Explicit Epistemology

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Introduction

In this paper I deal with certain issues of *internal observation*, an idea recently amplified in the concept of "Endophysics"[1]. The basic thought is disarmingly simple: it is the study of systems by experimenters and theorists who find themselves inside the very systems studied, scientists who collect data and form theories from a intimate yet limiting perspective of *containment*. Despite the utter triviality of this idea (for we are such observers in our Universe), I believe there is a potential in it for the renewal of philosopical naturalism and for the rethinking of basic aspects of the scientific method.

We will understand this in a moment with the help of the perennial metaphor of the black box of cybernetics.

A "black box" is any system that we examine exclusively by what it reveals about itself in terms of relations to some external states of affairs, called the inputs and the outputs. The usual point in the black box story is that under very mild conditions the "blackness" of the box (that is, that we don't know what's inside) can be undone, and the internal structure of the box can be discovered, thereby yielding, well, a "white box" which is transparent for us. More than a marginal result of engineering, this is a big success for scientific epistemology. A form of black-boxing playes a central role in science. Consider how we obtain our knowledge in the laboratory. In comes the experimental question, out goes the empirical result. The magic in between is done by Nature behind the veil, so we don' t know it in the first place. How the magic is done we learn by forming theories to fill the gaps between the two ends. The black box legend tells us that theories have a good chance to succeed.

Yet life is more complicated than we'd like. There are bad news: we soon find out that with every white box (meaning "to every known part of reality") there comes a new

[1]Literally, *endophysics* means internal physics (whatever that may be). Of course, as so often in philosophy, literal meanings are misleading. In this case, by "physics" we should rather understand "Nature" - in accordance with the Greek origin of the word, and with the usual loose parlance of philosophy that does not distinguish between *naturalism* and *physicalism*. Although there have been numerous predecessors and competitors, I take Otto E. Rössler to be the originator of endophysics as a separate concept for the study of internal observing; the more so because, as revealed in Rössler's book *Endopysik* [1994], the very term comes from a correspondance between him and David Finkelstein. The first conference on the subject was organized by Peter Weibel and George Kampis and was held in 1992 in Linz, Austria [Kampis and Weibel 1993]. Since then, there have been several events and publications that dealt with these problems [for the endophysics home page see http://hps.elte.hu/endo.html].

black box (meaning “an unkown part of reality”) that inevitably pops up at the very point where we interact with the first mentioned box. Besides that original box, which may be white-washed, there is an imaginery box (a perfectly well definable box all the same) which contains the scientist and the old black (now white) box together. The properties of this new box are as little known as were those of the original before anything happened.

This is one of the many forms of the philosophical observer-problem: every scientific description gives rise to “an excluded volume” of undescribed facts about how the scientific description comes about. Epistemology, the study of the nature and of the preconditions of knowledge, is rendered implicit by this circumstance.

Now what endophysics aspires for is the study of the encompassing big black box of which the observer and his epistemology are a part. The original picture is turned upside down (or, rather, inside out): the examiner is put inside the box, allowing him or her to access its internal qualities. By studying the methodology of this new situation, we can hope to reflect on the epistemology within the box as well; in other words, with this method, (certain aspects of) epistemology can be made explicit.

One might think that we can only gain by climbing into the box, but that’s not the case. An enclosed observer is bound to the same laws as those of the system observed. Causal and temporal constraints, as well as self-referential paradoxes can arise. As a price for explicit epistemology, there may be more loss than benefit. Yet no doubt this is one step towards a more complete picture of scientific knowledge, for it also gives an account of the origin and of the limitations of scientific knowledge. In this writing I will attempt to chart critical steps of the intellectual history of the idea as well as some of the most promising applications.

Prolegomena: from Descartes to Kant

In this section I begin to review and comment on some earlier concepts. As can be expected, the difference between “external” and “internal” observing is anything but new. It is already present is the allegory of the birds-eye view, a concept that played an important role in Descartes’ notion of a co-ordinate system. Or why should anybody take a birds-eye view if not because it’s different (maybe only topographically) from what one sees from inside the ground level situation?

Next, there is the medieval notion of an omniscient Christian God who stands outside matters (cf. the notion “God’s eye sees it all”). The God’s eye case is more complicated than the bird case, however, since instead of one clear idea here there are two (partly contradicting) ideas: first, that of God’s superiority to human abilities of knowing, manifested in the detached nature of the divine perspective; and second, the twin idea that God is like man, consequently, that man is like God, so what he can know we can also know (or at least we can hope that). The divine perspective has later been rehumanized in another Cartesian invention, that of the separation of object and subject, called the Cartesian cut, a construct which imports a God’s eye perspective to human matters, completing the circle from man to God to man.

The legendary Cartesian cut of philosophy textbooks is a radical solution to the observer problem. It simply removes the observer from the scene. This generous yet ignorant stance suggests a methodology exactly complementary to the ambitions of endophysics. It is proper to call it “exophysics”. The conception that scientific method (including black-boxing and all that), as far as conceived on essentially Cartesian grounds as in our science, is an “exo”-type of enterprise has been elaborated in detail in some of my earlier writings [Kampis 1991, 1993].

Already at this early point of the discussion we can notice two key elements. One: the “exo” view of the world, which we recognize to be the “normal”, or usual, perspective, is an *enhanced* view. Detachment and a globalization of the viewpoint provide a better overview of facts as compared to what is available for a situated, embedded knower. The bottom line of the taking of a God’s eye perspective is superhuman knowledge. Two: the “exo” perspective stands in contrast to man’s own role in the world. Abstraction, or negligence of actualities, is an important tool without which science could hardly proceed if at all, but at this point abstraction seems to go too far. Ignoring that science as a human activity is bound to human relations to the world and to human resources within this world invokes the danger that the answers which science can provide may be meaningless, or meaningless from a human viewpoint, which is the same.

To take a distant example, even within physics which is often praised for being the most “objective” of all sciences, it is human curiosity and other human properties (biological, social or otherwise) that select those features of matter in which we are interested. It is the time scale of our life span and of our everyday activity, and not some “phsyical” property of the subject that makes the swinging of a pendulum significant for science. If we were bigger or smaller in size by a few orders of magnitude, or if we lived just a few seconds, or a million years instead (with properly readjusted biological clocks and a feeling for time), the abstraction of the mathematical pendulum would most probably never be born, as was emphasized by M. Polanyi [1958] and several others since then. The pendulum is an abstraction which ignores (among other things) all small scale and large scale processes; in the world there are no pendulums as such. “Pendulumness”, the property of being like an abstract pendulum, is our invention justified only by its usefulness in answering the questions that *we* ask.

Now if we refuse all yet uninvented pendulum-less sciences because the pendulum finely reflects our factual relations to the entities of the world whereas a pendulum-less picture does not, I wonder why anybody should be satisfied with “exo” accounts of epistemology that forget about the “endo” situatedness, or imprisonment, of the scientist in his subject.

What this call amounts to is essentially a recourse to Kantian ideas. By the latest it was with Kant that the impossibility of a completely detached or “observer-free” viewing, which looks outwards from a “point of nowhere”, has been recognized in Western philosophy. We know that as a result of Kant’s devastating analysis in “The Critique of Pure Reason”, the notion of *sub specie eternitatis* (the imperative of a neutral, cosmic viewpoint) has been replaced with *sub specie homini*, or human standpoint. Endophysics offers itself as the ultimate extension of this philosophical turn, making human standpoint a subject of its study while at the same time absorbing it as a part of Nature.

Laplace's Demon and Popper's Indeterminism

That the cosmic perspective of knowledge which was challenged by Kant is far from being a neutral platform but in fact implies an attempted superiority to what is achievable by justifiable means and therefore it potentially leads to unjustified knowledge claims is best seen on the example of Laplace's demon.

In this section I follow Karl Popper whose concern with scientific determinism anticipates endophsyics in various significant ways; we begin with his analysis of Laplace. Laplace assumed that the world consists of a finite amount of permanent Newtonian particles whose positions and momenta, together defining the current state, determine all future motions. Consequently, he believed, precise knowledge of an initial state should suffice for the deduction of all other states. Most interestingly, Popper notes, Laplace in his recourse to this fiction of omniscience did not assume a God but rather a super-scientist; that is why the protagonist is called a mere humble *demon*. By keeping the argument quite human-like Laplace might hope to *"make the doctrine of determinism a truth of science rather than of religion*" [Popper 1956, p. 30]. It is of course true that no human or no human community can actually gather a sufficient amount of information about the world to make this plan workable, and it is also true that no human can carry out the necessary calculations, partly because of the limited resources available within the lifetime of this universe, partly due to theoretical difficulties of the extended calculations of a many-body problem; however, any scale-down version of the problem is entirely within human possibilities, and any given fragment of the grand plan, if not the whole plan itself, can be carried out by a full flesh human scientist, if somebody else does the rest.

What is important in the Laplacian speculation for the present discussion is not whether it's realistic at all to assume that the world is like a clockwork or a billiard pool. *The important point is in the recognition of the difference between human and superhuman faculties as related to constraints imposed by the world itself.* If the world allows us to become aware of certain facts, then a proposition which refers to the knowledge of these facts can be used in a scientific theory; if not, than not.

Popper suggests to derive scientific determinism from a distinction between foreknowledge in general and predictability by a rational scientific procedure. Now, to be sure, the question is what amounts to a rational scientific procedure. In characterizing such a procedure Popper follows the Laplacian idea but goes way beyond it by asserting that the procedure should directly rely on human experience. Scientific methodology may idealize human powers but may not go beyond it by principle. Let me quote Popper's important passage directly:

> The daemon, like a human scientist, must be assumed to belong himself to the physical world whose future he is to predict; at least it must be assumed that *phsyical* processes exist in the world which may be interpreted (a) as processes by which the demon may obtain information (b) as processes of calculating the prediction, and (c) as processes of formulating the prediction. In other words, the daemon must be visualized not as a disembodied spirit, outside the physical system which he is to

predict, but rather as the physical incarnantion of a spirit, as it were: his essential activities must, in some way, interact with the system. We may sum up this requirement by saying that he must *predict the system from within*, rather than from without. [Popper 1956, p. 35.]

Popper also poineered the argument that in accepting this premise we do not introduce an *ad hoc* requirement but rather acknowledge something implicitly present in modern science. In other words, by articulating the premise we in fact unfold certain implications which follow from basic notions of physics as e.g. Heisenberg uncertainty. If, namely, the Laplacian view of the world collapses in view of the fact that the process of measuring interferes with the state of the measured system, then the deamon (or the scientist) responsible for this is factually no longer considered a disembodied spirit outside the world.

Needless to say, we don't have to accept Popper's above arguments, in order to accept his predilection for the inside view. Be it as it may, the specter of endophysics haunts in other Popperian considerations as well. Popper was a true collector; he refuted determinism (or he thought to have done so) a hundred different times, with a hundred different arguments. One of these is his proof for the impossibility for self-prediction.

The problem of self-prediction as well as the structure of Popper's proof has the flavor of the famous *halting problem* of computer science. The halting problem is this: is it possible to decide whether a given computer program, if executed, will ever halt? Whereas for some programs such a prediction is possible, it is easy to prove that the general halting problem is unsolvable, that is, that there can be no formal method (carried out by some machine) which solves the halting problem for all programs. The proof requires two steps. First suppose that the required decision procedure exists. Then we can write a program *q* that can be programmed into a machine which when presented with any other program *p* as an input, will print out (say) a 1 if *p* halts on a separately specified set of data and a *0* if *p* does not. Now the second step is to ask whether *q* halts on itself as the input. It turns out (if you follow the argument which we don't) that if it halts, it does not halt, and the other way around. As it cannot both halt and not halt, the required program *q* cannot exist.

In a more intuitive fashion, the unsolvability of the halting problem can be seen from a different train of thought as well: if a program did not halt within a given time, that does not mean it will never halt. Suppose we start all programs at once. No matter how long we wait, we can never know whether the programs that still run at a given time will continue to do so forever, or will halt the next very moment. (That is, execution time can be finite but unbounded.) Note that this plausible yet unsatisfactory treatment already assumes the impossibility of self-prediction for a program, and more specifically, it assumes that a computer program's future states cannot be calculated by any method other than the direct execution of the program (that is, that no shortcuts or speed-ups are possible). Keep both proofs, the real one and the fake, in mind when discussing Popper.

As an aside, I note that there is a bunch of results about the problem of self-description, a sufficient but not necessary starting point for self-prediction. Von Neumann suspected a self-referential paradox here, called the Richards paradox, which implies that the active part of a machine can never be properly described by itself, for it changes its states in the course of the very description activity [Burks 1971]. However, later R. Laing [1977] succeeded to devise some machineries which nevertheless make (a limited form of) self-description possible.

But back to Popper and the problem of determinism. As scientific determinism was defined by him relative to a rational prediction method, it is plausible to assume next that the task of the prediction becomes a problem of mere calculation by some machine which realizes the predicton method, a "predictor", as Popper called it. Now Popper's proof (or, better, his alleged proof) says *that no predictor can predict the results of its own predictions*. This attempted proof relies on a self-application, dubious as it were, of the intuitive no-speed-up principle we have seens already; why it's so interesting despite its faults is that this is the place where Popper the most explicitly turns to what we call endo/exo distinctions.

Popper instructs us to imagine two identical predictors each with the power of a Laplacian demon. This condition implies that both predictors are incarnations of a determinisitic theory and, as a consequence of that, they are predictable, or *predictable from the outside* ("from without"). Now let the prediction task of each predictor be the calculation of a certain future state of the other predictor, the same future state in each case. This second conditon implies that the prediction task given to the predictors can be interpreted as a self-prediction task. By their definition of being embodied Laplacian demons the prediction can be calculated by the predictors; however, the two predictors being identical, they must follow the same sequence of states, so if, for instance, the first predictor's task was to predict the state in which the second machine prints out the result of its own prediction task (which is identical with this very prediction task, by our assumption) then the first predictor cannot finish its calculation *before* the second machine actually arrives in that state.

This yields the result that self-prediction, or *prediction from inside* is impossible for a machine, even if empowered with ultimate foresight. For Popper it also follows that scientific determinism cannot be true, because now a predictor, in lack of knowledge of its future actions, cannot calculate the effects of these actions on its environment, hence, given the initial conditions of the environment, its future states cannot be calculated, *only observed a posteriori*.

Besides attacking determinism, Popper's main critique concerns the confusion that arises when various forms of determinism are mixed up. Besides prima facie determinism, or determinism of a theory, and scientific determinism, which we have discussed briefly, he speaks of a "third" version of determinism as well:

> ... every physical system is predictable in the sense that *at least after the event to be predicted has occurred*, we can see that it was determined by the state of the system, in the sense that a sufficiently full description of the system (together with natural laws) *logically entails* the prediction. [Popper 1956, p. 79]

This third form is very close to what Whitehead calls *the causal objectification of the past*: Whitehead denies that the past vanishes with the vanishing immediate experience of it as a transitory present. The past is available, he claims, and is influential in the emergence of the new present. We note, however, that the Whiteheadian maxim does not imply the predictability of the present as the past's future; just as with Popper.

Relativity and Slow Causality

In an attempt to keep this paper within limits, of the various applications of *the physics of knowledge*, as explicit epistemology could also be called, I only discuss two contemporary ideas, first the use of relativity theory outside the context of fundamental physics, more specifically, in the historical context of external versus internal predictability.

Think about Popper's statement that "*... a sufficiently full description of the system... logically entails the prediction*". Taken seriously (and I think we can risk this for the sake of our discussion), it means that if in a causal system the deterministic prediction fails it can fail for one of two reasons: (1) we cannot have a "sufficiently full description of the system" at the time of the prediction, so the entailment cannot be formulated before the corresponding causal act takes place (2) we cannot compute the logical entailment fast enough, i.e., again before the corresponding causal act takes place. In both cases, prediction will be possible after all, but it will be late and therefore useless (post-diction). (Note that here I implicitly defined causality as an ontological trait of a system that establishes a unique link between the states of the system at different times.)

Clearly, Popper's thought experiment with the two predictors was concerned with the second situation. We now deal with the first, which also seems more fundamental.

A useful notion of internal observations is that of information set [Kampis 1991]. An information set is defined as a set of observations available in a given time window *from within*. Information sets can be used as natural tools to construct histories, or sequences of events at subsequent "now" instances. Of interest is that the time parameter of the information sets satisfies a partial order: any event can be locally ordered together with its successors and predecessors. However, this local ordering canot be automatically extended to the whole endo-system by some transitive closure, as *not every observation is simultaneously available from within*. As in relativity theory, in "endo" observations the notions of simultaneity and hence of temporal ordering crucially depend on communication and interaction between the separated parts of the system. Embodied observation and measurement proceed by causal processes that take *time* to take place. External, or "exo" observing assumes that the time scales involved are very small compared to the own deterministic evolution of the system; internal observing in lack of better resources is bound to use the same rate of interactions as the studied process uses (hence the name *slow causality*[2]).

To give an impression of how this works, and of the no-speed-up situation that inevitably follows, let us think of the example of a large computer network, say the Internet, and consider a network maintenance or network configuration problem where

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[2] I am indebted for this term to Prof. Nuel Belnap, Pittsburgh University.

we need information about the state of the system and where the Internet itself is used for communication. It is clear that information does not arrive instantaneously in such a case; it is also clear that delays, especially long delays have far-reaching consequences. Something may already have happened somewhere, but the effects are not yet "felt" at some other point where the experimenter is located.

The theory of relativity uses a fundamental constant of phsyics, the speed of the light, to deal with these kinds of phenomena. It is clear, however, that every interaction has its own maximum speed. For cellular automata this "speed of the light" is one cell per transition. That is, it is not the ultimate physical limits but the logic of the situation that makes relativity theory important for "slow causality" situations. Unless synchronized externally by a global clock, and overviewed by a central scrutinizer, the events that do not "see" each other are temporarily as well as causally unrelated until they (or their consequences) first interact.

From the information set viewpoint we can speak of various types of histories using relativistic logic: we have convergent, parallel, and divergent histories. A pair of convergent histories is constituted by two trajectories that are noninteracting up to a given point but interacting afterwards. Parallel histories are constituted by those trajectories that never interact; they do not only belong to different parts of a Universe but in fact to different universes. A given universe can always be partitioned to non-overlapping parts by noncommunicating processes. Divergent histories pose the problem of "bifurcation" of a deterministic time evolution, that is, the indeterministic continuation of a deterministic trajectory. Whether or not the latter kind of multiple-futures scenarios make sense as feasible descriptions of real events, they can be analyzed formally in our framework.

The external and the internal descriptions of the above situations differ significantly. As it is not always possible, in a given time window, to fully describe the relevant state of a system from within, an internal account is not compatible, in general, with global determinism. If the future state of the system is to be predicted, even a perfect Laplacian demon may fail due to the inappropriateness of the prediction task (i.e. incomplete information) with which it is presented. For example, in convergent histories, viewed from the position of one of the participating trajectories, the maximal description of the system if formulated before the interaction point does not include the other trajectory; similarly, in parallel histories we fail to predict the global state of both (or all) trajectories by mistaking it for the local one of a single trajectory; in divergent histories prediction is impossible if the reasons for the multiplicity of continuations may not be available before "bifurcation" time.

External descriptions can, however, probably relax the temporal constraints that arise from the slowness of the interactions. As suggested by the computer network example, an external agent could use different, and more efficient, methods (make phone calls, use optical communication etc.). Therefore, it is more likely that by such an observer a simultaneous and global description of all subprocesses, in effect a complete description of a global state can be given, where the convergent, parallel, and divergent histories coexist as special cases of the same deterministic family of processes.

The perhaps most radical application of slow causality is in the denial, from an internal point of view, of a *unique history*. Instead of one history, there will be histories in plural, where these histories will themselves become historical. Upon shifting the time window of observations, the history (meaning the best scientific history possible) of one and the same events can become different; as time passes, not only the future but also the past "changes".

The simplest case is that of convergent histories. When traveling along a trajectory *A*, our account of history is solely based on *A*-events until interaction with trajectory *B* occurs, at which point the history of the system has to be revised to include the past *B*-events as well.[3] In a more complicated case the observer is associated with a different trajectory *C*. Then, it can happen that *B* interacts with *A* at some time *t*, but does not interact with *C* until *t'*, and further, that *C* also interacts with *A* (but not *B*)in the *t-t'* window; in this case the past history (of *A*) changes at *t'* in such a way that past causes that already had *past* consequences (i.e. the causes affecting *A* in *t-t'*) need to be revised. These forms have been examined in detail in [Kampis 1993].

Multiple Causation

In this final section I apply some of the ideas we discussed to the problems of causality. Causality is a difficult concept. Every event has a whole infinity of causes. Sometimes a distinction between the total cause and the specific cause is used. The total cause of an event is a list of all conditions individually necessary and together sufficient for that event to occur. This concept is rather unilluminating in the operative sense, for the list in question certainly includes the Big Bang as well as everything else since then for every particular event (if there *was* a Bing Bang, even this paper could not have written without it). The specific cause, in contrast, is a select list of factors taken somewhat arbitrarily to be a *sine qua non* condition (i.e. an irreplaceable condition) in the context of a *ceteris paribus* (i.e. all other things equal) backdrop for the given phenomenon.

Specific causes stand in close parallel to the initial conditions of a deterministic system. Therefore, just as in the case of Popper's scientific determinism, the notion of specific cause already assumes a linear ordering of events and a complete description (relative to the *ceteris paribus* background) of every causal factor that evokes these events. To give an account of the causal forms that appear in internal viewing where complete description is not always possible we need a new concept, that of multiple causation.

Unlike with specific causes that assume a sharp and invariant identification, of a given state vector for instance, in multiple causation we deal with causes that have an opaque "bandwidth" or "depth" to them. Besides the well-described causal elements there is a twilight zone of subprocesses and interactions here, something that cannot be completely identified from within, prior to its effects at future time points. The reasons

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[3] I cannot help citing a sentence from J.L. Borges, a masterpiece cited by me on all occasions. *"In 1876 Adolfo Suares won the battle of Junín, in the same year De Quincey wrote a pamphlet against Wilhelm Mesiters Lehr- und Wanderjahre, the two events were not simultaneous, today they are. The two men died without knowing anything about each other.*

for the opacity have already been discussed; one of them is the relativistic slowness of measurement processes, another is the uncertainty in the present of the future subprocess interactions with previously causally isolated trajectories. Which of the interactions will ever take place can depend on still further future interactions, and so on; there is an infinite regress towards the future in the definition of the present causal state. There still is a causal determination, only not singular but plural; endo-systems carry germs for the future instead of full-blown explicit causal properties. Multiple causality mechanisms as described above were discussed in the context of biological evolution in [Kampis 1994] where they were held responsible for the temporal emergence of new qualities.

While the critical method of explicit epistemology alluded to here can keep the isolated and later recombining causal factors separate, the *retrospective omniscience* implied by a detached viewing would certainly lump them together, obtaining a monolythic picture of a causal process not very much different from any other causal process.

Let me finish with a few critical words about evolution theory, the stage for which criticism is set by our last remarks. Neo-Darwinian theory is widely appreciated as a dominant explanation of evolution yet it is easy to see that it is slightly incomplete. The nature of this incompleteness cannot be fully discussed in the present end remark, but the general sense of the problem can be easily indicated: it has to do with the issue of the origin of evolutionary forces and, with that, with the snowball-like self-extending circularity between the causes and the effects of natural selection [Kampis 1995]. Neo-Darwinism pays little attention to the *inside* temporal dynamics of this growth process; in evolution theory, it is usually assumed that the selection forces are somehow given in a well defined form, independently from the temporality of the process of evolution. To use an analogy that refers to our earlier discussion, it is like assuming that there is a complete description of the system in terms of a unique set of conditions and, consequently, that there is a unique and invariant history to explain. But exactly that seems to be questionable in the light of the existence of causal yet non-deterministic phenomena which as we indicated evolution is very likely to utilize. How explicit epistemology can help formulating these missing parts of evolution theory is yet to be seen, but it can certainly diagnose them.

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