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The Scope of Hermeneutics in Natural Science

Patrick A. Heelan
Georgetown University, heelanp@georgetown.edu

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PATRICK A. HEELAN
Georgetown University
Washington, DC 20057

Abstract: Hermeneutics or interpretation is concerned with the generation, transmission, and acceptance of meaning within the lifeworld and was the original method of the human sciences stemming from F. Schleiermacher and W. Dilthey. Hermeneutic philosophy refers mostly to M. Heidegger's. This paper addresses natural science from the perspective of Heidegger's analysis of meaning and interpretation. Its purpose is to incorporate into the philosophy of science those aspects of historicality, culture, and tradition that are absent from the traditional analysis of theory and explanation, to re-orient the current discussion about scientific realism around the hermeneutics of meaning and truth in science, and to establish some relationship between the current philosophy of natural science and hermeneutical philosophy. The paper has particular relevance to the history and social studies of science and technology.

Introduction

The title of Heisenberg's momentous paper of 1925 that presented quantum mechanics to the world was 'About the quantum theoretical re-interpretation of kinematical and mechanical relationships' (Heisenberg 1925). The title reflected Heisenberg's view that quantum mechanics was not a new solution within the old mechanics, but a new mechanics that was sensitive to the intrinsic dependence of quantum objects on measurement interactions and where measuring instruments, unlike the quantum objects they measure, followed 'classical physics' rather than the new quantum physics. This, he said, was a *re-interpretation* inspired by the way Einstein in 1905 solved the Lorentz and Fitzgerald problem of apparent length contraction and apparent time dilation by the apparently simple expedient

of re-interpreting the character of space and time, taking the *apparent* lengths and intervals to be the *real* lengths and intervals.[1] I am not going to defend Heisenberg's or Einstein's notion of interpretation, but to explore at a philosophical level the sense in which interpretation is at work in all of physics and other experimental science, and to contribute to opening up a new philosophical -- and metaphysical -- perspective on physics that was possibly foreshadowed by Einstein and Heisenberg in their attempt to make sense of their discoveries.[2]

Interpretation -- alternatively, *hermeneutics* -- belongs to the method and thinking of those other sciences, the human sciences, among which are to be counted history, classics, philology, linguistics, anthropology, psychology, sociology, biblical theology, jurisprudence, and philosophy. Most of these sciences have diversified over time, but I mean them insofar as they have retained their original focus on cultural meaning and its transmission, rather than on physics' explanation, prediction, and control. In Europe the human sciences have always been as revered as the natural sciences and were included in any listing of the sciences; in German, they were '*Geisteswissenschaften,*' in French, '*les sciences humaines*.' This describes a tradition of scholarship oriented towards the 'space' of shared and transmitted meanings within the context of the social historical lifeworld, its characteristic method being that of the (so-called) hermeneutical circle (or spiral) with multiple foci, 1. on the discovery, articulation, and fulfillment of meaning in the lifeworld, 2. on the historical transmission of meaning, and 3. on the transformation of meaning under the historical conditions of its transmission.[3] I aim to look at the natural sciences from the philosophical way of thinking originally developed to support the human sciences.

The *hermeneutic* orientation is contrasted with the *explanatory* tradition which in the English-speaking world is simply called 'science.' Explanatory method aims at the construction of a mathematical model comprising measurable (theoretical) variables, to be accepted or rejected by reason of its ability under laboratory circumstances to predict and control the causal outcomes of assigned initial conditions. Such is in general the methodological profile of the natural sciences.

Not that the human sciences have to be exclusively interpretative, nor the natural sciences exclusively explanatory. In fact, during the past fifty years, the human sciences have taken a strong turn towards the explanatory orientation under the name of 'empirical' or 'cliometric' social sciences, though with disappointing accomplishment on the whole in relation to predictive power. As for the natural sciences, the search for an inherent cultural meaning has come

predominantly (but not exclusively) from outside the sciences, in particular from religious interests looking for traces of divine action in the world, large and small.

In recent years, however, scholars have begun to use both hermeneutic and empirical social science methods to study the actual and historical profiles of activity of communities of scientific researchers. One outcome was the strong claim that the march of science was not continuous but rather characterized by abrupt theoretical discontinuities or (what T.S. Kuhn called) 'scientific revolutions.' Similar discontinuities were shown to exist even among co-existing explanatory theories.[4] Other studies have convincingly uncovered a diversity of internal and external cultural goals to scientific research.[5] The outcome of this research has brought philosophers of science to a moment of reflection about the identity and goals of explanatory science. This perplexity has affected the status of the natural sciences in a special way since, because of their success, they were assumed to provide a privileged route to knowledge, a route that became exemplary for all the other sciences, and even for the philosophy of science itself.

The received tradition of the philosophy of science is a philosophy of modern origin with roots in the classical philosophy of Plato and Aristotle. Among its distinguished modern forbears were Descartes, Bacon, Hume, Leibniz, and Kant. In this century it became a specialized branch of philosophy under the influence of Russell, the Logical Positivists and Logical Empiricists of the Vienna and Berlin Circles, and today it is represented by a galaxy of honored names among whom it would be invidious to make a selection.[6] This is the tradition that is presently now deeply divided over how to respond to the picture of scientific culture newly laid out by the best scholarship in the empirical social and historical sciences.[7] The story they tell about the natural sciences can hardly be reconciled with the noble ideals of knowledge and reality stemming from the philosophical tradition just mentioned. Whence comes an embarrassing dilemma: *either natural science is not worth the name of 'knowledge' and deserves no more than to be called 'useful opinion,' or the philosophical analysis of knowledge and reality needs to be revisited and reviewed.*

I suppose that most philosophers of science think they will eventually find a way out of this dilemma that preserves for the natural and other theoretic/empirical sciences a privileged epistemological and ontological status. Much of the enormous cultural prestige of natural science in modern societies has come from its Faustian powers, but even more derives from the noble-- perhaps, mythic-- belief that science helps us to see Nature, perhaps as God sees it, in a way unmixed with human error, construction, or superstition. If the dilemma can be resolved, it surely will be done with the brilliance of the talent available.

My goal, however, in this paper is to revisit and review the natural sciences from the perspective of hermeneutic philosophy in order to get a clearer or at least

a different assessment of the status of theoretical explanatory knowledge and its relation to the lifeworld, and possibly also to get some sense of how the current logical empiricist and the hermeneutic traditions relate to one another with respect to the short term explanatory goals of science and the long term goals of knowledge.

Just as the philosophy of science has its own fundamental literary corpus, so interpretative or hermeneutical philosophy has its own basic corpus. This comprises works by F. Schleiermacher, E. Husserl, M. Heidegger, W. Dilthey, M. Merleau-Ponty, H.-G. Gadamer, P. Ricoeur, and only in part, their structuralist, post-structuralist, and critical theoretic successors who remain strongly tied to the empiric/theoretical tradition.[8] The principal author used in this essay is Heidegger. I include a working bibliography here because Heidegger is not often found cited in the philosophy of science.[9] Though these writers may be relatively unfamiliar to philosophers of physics, their approach and concerns have long been the business of the human sciences. They have, however, recently become relevant to the philosophy of science because of the dilemma mentioned above.

Scientific knowledge, like all expert knowledge, is a domain of common meaning that finds fulfillment in the experience of local communities of researchers sharing a common scientific culture. Knowledge such as this is transmitted synchronically from local community to local community and also diachronically in the historical chain of transmission and reception. What is transmitted is not-- to use J. Dewey's term-- a museum piece, but the product of human understanding in action, re-creating and re-constructing meanings from the sources of meaning that are transmitted. This process is called 'interpretation,' and out of it, a certain diversity of understanding is inevitable among different local expert communities and, of course, among different generations of researchers.

Turning in particular to historical transmission, what is handed on by past researchers to their successors is not always what is received by these successors, for changes occur both in the transmission of common meanings and in the cultural matrix in which the received meanings find fulfillment. We scientists are today Galileans in a way in which Galileo himself was not a Galilean. I am not referring to episodic (say, Kuhnian) paradigm shifts, but to the general conditions under which any tradition of knowledge is historically transmitted.[10] Not only do such changes occur, but they must occur in any chain of knowledge transmission, let alone in any progressive research program. The interpretative character of science shows itself then historically in two ways: (1) in the way the *meaning-field* of the lifeworld is continually being refined, replaced, or transformed by scientific theorizing --an enterprise that is easily misconstrued if the role of interpretation is misunderstood; and (2) in the way *meaning-fulfillment* in the

lifeworld changes as the lifeworld is transformed by a succession of new technological praxes (among them, available instrumentation) embodying new or revised scientific theories. Of these, (1) focuses on *meaning* discovery, development, and transmission; and (2) on *meaning-fulfillment* in experience, culture, and perception. The continual historical dialectic between these two transcends all monisms, and all older dualisms.[11]

The following discussion will be shaped by some specifically philosophical topics and connected theses. For the purposes of this paper it is sufficient to get a feel for what they mean, for while the hermeneutical literature is large, the part that explicitly refers to natural science is small and needs development.

I. *Lifeworld*

The lifeworld is the philosophical 'field' ('space' or 'domain') of and for human understanding, characterized by the action of embodied human inquirers in communication with one another and with their environment against a background of active cultural networks.[12] Human inquirers by a species of philosophical reflection discover themselves to be contingently 'located' at some place and at some time in human history not by their choice but, as it were, as 'having-been-thrown' into the lifeworld conscious of having no more than a finite lifespan (Heidegger, 1996, 63-114, 236-263). Each individual inherits a language, a culture, a community, a set of cares-- perhaps, more than one of each-- that give meaning structure and purpose to the lifeworld he or she shares, and although the lifeworld is not of the individual's own creation or choice, it nevertheless permeates at conscious and unconscious levels the individual's life experience.

The philosophical notion of the lifeworld is derived by a special kind of reflection from the everyday world of purposeful intelligent social activity in which people converse with mutual understanding, conduct their business with intelligence and forsight, resolve problems with theoretical and practical skills, etc., all with more or less success. It would be wrong to think of the lifeworld as perhaps explanatory of the everyday world, for it is neither a model of nor a theory about the everyday world; nor is it merely descriptive of the everyday world for its does not reduce to a categorial list of contents by abstract kinds. The lifeworld is rather an attempt to *show* human understanding or Being at work historically within the practical reality of the everyday world by directing our reflective attention to the pre-theoretical, pre-predicative,[13] pre-conceptual activity that is prior in our thinking (not temporally but as a grounding condition) to all categories of things and institutions, and all theories of mind. What is thus shown is Being as the *ontological* dimension of human experience, Being as the

lifeworld outside of which nothing exists, and each human as being *there*-in-Being-- or *Da-sein* as Heidegger spoke

II. *Interpretation and meaning*

Human understanding functions by *interpretation* and its product is *meaning*. Meaning is nothing physical; it is not a text, a behavior, a neural network, a computation, not even a sign or a medium, nor any relationship among things, though all of these may be generated by and productive of meaning. Nor is it a private 'domain' accessible only by some kind of introspection. Rather meaning is a public 'domain' where people share the products of human understanding first by common habits of action (in which diverse networks are recognized) and then through the use of language and language-like media. Meaning is the 'domain' in which people understand one another, argue with one another, give reasons, establish goals, set up norms, define kinds, etc.-- more or less effectively according to the purpose, intelligence, language skills, and education of the parties involved. Meaning is historical because language is constitutive of history; it is also deeply affected by human temporality[14] and historical forgetfulness because the community/lifeworld milieu in which it is transmitted has gains and losses over time; it is local and social, because it is the product of active local interests and social communities and constitutive of their interests; it is then neither once-and-for-all fixed, nor ever perfect and unchanging. Finally, though subject to change under transmission, it is not on this account devoid of truth, rather is meaning the instrument through which truthfulness makes its appearance in the lifeworld.

III. *Scientific traditions or the historical transmission of scientific meanings*

Meaning, however, is articulated and transmitted only through the medium of language, actions, and other public expressive signs. These serve as the 'conduit' for meaning, but do not constitute meaning, for meaning is not a transportable substance like bricks or water. Meanimg has to be re-created from its transmitted sources by readers of the receiving community and there is no guarantee that the meaning derived from these sources by readers from one community will be the same as the meaning derived from the same resources by readers from a different community separated from the first by history and cultural environment. As historians of science well know, this is as true for natural science as it is for literature and politics.

Meanings are adopted from traditions of interpretation, or constructed or re-constructed in keeping with the responsibilities, constraints, and presumptions of

rational hermeneutical method (see below).[15] One of these responsibilities is that each legitimate meaning be appropriately fulfilled in a reader's experience or imagination. One of the constraints is the relative richness or poverty of the linguistic and cultural resources available to the reader.[16] One of the presumptions is that there is no single legitimate meaning relevant to all readers of, say, a text (and suchlike material), for meanings depend on use.[17] One kind of use that a text or sentence serves is its ability to be asserted as true in a chosen context by a user. Contexts and uses are multiple. A text then is like any piece of equipment,[18] say, a hammer (to use Heidegger's example), it can usually be used successfully for several meaningful cultural purposes. The uses are not arbitrary, for nothing but nonsense would be gained by arbitrary use, but this does not imply that there is forever just a single legitimate meaningful use. But, as in the case of the hammer, for each useful purpose there are lifeworld criteria as to how well a text performs for this purpose. Again as in the case of the hammer, there may be a conventional priority of uses with 'ownership' set by cultural tradition-- hammers are to be used for construction, scientific results are to be used for scientific research communities-- but no one use or 'ownership' need go unchallenged either by logic or by experience nor should any one use become the sole property of just one interested group.[19]

However, it is not the case that anything goes. Rational hermeneutic inquiry acknowledges the existence of *traditions of interpretation* that give today's readers and inquirers a culturally privileged version of past sources, shaped always to the goals of the linguistic and cultural environment of the community with special 'ownership' rights in the subject matter.[20] Within the sciences such traditions of interpretation approximate to what Kuhn called 'paradigms.'

In addition to meanings construed on the basis of a common tradition of interpretation (with its presumption of historical continuity), legitimacy can be gained by other meanings independently of any presumption that there exists a historical continuity of meaning with the source through a common tradition of life, action, and interpretation. Such *discontinuities of meaning* within the sciences are at the heart of what Kuhn called 'revolutions' in which old 'paradigms' are replaced by new ones.[21] In the work of hermeneutics, however, a radically new meaning need not expel the old, because each, though different, may be a valid historical and cultural perspective. Indeed, despite some sense of discomfort, we often find in the sciences the old flourishing side by side with the radically new, quantum mechanics with Newtonian mechanics, statistical thermodynamics with phenomenological thermodynamics-- though with respect to their formal models they are mutually incompatible-- and so on. Each acting within its own horizon of research purposes is in dialogue with relevant data through its own empirical processes of testing and measurement.

The appropriate philosophical approach to the method or process of interpretation is the 'hermeneutical circle (or spiral).' Briefly, following Heidegger (Heidegger 1996, 150-151), any inquiry is initiated by the breakdown of a task and begins by calling on the deep structure of pre-theoretical pre-categorial understanding[22] of Being which is found in the lifeworld (*Vorhabe*). Heidegger's name for the human inquirer is '*Da-sein*'; *Da-sein* is 'existence,' the embodied understanding of Being, a 'there-ness' (*Da*) in the domain of Being (*Sein*).[23] Inquiry is awakened when *Da-sein* poses a directed question (*Vorsicht*) which, like all directed questions, already implicitly contains an outline of a search and discovery strategy aiming at uncovering a solution. The question so construed in this case is not yet in an articulated form; only later will it achieve an adequate expression in (what philosophers of science call) an 'explanation.' There follows an active dialogue between *Vorsicht* and *Vorhabe*, accompanied by actions seeking practical fulfillment in the awareness that the sought-for understanding (*die Sache selbst*) has presented itself and made itself manifest to the inquirer (*Vorgriff*). If on first trial the sought-for understanding is absent, something nevertheless has been learnt, and the search resumes, dipping again into the available resources of *Vorhabe*, *Vorsicht* and *Vorgriff*. This hermeneutical circle of inquiry is repeated until a solution presents itself within a new cultural praxis in the lifeworld. Only at that time is it in order to express the solution linguistically in the form of an explanation.

In summary, hermeneutic method is a process--and difficult work it can be--done by a current inquirer who, say, is challenged to construct a contemporary meaning for a source event, such as, for example, Galileo's observations on the phases of Venus, originating in a different linguistic and cultural environment and possibly elsewhere at an earlier time. This is the *method of the hermeneutical circle (or spiral)*. Interpretative work of this kind is clearly historical, cultural, and anthropological, multidisciplinary in character and in need of a philosophical foundation which hermeneutical philosophy tries to provide. In this work lies the significance and power of hermeneutic method and hermeneutic philosophy for the history and philosophy of science. And not just for these, but also for understanding how quantitative empirical methods give meaning to empirical contents, how theory-laden data depend on the public self-presentation of the measured entity as a public cultural entity and, in particular, how measurement equipment plays a double role creating and refining both theoretical and cultural meanings. These are topics that will be addressed below.

IV. *The furniture of the lifeworld*

The lifeworld has a furniture that comprises those physical and embodied cultural objects, both 'natural,' like trees, and 'cultural,' like institutions or

technologies, which have names or descriptions in the language; among them are perceptual objects. All of these are (to use Heidegger's term) *ontic beings.*

V. *Hermeneutics of theory-ladenness: theoretical understanding as explanation*

Since in the age-old tradition going back to Aristotle the characteristic goal of all scientific or scholarly inquiry is theoretical understanding, it is important to understand what theory does in modern science. A theory explains why some event occurs (or does not occur) by providing a model of the causes or conditions that control its occurrence (or non-occurrence); its goal is experimental prediction and control. Alternatively, a theory may explain a lawful regularity among empirical events by providing a model of the causes or conditions that, if fulfilled, necessitate the lawful regularity among these events.

To probe what is implied by this meaning of theory, I follow Heidegger (1996, 357-364). He begins with a broken hammer and a construction project. A hammer is a tool used in a construction project; a worker generally does not ask what a hammer is until by bad luck he has to find a replacement for it or a substitute. Only then he asks: what are the specifications of a hammer (so that the project engaged in can be finished)? The answer will be a theory (about hammers) that explains its ability to do a hammer's job in carpentry or the building trades. In Carnap's terms: the *explicandum* is 'the ability to do a hammer's job,' the appropriate *explicans* is a theory (of the hammer) which will give physical specifications for a hammer.

Consider now the question: What meaning should a speaker attach to a hammer? Without a specification of context, the question is indeterminate, but in the line of our inquiry we can distinguish two questions and two answers. In the context of a construction project, a hammer is a cultural entity possessed of a cultural meaning related to the practical needs of carpentry and the building trades. In the context of the explanatory project of science, the hammer is a physical entity specified by a theory that lays out the conditions under which it can become the host of the cultural meaning of a hammer. The first meaning is a *cultural praxis-laden meaning,* and the second is a *theory-laden meaning,*[24] and they are not independent for the *theory-laden* meaning makes sense only if the hammer-referent is in point of local contingent fact *praxis-laden* within the building project either by reason of actual use or by social designation.

Despite the fact then that (hammer-) theory 'explains' (hammering-) praxis, the language of theory and the language of praxis belong to different though coordinated perspectives. Coordination does not imply, however, isomorphism between the two perspectives,[25] for the hammer could alternatively be designated to serve as a nutcracker, and the worker on the construction project could,

perhaps, be served on this occasion by an old boot or means other than the use of a theoretically specified hammer. Theory, as we know, is underdetermined by practice and vice versa.[26] Since theory and praxis are merely coordinated but not isomorphic, they can be taken as axes for a kind of cultural phase space within which revolutionary changes can occur stemming either from theory or from praxis. Examples of such revolutions abound. New theoretical insights can generate new cultural practices as, for instance, when theory-based bacteria research transforms a host of cultural practices dealing with food handling, personal hygiene, sewage and water systems, the urban environment, and the treatment of bacterial diseases. New cultural practices can also generate new theories as, for instance, when the steam engine inaugurated revolutionary changes in calorific theory leading to the development of thermodynamics. A creative historical tension then arises in the lifeworld between theory making and cultural practices, and this can-- and does-- result in changes in the lifeworld with concomitant changes in the conditions for meaning-fulfillment within the lifeworld. Noting such changes, one also notes something about the historicity of hermeneutic truth.

Returning to an earlier point, 'this hammer is theory-laden' always implies an implicit cultural hypothetical, 'provided this hammer has been socially designated for a hammering role in construction.' Note that the theory-ladenness of the hammer as such omits to include explicit reference to this local and contingent condition, but the reference is, nevertheless, implicitly assumed by the logic of theory as explanation. Let us consider what the case would be if this local and contingent condition were absent. Then, 'this' would not be a hammer, 'this' would not be theory-laden, 'this' would become (in Heidegger's words) 'a mere possible resource,' and 'this' would have no more title to being listed in the hammer category among the furniture of the then-lifeworld than old boots.[27]

What kind of entity then is a hammer as a socially dedicated resource? It can only be said that it is a public cultural reality, a physical reality constituted by a socio-cultural meaning.[28]

Now, to the extent that no individual thing--or almost none-- in our experience is without a human purpose, everything in our experience, including scientific entities, bears some resemblance to a hammer, or other tool or equipment. There are then (at least) two perspectives on (almost) any individual thing in the lifeworld: a praxis-laden cultural perspective and (given a successful theoretical explanation) a theory-laden perspective.

One may argue that Carnap's explanatory schema does more than specify physical means to cultural ends, and aims beyond this to specify the culture-independent reality underlying and controlling cultural life. Whether or not explanation can go beyond culture and history is a separate assumption the basis

of which is in metaphysics, not explanatory science. Clearly the search for explanatory theory in the modern sense is not the same as a search for realistic theory in the metaphysical sense despite the ancient classical assumption that possessing theoretical knowledge **is** knowing the real. The debate about *realism* and *anti-realism* is often confused about what is perceived to be at stake in theoretical scientific research.

VI. *Measurement and data*

These conclusions have important consequences for understanding measurement, since they illuminate the binary valence of empirical 'facts,' something not given by the usual empiricist accounts.[29] The process of measurement in science fulfills two different but coordinated functions. It presents the *object-as-measurable*, this is the praxis-laden cultural function. And it takes the data from the presented object, this is the theory-laden *data-taking* function.[30] These are the binary valences of scientific data. The data-taking is usually called 'observation'; but there is no observation without the prior preparation and presentation of the object-as-measurable.[31] A well-defined measuring process does both jobs, presenting the object and recording the data. These involve two different epistemological perspectives, a praxis-laden cultural one (which belongs to the strategy of experimental culture in laboratory environments) and a theory-laden (or explanatory) one. These two perspectives can and should be logically, semantically, and pragmatically distinguished (see Heidegger, 1996, 358-359). Let us consider what these two perspectives reveal about the measuring process, scientific entities, and data.

Consider the theory-laden perspective.[32] Since it is the function of theory to oversee the experimental design (what will do the job of presenting the object-as-measurable?), the ontic referent of theory as such is the measuring process viewed from the construction or engineering or technical point of view. Think of the theory of the hammer in relation to the cultural praxis of hammering! Within the life of science, theory refers directly to the internal structure of the (particularly measurement-presenting) processes by means of which 'theoretical entities' enter the public cultural domain of science where they then provide data to observers. *This leads to a first conclusion: what is formally theory-laden is experimental design.*

In the praxis-laden cultural perspective, the presentation of the object-as-measurable is a public cultural event praxis-laden in the scientific culture of the laboratory, deriving meaning not from the observation event itself but from a research program. The object-as-measurable is recognizable as such because it comes 'dressed' in sensible 'clothes' provided by the experimental strategies

used. Whether such 'clothes' render the scientific entities perceptible will be discussed below. *This leads to a second conclusion: observation events should not be called semantically 'theory-laden'-- this appellation should be reserved for experimental design*[33]*-- but rather semantically praxis-laden like all dedicated or designated cultural objects of the lifeworld presented as fulfilling experience.*

The meaning of data is also bivalent and, like the meaning of a hammer, subject to ambiguity. Data belong *hypothetically* to the theoretical perspective of measurement but *affirmatively* to the cultural perspective of the lifeworld forum of scientific research strategy; the research 'narratives' that Rouse[34] speaks about would belong here. This is the special environment of the expert researcher and, though public, is usually closed to the understanding and experience of the ordinary citizen. So-called 'theoretical entities,' such as, for example, *electrons* and *electron-data*, are theory-laden but, for the reasons given above, they cannot be said to exist as such unless locatable in a public forum, the primary public forum being that of an experimental scientific research program where as public cultural entities they are explicitly praxis-laden with respect to some standard configuration(s) of laboratory equipment. Though the theory of electrons may change, it is never the case that what we call 'an electron' fails to have an in principle relationship to contingent local practical cultural milieus.

VII. *Theoretical entities as cultural entities*

In addition to the public forum of scientific research, there are other public fora within which individual 'theoretical entities' and the data about them can become cultural entities.[35] These are, for example, public fora featuring technology, finance, political power, religion, art, media, and so on. All of these-- like the scientific research forum itself-- are local fora in which a scientific entity, usually in some technological context, can play the role of a dedicated cultural resource (for the life of finance, politics, religion, art, media, etc) and by this means become part of the local furniture of the lifeworld. For example, choosing television as one such local technological forum, then, electrons-- or, at least, electron-beams-- can be designated even to children and others unlettered in physics as cultural entities in that forum because of their role in 'painting' the TV picture. In all such local fora, the scientific entity and its data are meaningfully bivalent and emulate the relationship between theory and praxis in the study of a hammer. Removed from all such local fora the putative 'data' are not data at all[36] since they do not make manifest in the lifeworld the presence of anything but 'themselves'-- but of 'themselves,' having no determinate lifeworld meaning, they are just noise.

When new theory-based technologies are added to the lifeworld, theoretical scientific terms can be introduced into everyday descriptive language with new non-theoretical cultural meanings. For instance, *temperature* as a cultural entity is endowed with non-theoretical, practical lifeworld meanings which can be used to create, designate, employ, and control new classes of equipment, for example, thermostats, in the lifeworld. With the help of these new resources, the old cultural environment can be changed, perhaps, in revolutionary ways. Public space, for example, was revolutionized in renaissance Italy in the *quattrocento* prior to the Copernican revolution and the development of modern science when it came to be subjected to universal measurement, and to analysis according to the principles of the newly discovered mathematical perspective. It was transformed by this process, from a manifold with diverse local geometries into one with a single measurement-based Euclidean geometry. For those who looked for a unified cosmology, the way was prepared for Galileo and the Copernican revolution.[37]

The second example is from medicine and illustrates how the bivalence of scientific descriptions can create new moral perplexities in the lifeworld. Duden[38] asks, is the term 'foetus,' merely a scientific redescription of the lifeworld entity, a baby? Or is it the replacement of one lifeworld entity, a baby, by a new scientific entity, a foetus? The terms are, of course, correlative (each in its own context reveals something about what the other term refers to) but they are not isomorphic (there is no unique mapping from one to the other). But a foetus is something that the medical profession alone can discern and control with its sonographical and other techniques apart from the mother; a baby is what the mother knows by feeling it within her, defining it in terms of her own familial response to it. Duden then asks, should ethics and legislation, say, concerning pregnancies, be written exclusively in terms of the foetus, as one finds increasingly in the current practice in the West? Or should the difference between the two perspectives be recognized and an accomodation found that defers to the special cultural role of the mother in decision-making about the baby?

Beyond the life of science then 'theoretical entities' are recognized as public cultural entities through the technologies that embody them and through the public data that monitor their part in the way these technologies work. Theoretical entities then are not extra-cultural extra-historical entities, but to the contrary their theory-ladenness implicitly binds them, not just to the arcane culture of scientific research, but also to the broader cultural historical lifeworld wherever their presence is recognized in public experience. Removed (in principle) from the lifeworld, they are simply non-entities.

VIII. *Truth and meaning*

Truth in the classical sense grasped the object's inner intelligibility leaving behind what was material, irregular, and unintelligible; it was the immaterial (mental, spiritual, intentional) possession of a material object leaving it, however, unchanged. The mental representation so formed conformed to the object represented, it 'mirrored' Nature in Mind. Language and life did not enter into the shaping of what is so presented as truth. Powerful and historically significant as was the classical notion of truth, there came a time, however, when the function of language eventually could not be ignored. Tarski, for instance, proposed to define truth as a property of statements. Thus, let 'p' ('Snow is white') be a statement, then: 'p' ('Snow is white') is true if and only if p (snow is white). From the hermeneutic perspective such an account turns out either to beg the question or to be vacuous. For consider: how is the meaning of the sentence 'p' ('Snow is white') arrived at? Words to be meaningful need a context of use and a users' community, but there are an infinite variety of contexts of use and of users' communities for the sentence 'p' ('Snow is white') giving different meanings, yet none is specified in Tarski's definition. Turning to the other half of the definition, how is it determined that p (snow is white)? By experience, of course! But either experience presupposes an ability to use language correctly which begs the question or is indeterminate and so cannot function as a criterion. Tarski's logical definition, however, was proposed within a philosophical framework different from the one used in this paper and within that framework was unquestioned until recently.

In the hermeneutical perspective, truth is the product of a human understanding that works through interpretation. Interpretation, however, functions through the construction of meaning by common action, theory, and language. Theoretical meanings contribute an abstract component and common action contributes a cultural or practical component.

Heidegger embodied this duality of meaning in his choice of the Greek term, *alethia* (literally 'uncovering') for truth (Heidegger, 1996, 213-4). It signalled a change in the notion of truth from the classical model of full transparency to human understanding, towards one of only partial, historical, local, practical, or contextual transparency (see, for example, Heidegger, 1996, 34-39).[39] As in the case of the hammer, the theoretical set of parameters addresses just one aspect of the individual exemplars, that chosen for explanation (the *explicandum*). Other aspects of the exemplars than those chosen for explanation are outside of the perview of the inquiry.

Moreover, in the search to explain the *explicandum*, the theorizing process soon discovers the extent to which the cultural function of the *explicandum* can be transferred to different artifacts from the individual exemplars originally studied. An old boot can on occasion do the work of a hammer! This leads to the

following (surprising?) conclusion: *what makes this or any individual hammer to be a hammer--or what makes this or any individual thing in human experience to be what it is perceived to be-- is not a defining permanent essence but a set of contextual properties any one of which can be found in, or retro-fitted for, a variety of different physical hosts.*

The truth about things in the lifeworld then is not a classical conformity between a mental representation and the object represented but a property of complex meanings with local and historical uses.[40] The meanings we entertain about things are disclosed by praxes that are implicitly theory-laden. These meanings are not permanent but historical, local, and changing. They are local, because expert communities of use are exclusive. They are changing because, it happens that, when the particular theory-ladenness of the praxes becomes explicit, new, better or, at least, different, praxes can often be engineered with a consequent transformation of cultural meaning. It can happen, say, that some old boots function as hammers, or that hammers eventually disappear entirely in a world of plastics and high tech. Such a spiral of meaning change turns endlessly within the historicality of Being (see Heidegger, 1996, 9) as such trivial examples show. Such a process of theory-driven cultural change brings new historical perspectives into play and through forgetfulness inevitably puts old ones out of play. The big mistake of modernity was to commit itself to a classical static conformity notion of truth that could only be retained by supposing that scientific theory could be separated logically or ontologically from temporality and culture. This is what hermeneutic reflection shows to be contrary to experience.[41]

IX. *Scientific technologies*

Heidegger feared that, to the extent that scientific inquiry is successful in the construction of explanatory theories, it would turn the focus of philosophical inquiry away from 'meditative thinking' about the lifeworld as the cultural arena for human life fulfillment, that is, away from meaning and meaning change, and toward (what Aristotle called) 'calculative thinking' ordained toward management and control; in the latter, things are treated as means to ends within *Gestell*, the assumed 'objective' frame of 'objective reality' (Heidegger, 1968, pp. 3-35; 1966, p. 46).

No minimizing is intended, however, of the great benefits that can and do flow from the 'calculative thinking' of scientific inquiry. Nevertheless, Heidegger foresaw that such benefits could have a human cost, for they affect the way cultural life teaches people to be human and communicates to them the sense of the wholeness, integrity, and goodness of the world, the self, and human communities. This is Duden's point (in the example cited above) in questioning

the implication of using the scientific term 'foetus' exclusively in place of the older maternally related vocabulary. Changing the traditional vehicles for the transmission of these core meanings inevitably changes how people regard themselves, their personal destinies, their neighbors, and the world around, with consequent risks of cultural instability in all these areas.[42]

X. *'Theoretical entities' as perceptual entities*

It was argued above that 'theoretical scientific entities' are public cultural entities. Among the latter are perceptual entities. Is it possible that some 'theoretical entities' are also perceptual entities?

Much depends on what perceptual objects are taken to be. In the empiricist tradition perceptual objects are explained as organizations of sensations, and from this position it can be argued that sensations received from a measuring instrument can only be ingredients of the scientist's perception of the state change of the instrument, and not of the 'theoretical entity' that caused that change. In a more developed version of empiricism, an argument is sometimes made for the partial observability of the 'theoretical entity'.[43] This whole line of thinking derives from a theory or model of perception-- one incidentally that has little supporting evidence-- and when applied to the perceptual object itself as a cultural phenomenon, it makes no sense at all. The perceptual object is the *explicandum* and should not be confused with the empiricist *explicans*.[44] Nevertheless, the empiricist theory of perception exercises an influence far beyond its weight in discussions about the ontological status of 'theoretical entities.'

What then are perceptual objects as phenomena in the lifeworld? A brief sketch of an answer would go something like this: they are substantive individually localized cultural objects in the lifeworld, presented to local human perceivers in sensory experience, and understood by the character, multiplicity, and systematicity of their sensory presentations or profiles.[45] Given that (on the basis of the argment already made) a scientific 'theoretical entity,' say, an electron, is a substantive cultural entity in the lifeworld, we ask: can it have the appearance of a perceptual object? The answer I gave in an earlier work is Yes! and this answer still holds.[46] Let me revisit the question briefly.

In section VII, I referred to the historical influence in the *quattrocento* of two technologies, distance measurement and mathematical perspective, on public space transforming it from a diversity of local and mostly non-Euclidean public spaces to one universal Euclidean public space. Such technologies as those mentioned above I called 'readable technologies,' because they made it possible to make and mark environmental cues that enabled the learning of Euclidean vision. In general, readable technologies are technologies capable of transforming

perception.[47] Some laboratory measurement devices when standardized have the capacity of presenting a cultural entity, such as, for example, an electron or a molecule, as localized in the lifeworld and as 'clothed' with systematic sensory profiles that can be taken in context as an electron's recognizable signature. Such technologies are *readable technologies* and confer perceptability on the scientific entity in question.

XI. *Contextual Logic and Bivalent and Multivalent meanings*

Tools, such as, for example, hammers, and practically everything else in the lifeworld including 'theoretical entities' have multivalent meanings. By 'multivant meanings,' I mean, a minimum of two synchronic meanings in different, coordinated but not isomorphic, perspectives that are descriptive of a public cultural entity. Such perspectival multivalence raises the further question: Are there articulate logically reasonable conditions (within the purview of hermeneutical philosophy) that would give coherence to such perspectives?

The answer I gave in an earlier work is still fundamentally the one I would give today though with some corrective glosses.[48] The core of the solution is that the two complementary perspectival languages-- theory-laden and praxis-laden-- must be partially ordered by statement inclusion within a complemented non-distributive lattice (or *context logic*).[49]

XII. *The scope of hermeneutical philosophy for the philosophy of science*

The hermeneutic turn in the philosophy of science is necessary to study aspects of science for which the traditional philosophy of science is not well equipped. These are the dynamic, narrative, historical, and lifeworld aspects of science. In this light the traditional philosophy of science appears to be a version aimed at fulfilling the cultural goal of supporting theoretical research with a strong interest in management and control, and as a philosophy it is cropped of much of its background in human life and history that is relevant for broader and longer term issues.[50]

The wider scope of a hermeneutical philosophy of science can be judged by the topics it needs to address, some of which I and others have already begun to address in publications.

1. *Scientific discovery, or how traditions begin*, needs to be studied in individual exemplary cases, such as Galileo's telescopic observations of Venus or Heisenberg's quantum mechanical explanation of the hydrogen atom. The

appropriate philosophical approach and method is that of the 'hermeneutical circle' as sketched above

2. *Meaning persistence or change* needs to be studied in the process of transmission of a scientific tradition under ordinary and extraordinary conditions of diverse and changing cultural and theoretical interests.[51]

3. *The role of metaphor*[52] needs to be studied; metaphor is as fundamental for the hermeneutical perspective as literality is for traditional philosophies of science. Since theory is mathematical and the lifeworld is empirical, it makes no sense to predicate abstract and mathematical theoretical properties literally of the lifeworld; at best, the two come together in some unambiguous way in a variety of authoritative contexts each comprised of experts, guided by (what Aristotle called) 'phronesis,' and conscious that they are seeking a consensus about a set of relevant soluble issues. Among these authoritative contexts the scientific discipline has a certain privilege of 'ownership'; it might be called the 'producer ownership,' others in contrast being 'user ownership,' though the notions of 'intellectual ownership' and 'use' as they relate to science is a matter that is not to be resolved here. One last important comment: underlying the literalist view are a series of cropped understandings (misunderstandings?) of the nature and role of mathematical models, for instance, of how theories relate to the empirical world, of the nature of truth, and particularly, of knowledge as only a short term causal objective snapshot in contrast with knowledge as long term dynamic, historical, and social assessments that function of necessity in a cultural milieu that, being praxis-laden, does not need or support unlimited univocity, precision, or causality.[53]

4. *The role of metaphor in the history of science* is revealed as a powerful source for shaping theory and needs to be studied. Images of perfectly smooth balls, perfect elastic bands, imponderable aethers, frictionless mechanical devices, 'molecular' bench models, ideal computer simulations, sine-wave oscillators, ten-dimensional spaces, and God's Mind's Eye on Nature have all helped to shape scientific theories. Nor is it possible to come to understand, say, modern physics or biology, without passing through stages of metaphor in the learning process. As in the search for theory, so in its application, theoretical instruments apply to real situations in socially negotiated ways, using metaphors.

5. *How scientific traditions end* needs to be studied from the hermeneutic perspective. Kuhn and others argue that the abandonment of a tradition is not simply a function of having failed the challenge of anomalies, but of a decision of those who principally 'own' the tradition to make the tradition vulnerable to challenges. Resistance to such a move is strong, because what keeps a tradition alive is usually some transcendental good it offers or some hope beyond the particular useful solutions it has generated. That good could be mythic or

aesthetic. A mythic good is religious in nature, connected with the notion of theory as a sharing in divine or transcendental knowledge[54]; this is the spiritual good that Galileo, Newton, and Einstein sought in their science. Alternatively, it could be an aesthetic good like the styles of art, music, and cuisine that is connected with the fulfillment of human embodied activity in the world; this is a good associated more with laboratory virtuosity than with disembodied spirituality[55]; one thinks of some great experimenters, a Pasteur or a Fermi, in this connection.

6. *How myth as a grand narrative, understood as normative, metaphorical, and metaphysical,*[56] operates in the transmission of scientific traditions needs to be studied in particular cases. For example, the historical Galileo and today's physicists share something associated with the term 'Galilean,' but today's physicists are 'Galilean' more in a mythic than a historical sense.

7. While we do not ask of a philosophy that it contribute to the successful practice of science, science nevertheless continually throws up philosophical questions that divide the scientific community and constrain or limit its energies in a world of finite resources. A survey of recent literature[57] suggests that many currently frustrating and contentious topics should be looked at through the optic of hermeneutical philosophy. Some of these are epistemological or metaphysical framework topics, such as, for example, *realism*, *relativism*, *constructivism*, *truth*, *objectivity*, *causality*, *purpose*, and *history*, and some are issues that call for liaison with the lifeworld, such as, for example, *space*, *localization*, *time*, *measurement*, *data*, *explanation*, *macroscopic* and *microscopic*, *elementary particles*, *multivalence of scientific claims*, *indeterminacy*, and *the paradoxes of quantum physics*.[58]

8. Since theory-based technologies can change the lifeworld and the range of possible meanings available to human life and action, hermeneutical philosophy should ask: *in what way does a changing lifeworld change the playing field for science, old or new?*

9. Science also throws up epistemological questions regarding *interdisciplinary studies of science*; communities of historians, philosophers, sociologists, cultural anthropologists, etc. are deeply troubled by their inability to communicate well among themselves.[59] A common platform in a hermeneutic philosophy of science might ease this situation by disclosing the different agendas and different fundamental resources (in texts, technologies, cultural habits, etc.) that define these disciplines in relation to the differing perspectives they engage in a postmodern lifeworld.

10. An important focus of interest for hermeneutical philosophy is the empirical social, cognitive, psychological, neurobiological, and medical sciences,

where a profusion of theoretical models vie with each other and conflict with the way people understand themselves in their own cultural practices. [60]

11. On the ethical front, questions like, 'how does scientific theory, say, in medical science, relate to the lifeworld of cultural experience, say, a woman's pregnancy?' need to be treated hermeneutically. It is often assumed that scientific theory should replace the 'folk wisdom' of human culture[61]: but that is by no means evident.

12. On the religious and political front where hermeneutic methods are strongest, there is need for a more hermeneutical account of science's public role as the principal agency of theoretical knowledge within a culture that is in great need of such knowledge, has such great respect for it, but is racked by deep uneasiness about its often implicit cultural agenda. [62]

13. Finally, returning to Heisenberg's description of quantum mechanics as a re-interpretation of classical mechanics, the writer has confidence that a hermeneutical analysis in the spirit of this paper would go far to throw light on the basic 'mysteries' of the quantum theory. [63]

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NOTES

1. See Heisenberg (1925, 1977); cf also Heelan (1965, 1975a).
2. The polarity between the methods of the human and natural sciences, that is, between hermeneutic (*Verstehen*) and explanatory (*Verklären*) method, has been the subject of many studies, from Dilthey to Gadamer. To mention a few: Dilthey (1989), Follesdal (1979), Gadamer (1975, 1988), Margolis (1987, 1996). The concern of this essay, namely, to address the explanatory method of the natural sciences from the philosophical perspective of hermeneutic philosophy, is shared with, among others, Babich (1994), Bubner (1975), Crease (1995), Eger (1993), Feleppa (1981), Fjelland (1991), Gadamer (1982), Hübner (1983), Kockelmans (1985, 1993), Markus (1987), Ricoeur (1978, 1981), Rouse (1987), Scharff (1995), and the present writer, e.g. Heelan (1965, 1975b, 1983a/1988, 1987a, 1987b). Many important writers, including Gadamer, Apel, and Habermas, are too imbued with the classical view of natural science as uniquely explanatory that for historical-- and perhaps, also practical-- reasons characterizes the culture of empirical research to be open exponents of a hermeneutic philosophy of natural science. This essay then will draw mostly from Heidegger and his commentators.
3. Cf. Dilthey (1989); and among other works, Bleicher (1980, 1982), Heelan (1991, 1994).
4. See Kuhn (1970, 1977), Fleck (1935/1979), Crombie (1994), and others.
5. See, for example, the work of B. Barnes, D. Bloor, H. Collins, M. Jacob, B. Latour, A. Pickering, and S. Shapin, as well as the monumental work of Crombie (1994).
6. Among the scholars in this field to whom I implicitly refer in this paper are N. Cartwright, I. Hacking, M. Hesse, K. Popper, H. Putnam, W. Quine, W. Sellars, van Fraassen, and J. Ziman.
7. See, for example, how Cartwright (1983) and Earman (1992) address some of these questions.

8. For an overview of the tradition see, for example, Bleicher (1980, 1982), Heelan (1983a/1988), Kockelmans (1993). The German tradition is covered Mueller-Vollmer (1994) which contains brief bibliographies. Some of the basic works of the authors mentioned are listed among the references.
9. Among the many excellent commentaries on Heidegger and the hermeneutic tradition are Bernasconi (1993), Buckley (1992), Dreyfus (1991), Grondin (1994, 1995), Guignon (1983), Gurwitsch (1966), Kisiel (1993), Kockelmans (1985, 1993), Mueller-Vollmer (1994), Okrent (1988), Pöggeller (1987), and Richardson (1963).
10. Crombie's and Shapin's work illustrate this approach.
11. Recognition should be given to P. Feyerabend for drawing attention to *Reason's* difficulty-- *Reason* being theoretical science and the philosophy of science-- in attempting to make sense of the richly varied real life historical circumstances in which scientific theory grows and from which it has sought to exercise hegemony over thought. See, for example, Feyerabend (1987). Much of this material needs to be re-assessed in a different philosophical setting, a more hermeneutical one, from the one he was familiar with.
12. The notion of *lifeworld* was used by Heidegger (1996), Husserl (1970), Merleau-Ponty (1962), Schutz (1973), Heelan (1983a/1988) and others; it plays an important role in the tradition of hermeneutic philosophy.
13. Cf also Heidegger (1996), 354-364.
14. Also influenced by human temporality are, for example, C. Hooker, R. Neville, A. Shimony, M. Wartofsky, and others working in an evolutionary naturalistic perspective; see Hahlweg and Hooker (1989). As in the tradition of pragmatic philosophy of which this is an extension, the energy of discovery comes from action which, like hermeneutics, presupposes a certain priority for the Good.
15. Cf for example, Heidegger (1996), 150-151 (on the 'hermeneutical circle'), Dilthey (1989), Gadamer (1975), and, say, as exemplified in Toulmin (1992).
16. For example, our current resources may be poorer than the past to understand, say, the term, 'magic,' while for the term 'disease,' our current resources may be richer--or, at least, different.
17. See Heelan (1991, 1994) for the dependency of meaning on an assumed fundamental corpus of literary resources, as exemplified, say, by a shelf of books in the library.
18. See Heidegger (1996),357-364.
19. There is a vibrant and copious cross-disciplinary literature about historical, religious, ethical, political, and other cultural meanings of topics ranging from Big Bang Cosmology to ethical aspects of science. Among the scientist contributors to these discussions are Stephen Hawking, Steven Weinberg, Paul Davies, and Richard Dawkins. The non-scientists include, for example, ethicians, historians, sociologists, and cultural anthropologists of science, and feminists.
20. Such traditions of interpretation tend to possess from the short term perspective a static quality that from the long term perspective shows up as an inauthenticity to be overcome for the sake of growth of knowledge; cf. Heidegger (1996), 9.
21. For the study of scientific revolutions, see Kuhn (1970), and the extensive literature that followed the publication of this work; in particular, Lakatos/Musgrave (1970), Gutting (1980), Hoyningen-Huene (1993). Paradigm revolutions are also associated with the temporality of the human knower and communities of knowers, cf. Heidegger (1996), 372-373.
22. Readers may find some difficulty with the meaning of this language. It attempts to direct thinking to the foundations of every articulation of human experience in the lived understanding of the lifeworld, antecedent (in principle) to the formation of perceptual kinds (of things, events, etc.) and their representations in language or language-like signs. I have translated *Vorhabe* as *lifeworld background*, *Vorsicht* as *proposed theory*, and *Vorgriff* as *looked-for fulfillment in experience or experiment*.

23. This may be expressed in a hermeneutical principle: the Being of understanding is the understanding of Being. The object of understanding-- "*die Sache selbst*" --*necessarily* belongs to Being. This may be looked upon as the hermeneutical joining of an upward movement which is the search for understanding (*Vorhabe*; see below) and a downward movement resulting in the self-manifestation of that (*die Sache selbst*) which is articulated by theory (*Vorsicht*) and given in experience (*Vorgriff*).
24. The term, 'theory-laden' was first used by N.R. Hanson against the empiricist view of scientific observation; he argued that scientific observations were theory-laden; see Hanson (1961)-- there is more about this below.
25. By *isomorphism* is meant a one-to-one translatability of any statement in one language into a unique statement in the other language. The two context-dependent languages refer to the same things but from different, often interacting and mutually interfering, perspectives. I have argued that these languages are related among themselves within a lattice structure which includes a least upper bound (lub) and a greatest lower bound (glb) as well as complements. This thesis is presented in Heelan (1983a/1988), chaps. 10 and 13.
26. This is the Duhem or Quine-Duhem Thesis, arrived at by another route; cf. Duhem (1914/1954).
27. 'This' former hammer could now possibly be a museum-piece, but more likely it is junk.
28. The socio-cultural meaning then is not something that can be dropped, like slag from ore when a metal is refined, but essential to the intelligibility of the meaning. For an understanding of cultural meaning, see Geertz (1973, 1983).
29. Empiricist accounts of measurement are legion; many of them have purposes that are not strictly philosophical but methodological. Philosophers of science have also written on measurement but mostly from the viewpoint that empirical measures are grounded in ideal, objective, in the short term unique, and realistic values. For a hermeneutic view on *measurement* and *data*, see Heelan (1989a). For its background in Heidegger, see (1996), 357-364.
30. In physics, these are sometimes called 'preparation' or 'measurement of the first kind' and 'observation' or 'measurement of the second kind' respectively. See Heelan (1983a/1988), chap. 11. and Heelan (1983b, 1989a, 1992).
31. This is a point also made by Hacking (1983) but from a different perspective.
32. What follows comes from a further exploration and correction of Hanson's "theory-ladenness," and is also in part a critique of Fjelland (1991).
33. How this analysis applies to a 'closed' system, that is, one that is not interacting with its environment, needs further study. The study of 'closed' and 'open' systems within this context involves also a study of the space/time notions of 'body,' e.g., a body's 'spatial boundaries,' its 'size,' 'mass,' 'quantity,' etc. and how the notions of 'macroscopic' and 'microscopic' apply. Some of these have been partially addressed in recent literature, e.g., see Needham (1996) and the references he gives, but these studies are against a philosophical background that is object- and concept-oriented. None of these analyses addresses satisfactorily how the meaning of these terms relate to a body's lifeworld engagement, say, in measurement.
34. Rouse (1996), p. 27 and in chap. 9.
35. For the notion of culture, cf. Geertz (1973, 1983).
36. Of course, there is always an alternative strategy, the researcher may re-evaluate the interpretative context of the experiment and pursue another goal. For a more detailed study of *data*, see Heelan (1989a, 1992), also (1983a/1988).
37. See Heelan (1983a/1988), chap. 11.
38. The example that follows was taken from Duden (1993).
39. Polanyi seems to say the same in different terms: the *explicit meaning* conceals a *tacit meaning*; see Polanyi (1964), pp. x-xi.

40. Radder (1996) who comes to a similar conclusion.
41. These conclusions prepare the ground for Babich's reading of Nietzsche's philosophy of science (Babich 1994) in which she explores with elegance Nietzsche's perspectivalism or musical "concinnity" in relation to truth, morality, and the critique of science.
42. Contrast the views of Bly (1996) and Vattimo (1992) about the post-modern effects of the dismantling of Enlightenment culture. As David Bromwich wrote in a review of the former in *The New Republic*, September 9 & 23, 1996, '... progress for [Americans] means almost exclusively technological improvement ... But all the new tools a people master cannot assure their generous use. Technology travels a different road from political stability, moral well-being or aesthetic achievement...' (p. 34). See also, Duden (1993), for a feminist perspective. Also Heelan (1983a/88), chap. 15.
43. Such as, for example, made by Fraassen (1980).
44. This confusion can arise from the common but mistaken conception that the value of a theoretical variable is to be identified with the ideal or limiting value obtained by ever more precise measurements. Such a conception does not work, as Kant indicated, for any singular theoretical value must be postulated a priori. Neither can it be uniquely derived inductively from an empirical series. Moreover, as the argument above shows, empirical data belong to the domain of the culturally manifested object (the *explicandum*) while the theoretical values belong to the mathematical model of the measurement process (the *explicans*).
45. For a more technical account, influenced by Gibson (1979) and Husserl (1948/1973, 1970), of what constitutes a phenomenological perceptual entity, see Heelan (1983a/1988, 1985, 1986, 1987b).
46. Heelan (1983a/1988, 1986, 1997b).
47. For the transformation of public space in renaissance Italy, see Heelan (1983a/1988), chap. 6; for other relevant comments, see chapter 11. Putting the emphasis on the transformation of perception effected by instruments, this philosophy is 'horizonal realism'; putting the emphasis on the hermeneutical character of the processes of discovery and recognition in physics, this philosophy is 'hermeneutical realism.' I have used both designations. For the hermeneutic aspect of experimentation, see Heelan (1975b, 1983a/1988, 1983b, 1989a, 1992).
48. See Heelan (1983a/1988), chaps. 10 and 13, which is based on Heelan (1970). The glosses would correct the interpretation of the language lattice in the light of the more developed doctrine of this paper. The author intends to revisit this topic in another work.
49. The author has used context logic to articulate the sense of *complementarity* in the quantum theory. Data in the empirical social sciences are also subject to complementarity conditions, which suggests that theories of the quantum type and context logic might be useful in the social science domain. See Heelan (1995, 1997a).
50. This is the substance of Feyerabend's critique of the culture of science in Feyerabend (1987).
51. The recent history of science contains a wealth of material available for this study. Among recent publications should be noted the magisterial work of Crombie (1994). On the historicity of meaning, see Fiumara (1995).
52. For a profound discussion of metaphor and model, see Fiumara (1995); also Hesse and Arbib (1986). From the side of linguistics and discourse analysis, see Lakoff and Johnson (1980) and Johnson (1987).
53. Some brief reflections on the limits of precision: the chaos situation in physics is an anti-Cartesian phenomenon that arises when the unlimited precision of a theory in mapping inputs and outputs breaks down (fails in relation to the cultural scientific goal of control), as when small changes in practice produce large and uncontrollable outcomes. Perhaps, a like anti-Cartesian phenomenon occurs in dielectical discourse when unlimited clarity is pursued to a point where the overall cultural point of the discourse (better understanding? control over the discourse?) is no longer attainable.

On the side of the social studies of science Latour (1987) seems to be most aware of this impasse. Cf., for example, Heelan (1965, 1970, 1975a, 1975b, 1987b).

54. Kuhn (1970) hints at this view. Myth is an animating force at the level of deepest human commitments and its presence in a scientific tradition would confer on it a greater degree of nobility than would be accounted for if theory were just explanatory.
55. The view is defended by Heelan (1989a) and Crease (1995).
56. See Fiumara (1995), pp. 52, 61, 75.
57. How frustrating these topics are can be read from the literature, for example, Earman (1992), Hesse and Arbib (1986), Cartwright (1983), and the feminist writers in critique of science.
58. See, for example, Bell (1987), Cartwright (1983).
59. See Nickles (1995).
60. Some of the key areas are in the theoretical modelling of intelligence, perception, and decision-making. There is a large literature that addresses these questions from a variety of philosophical perspectives, but only a small proportion bases itself on hermeneutic philosophy. For a hermeneutic study of perception, see Heelan (1983a/1988, 1983c, 1985, 1986).
61. See Duden (1993).
62. Witness the current 'science wars' and the lamentable misunderstandings on all sides. From the science side, see Horgan (1996), Gross and Levitt (1994); from the science studies side, see *Social Text*, Spring/Summer 1996 and *Lingua Franca*, May/June and July/August 1996. For one account of the underlying tensions, see D. Nelkin (1996) and see also the responses it generated.
63. Among these are the *Uncertainty Principle*, and problems about *localization*, *causality*, *the observer's role in measurement*, and the *paradoxes of macroscopic quantum phenomena* as illustrated, say, by *Schrödinger's Cat*, the *EPR Paradox*, and *Bell's Inequality*.