequate language which is grounded in what is observable. But until now, what constitutes "observable" or even "describable" for Heisenberg has not been made explicit. Heelan gives a clear explication of Heisenberg's conditions for observability and describability in *The Observable*:

In ordinary usages, for an observer *to observe* in Lo entails the following conditions: 'To observe' has as its object a definite descriptive sentential content 'that-p' where 'p' is (1) an assertion, (2) made by particular observer (subject, describer, speaker) in an appropriate socio-historical community, (3) who describes the presence of a *fact (object)*, that sits in a public descriptive *frame (context or horizon)*, and (4) is represented by the vocabulary and grammatical resources of Lo, Ln, or Lr (see below).

(i a). The description 'p' performs a 'realistic' function, that is, it asserts univocally (r at least analogously—see below) the real presence of an objective fact;

(i b). This real presence is appropriately represented in the sensory medium of the observer, and

⁵¹ Ibid, 160.

(i c). It is represented publically within a public discursive descriptive frame that entails a priori constellation of invariant contextual conditions, subjective/social ('intentional,' that is, intending 'reality' in the social world) and objective (it has a horizon/niche in the social world); *the observer subject must possess the cultural (e.g., scientific, linguistic, and philosophical) background shared with the relevant community of descriptive discourse, and participate in the cultural and scientific activities that constitute the objective horizon of the discursive frame.*

(i d). Moreover, 'to observe that-p' within the appropriate discursive frame entails a certain '*perceptual immediacy*' in the cognitive relation between knower and known, so that with expertise the mediating channel becomes transparent—'seeing becomes recognizing common worldly reality.'⁵²

For my purposes, the most crucial element from above is (i c). If successful descriptions require an observer subject that is part of an intersubjective community and if objectivity is *partly* constituted by that intersubjective community, then a fully adequate explanation for the goings on of phenomena in question will require a description of what (inter)subjectivity brings with it. Though, I need to clarify what it means for subjectivity to bring something with it. When many contemporary philosophers hear or read talk of subjectivity "bringing" something, they interpret it as "whatever the subject chooses to believe somehow becomes truth or reality." But this interpretation is the result of unfamiliarity with the tradition of phenomenology or transcendental philosophy generally.⁵³ Just as a description of a quantum event requires the observers to be part of a cultural history of physical science, so too does a thinker need to be familiar with the cultural history of transcendental philosophy to understand the intended implications of the term "subjectivity" within this tradition.

Both Heelan and Heisenberg think that in order to adequately describe a quantum physical event we need to think of the scientists as "joined physically and epistemologically to the measuring instrument. The observer is the instrumentally-enabled-scientist who recognizes the presence of the QM object in its descriptive horizon."⁵⁴ Without our cultural practices of laboratory testing, our foundational beliefs about physics, our foundational epistemo-methodological beliefs about natural science (the importance of repetition, for example), the foundational concepts that we bring with us when we interpret our results, and (most importantly for my purposes) the subjective conditions which structure how we must interact with objects to get our results, we would not be able to do science. In order to fully understand the objectivity of our observations, we need to understand what conditions constitute those

⁵² Heelan, *The Observable*, 94–95.

⁵³ Heidegger, Martin. *Being and Time*, translated by John Macquarrie and Edward Robinson (New York: Harper & Row Inc., 1962). 270 (227). No phenomenologist or transcendental thinker should argue that truth is merely whatever the subject arbitrarily wants it to be. Heidegger, in *Being and Time*, makes this clear when he says "*Because the kind of Being that is essential to truth is of the character of Dasein, all truth is relative to Dasein's Being.* Does this relativity signify that all truth is 'subjective'? If one interprets 'subjective' as 'left to the subject's discretion', then it certainly does not."

⁵⁴ Heelan, *The Observable*, 95.

observations as objective. As stated by John B. DeBrotta and Black C. Stacey in “FAQBism,” “In physics, an explanation is not a statement made in isolation. We do not just say, ‘That rock will sit there without collapsing in on itself.’ We naturally go a step further: ‘That rock will resist being squeezed.’”⁵⁵ We test claims about physical objects while implicitly referring to the observer. Of course, I am not referring to the specific psychology of some particular observer but the necessary *observerness* that accompanies all scientific claims. Observerness is a tacit condition that is easily ignored in classical physics, but impossible to ignore in quantum physics. As Heisenberg says, “[There is] a subjective element in the description of atomic events, since the measuring device has been constructed by the observer, and we have to remember that what we observe is not nature in itself but nature exposed to our method of questioning.”⁵⁶ When we describe a physical event, our best descriptions describe the event as it would be observed by other subjects. An essential part of scientific explanation is then an understanding of *observerness* which is one of the conditions for human understanding generally.

While the Heisenberg quote above may seem like he is committed to a standard anti-realist account of science, we have to remember his Neo-Kantian commitments. If he were an anti-realist he would be committed to the idea that our explanations are merely coherent stories which best account for our observations and predictions, but do not actually approach the underlying explanations for our theories. This is opposed to a moderate realist account of science which holds that our best scientific theories are more approximately true than competing theories. This “approximately” leaves room for what feels like the inevitability of finding some error in our current theories. But for Heisenberg, physics, as the discipline that exposes how nature is as it relates to our methods, still “gets at” reality in a way that would satisfy a scientific realist who commits herself to so-called “approximate truths.” The only difference is what we think “reality” is. If one were to commit herself to the belief that when we say “reality” we mean “things as they are in themselves,” then Heisenberg vehemently disagrees. But if we define reality as the co-constitutive result of the forms of our subjectivity with what exists in-itself, then our best scientific theories certainly give us approximate insights into reality. Reality is nothing other than reality-for-us. But the results in quantum mechanics, as they are, hardly engender an image that could be said to be a reality-for-us. However, as stated above, Heisenberg never gave up on the idea that a revolution in physics was possible, that quantum phenomena could be reconceptualized in a way that allows us to understand it as reality.⁵⁷

⁵⁵ DeBrotta, John B. and Stacey, Black C. “FAQBism” [arXiv:1810.13401]. This article is an explanation of a new interpretation of quantum mechanics called QBism, which, I believe, has many similarities with Heisenberg’s interpretation. At the very least, this interpretation also puts the observer at the center of our quantum descriptions.

⁵⁶ Heisenberg, *Physics and Philosophy*, 32; Petersen, Aage. “The Philosophy of Niels Bohr,” *Bulletin of the Atomic Scientists*, 19. no. 7 (1963) 8–14. This resembles Aage Peterson’s famous paraphrase of Bohr, “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.”

⁵⁷ Heelan, *The Observable*, 113.

But what would it mean to reconceptualize quantum phenomena? Heelan, I believe, attempts to answer this question.

In his chapter “Logic and Language of Science” in *Quantum Mechanics and Objectivity* Heelan tells us that, “A measured property produces a macroscopic effect in the instrument; as for example a pointer reading on a scale, a “click” of a counter, or a track in a bubble chamber. This macroscopic effect is a material sign. A sign has a double reality: Its *material reality*...and its *intentional reality* proper to it as a sign...as indicating something beyond its material reality.”⁵⁸ Heelan then invokes a distinction between “observational language” and “explanatory language.”⁵⁹ This is not the usual distinction between observational language and theoretic language; instead it asserts that the two languages are “different systematic totalities; but the classes of object to which they refer are both *real*.”⁶⁰ It is not that one is real and one ideal, but we use the two different criteria based on how their reality is given to us. Bodies in perception are given to us in a synthetic coherence of fulfillment, and the coherence of fulfillment about our theoretical entities and how we explain their behavior is, structurally, no different. While Heelan appears to want to express a full-blown realism about theoretical particles from his analysis, I do not think we need to go that far. Rather than asserting the reality of quantum objects, we can determine a criteria of justified belief in our explanatory language about these objects. Epistemic justification is determined by the appropriateness of our acquisitions, not dependent on absolute certainty of the correspondence between our concepts and the world. While the aim is to accurately describe the world, our methods of explanation do not guarantee total success, but they are still the proper intersubjective process that makes arriving at a truth possible.

While explanations for quantum events are difficult because the only thing actually “given in primordial perception,” as it were, are the vague results from our instruments, the structures of consciousness revealed by *Evidenz* push us towards a synthetic unity of experience that goes beyond the immediately given to an intentional reality beyond its material reality. All conceptualizations that go beyond immediate material reality have to be directly tied back to what is observable and must conform to the forms of our intuition. Thus it is *not* that any story-like explanation that merely accounts for all observables will do (as in Van Fraassen’s view). Rather, we should view quantum objects as inherently incomprehensible to the forms of our subjectivity until we measure them and force the objects into a comprehensible category. The way to explain what is happening when the wave function collapses, is not to appeal to some speculative narrative that merely accounts for all of the observations, but rather Heisenberg appeals to “*descriptive ontology*,”⁶¹ which requires us to describe what is observed *as* being observed which means we must also account for the structures of subjectivity and the limitations of human

⁵⁸ Heelan, *Quantum Mechanics and Objectivity*, 174.

⁵⁹ *Ibid.*, 177–178.

⁶⁰ *Ibid.*

⁶¹ Heelan, *The Observable*, 116.

knowledge. The explanation is the result that emerges from describing *both* the observed and the observer (in general).

Thus far, I have been explicating a Heisenbergian account of explanation (and its dependence on his Neo-Kantian account of reality) in general, methodological terms. But what would a justified theoretical explanation look like on this account? As an example we can turn to Heisenberg's own attempts at explaining quantum mechanics. This is not a defense of Heisenberg's view, but I think it is necessary to give a rough sketch of the explanatory route Heisenberg chose.

In Heisenberg's 1955–1956 Gifford Lectures, he turns to an Aristotelian framework to explain the ontological status of potency in quantum objects. This Aristotelian concept serves as the a priori grounds for our descriptions and thus for our explanations.⁶² He characterized potency as “something in the middle between the idea of an event and the actualization of the event, a strange physical reality in the middle between possibility and actuality.”⁶³ In Bohr's complementarity interpretation, the wave function is an epistemic-mathematical tool, but not a description of reality. But for Heisenberg's definition of reality, there is no clear distinction between the best epistemic conceptualization and reality. If the wave function is a necessary component of quantum mechanics, then we are justified in holding that it is real in some way. Heisenberg caches out the ontological status of the wave function as a potency [*potentia*], in the Aristotelian sense. As Heelan notes, “he also used almost as synonyms, ‘possibility’ (*‘Möglichkeit’*), ‘objective tendency’ (*‘objektive Tendenz’*) and ‘probability’ (*‘Wahrscheinlichkeit’*).”⁶⁴ In Aristotelian philosophy *potentia* is a metaphysical principle that orders something towards its corresponding act. It is an ‘objective’ tendency because an object's potential is real, and part of what makes the object what it is. The wave function is thought to be our mathematization of the object's *active potency*, which, for Aristotle, “is *form*; *form* unites with *matter*...to generate *being*.”⁶⁵ With this descriptive ontology the wave function represents the reality-in-potency but *not* reality-in-actuality since to be actual is to arrive at the result of the potential, e.g. water always has the metaphysical potential to be hot, but is only actually hot when heated.⁶⁶ This way of conceptualizing quantum objects attempts to “go beyond and behind the phenomenon in order to arrive at the objective conditions of possibility of that experience,” while keeping in mind the

⁶² Heisenberg, Werner, et al. *On Modern Physics*. Potter, 1961. From *The Observable*, 117. “[I]t is first of all necessary to stress as von Weizsaecker has done, that the concepts of classical physics play a role in the interpretation of quantum theory similar to that of the a priori forms of perception in the philosophy of Kant. Just as Kant explains the concepts of space and time or causality a priori, in the sense that they already formed the conditions of all experiences and could therefore not be considered the results of experience, so also the concepts of classical physics form an a priori basis for experiments in quantum theory, because we can conduct experiments in the atomic field only by using these concepts of classical physics.”

⁶³ *Ibid.*, 115.

⁶⁴ *Ibid.*, 114.

⁶⁵ *Ibid.*, 115.

⁶⁶ I used this example as a nod to the scholastic-aristotelian tradition which commonly uses the heating of fire as a basic example of causal explanation.

limitations of human knowledge and restricting ourselves to the language of Lo.⁶⁷ We always think in terms of our ordinary concepts, but go beyond them when our observations allow, and only in-so-far as our observations allow. Which means that we can only go beyond our observations when also thinking in terms of the structures of subjectivity.

3 Conclusion

Lo is already a kind of accomplishment, it is not simply given. Likewise the fact that it is an accomplishment and not merely given justifies a position which says that Ln (the language of classical physics) is not *the* necessary idealized language, even if it is fruitful in certain contexts. Our explanation, which will inevitably be in some new language, must take this into account and understand that our language formation is both limiting (in that any language will not have an infinite range of applicability) and, at the same time, *that which makes Evidenz* and continued categorical judgements possible. That being said, Heisenberg's attitude when approaching new ways to think about explanation for quantum phenomena remains *critical* of our explanations. We must form our explanations while understanding that the process by which we cognize our explanations reveals its own limits and avoids the temptation towards a "God's eye-view" of explanation.⁶⁸ Both because the God's eye view is not accomplishable and because holding ourselves to such a standard will cause us to look diminishingly upon our already amazing accomplishments.

Heisenberg's optimism that we can create a new language to explain, at least partly, the ontology of quantum objects and events is justified if we understand language formation to be an intersubjective accomplishment founded in things themselves. While we do not perceive theoretic entities "in the flesh," the structure of our encounters with them follows the same structure of those phenomena which are given in primordial experience. That is, we start from what is given materially in front of us, we reproduce the effect to form a synthetic unity and then move beyond what is materially given to what is intentionally given. While Heelan's analysis of Heisenberg's philosophy of science does not utilize the Husserlian account of *Evidenz* that I have sketched out here, Heisenberg's own propensity towards the Kantian and the phenomenological tradition justifies my attempt to combine these thinkers into a single account of how we can both say that our explanations depend on an acquired language and have ontological significance.

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⁶⁷ Ibid., 117.

⁶⁸ Lindley, *Uncertainty: Einstein, Heisenberg, Bohr, and the Struggle for the Soul of Science*, 132.