Evolution and Projection

Approaches to a Modern Epistemology

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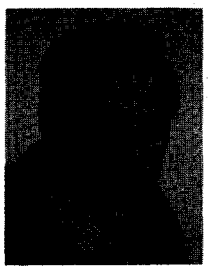
Evolutionary Epistemology is a young discipline combining elements from philosophy and individual sciences. It is based on the thesis that cognition is a function of the brain and as such is also a result of biological evolution. It examines the arguments for or against this view and tests their epistemological consequences. For this it requires the findings of perceptional, developmental and learning psychology, of linguistics, of neurophysiology, of comparative ethology, of genetics, but most of all of evolutionary theory in its currently accepted form.

Fundamental thoughts of Evolutionary Epistemology can already be found in Darwin and in many later authors. Whereas most of them were content to mention them in passing, however, as neither philosophers nor biologists were willing to venture too far into unfamiliar terrain, it was Konrad Lorenz in the 1940s who achieved the decisive linking of evolutionary theory and epistemology. However, his papers remained unread or misunderstood until the theses of Evolutionary Epistemology were further developed and made more widely accessible by the work of Lorenz, Campbell, Vollmer and Riedl in the 1970s.

What Is Cognition?

It is not easy to define the concept of "cognition" in a non-circular way. Here we will be content with a working definition or partial characterization: the cognition of reality is an adequate (internal) reconstruction and identification of external objects.

In our explication we restrict ourselves to the cognition of reality. Although logical and mathematical cognition also exist,



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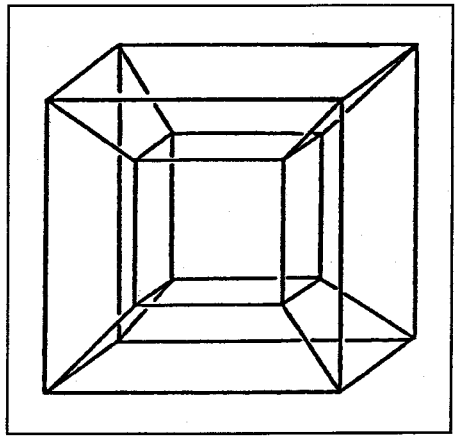
the structural sciences are adequately served by a less stringent concept of cognition. Apart from such formal conditions as internal consistency, the cognition of reality must fulfill further criteria; in particular, it must refer to objects in the real world. Moreover, it must be correct and true. A normative condition such as this is also already inherent to the concept of reconstruction. A mere construction would be totally arbitrary; a *re*construction must have the same structure as the actual object.

An essential characteristic of the (hoped-for) cognition of reality is thus the (hoped-for) isomorphism. Ethical, aesthetic, religious or mystic "cognition" do not fulfill these conditions, or at least not in a verifiable way, and will therefore not be further discussed.

An Example

Upon careful scrutiny, the two-dimensional line drawing in Fig. 1 can be *interpreted* as a three-dimensional object: a small cube is suspended within a larger one; the oblique lines connect the corresponding corners in pairs. Have we then recognized the object? The answer would be "yes" if it were in fact (nothing but) a wire construction. But we can take our reconstruction further and interpret the drawing as representing (in central projection) a four-dimensional cube.

The difference between cube and tesseract is, however, not just quantitive, i. e., one of the number of dimensions. Whereas we can *visualize* a three-dimensional cube intuitively, even with our eyes closed, this is not possible with a four-dimensional hypercube. Obviously, our spatial intuition is only adequate for three dimensions. Reconstructing the cube intuitively is thus quite feasible; the reconstruction of



A hypercube or tesseract such as this is a "generalization" of the common cube, just as the cube is a three-dimensional analogue to the common square.

a tesseract, however, can only be achieved with logical, mathematical or intellectual means.

Perception as Interpretation

The lesson of the cube is generally applicable: every perception is already an *interpretation* of sensory data. This interpretation can be difficult, impossible, ambiguous and even wrong. This can be shown with pictures with hidden objects, impossible figures, ambiguous drawings, optical and other illusions. All the same, such failures cannot disguise the fact that our perceptual mechanisms are generally quite reliable. Special attention, careful consideration and deliberate experiments are required to outwit them and make them give a false interpretation. Normally the reconstruction is perfectly correct.

A Projective Model of Cognition

As with the cube, we can interpret the relation between the real world, the cognizing subject and (presumed or genuine) cognition *projectively* in other cases, as

well. Real objects are projected – by light rays, sound waves, chemical substances, heat radiation or gravitational fields – onto our sense organs, most of them situated on the body's surface. Even such technical instruments for observation or measurement as telescopes, microscopes, thermometers, compasses or Geiger counters, only serve to widen this projection "screen," i. e., to translate incoming signals into stimuli which our natural apparatus can process.

In the cognitive process, we then attempt to *reconstruct* the objects from their projections. As every projection entails a loss of information, this information must be regained, at least partially, during reconstruction. Of course this reconstruction remains *hypothetical*. Thus, the projective model reflects an important result of epistemology and the philosophy of science: *all factual knowledge is hypothetical.*

Levels in the Cognition of Reality

If we accept the above explication, at least on a preliminary basis, at least three cognitive levels can be distinguished: perceptional, experiential and theoretical (or scientific) cognition. In perception, the internal reconstruction and identification of objects is usually *unconscious* and *uncritical* and usually cannot even be corrected. In experience, which includes linguistic formulations, simple logical inferences, observation and generalization, abstraction and concept formation, cognition is, in contrast, *conscious*, but remains uncritical. In science, finally, which avails itself of logic, the conception of models, mathematical structures, artificial languages, external data storage, artificial intelligence and instrumentally extended experience, the reconstruction is conscious and *critical*; however, the postulated structures often remain *non-visualizable*. For our purposes, still another difference is of crucial importance: scientific cognition is a phenomenon of recent centuries or, at most, millenia; in contrast, perception and experience have existed for millions of years.

Is Epistemology Descriptive or Normative?

Our explication also reflects the double character of the concept of cognition. "Cognition" designates both a process (cognizing) and its result (knowledge). But this is equally true for the concepts of "reconstruction" and "identification": they, too, stand for processes as well as for their results.

Epistemology as a "theory of cognition" has always tried to include both aspects. As a theory of the cognitive process it tends to be descriptive and explanatory; as a theory of knowledge it is rather explicative and normative. Any attempt to restrict the role of epistemology to explicatory and normative tasks (or, even worse, to the investigation of validity claims) and to discard everything else as "metaphysics of cognition" would not only exclude large areas of traditional epistemology forcibly (and certainly contrary to the intentions of the latter), but would also deprive us of the very instruments relevant to the clarification of cognitive claims. Admittedly, it is not possible to *infer* (epistemological) norms from factual knowledge (about cognitive systems), but *without* considering these facts it will be all the more impossible to solve epistemological problems. It is precisely this empirical orientation, this coupling of descriptive and normative functions, this regard for the factual, which has made such recent epistemological approaches as Piaget's Genetic Epistemology, Chomsky's Universal Grammar, or Evolutionary Epistemology so fruitful.

How Does Cognition Come About?

This age-old question has been given many different answers. Since these answers often contradict one another, most of them must be wrong. (Every philosophy student ought to sit down and think about that!) However, it is neither the task nor the intention of this article to give an historical survey of epistemological positions. We can only sum up a few fundamental insights which have been significantly brought to bear on Evolutionary Epistemology.

Cognition comes about by means of the constructive cooperation of the cognizing subject and the object of cognition. The subject's contribution can be perspective, selective or constructive. Such cooperation only succeeds when both constitutive elements *fit* one another. This fit may be taken in a perfectly instrumental sense. Just as a key fits a certain lock (and not others), or as/and as a screwdriver is suited to being used with screws (but not with nuts), the structures of our cognitive apparatus fit a few objects of the real world (and not others). Thus, subjective and objective structures fit each other at least in the sense that *together they make cognition possible.*

This could be otherwise. It would be conceivable that there is no cognition, no cognizing beings, no cognitive achievements, no knowledge. It could be that all attempts to achieve cognition fail, that all tools of cognition are unsuitable. But this is not so: cognition exists. That is an *empirical* fact which Evolutionary Epistemology – like other epistemologies – is trying to describe and explain. The fact that there is such a fit, is a *minimum requirement* for the realization of cognition.

Fits in Our Cognition Structure

This fit is not restricted to the dimensionality of the world and visualized space, it extends to many other structural characteristics of our perception and experience. It may indeed be difficult at first to designate such cases of fit. But they are easily found in any textbook of sensory physiology. To be sure, they do not appear under the heading of *fit*, but of *function*. But just as a tool only functions if and inasmuch as it fits the work piece, the eye, the ear, the sense of equilibrium, the brain only function because they fit the structural traits of the environment.

As evidence for this, usually properties of the human *eye* are cited: its sensitivity range lies in the optical window of the earth's atmosphere and around the maximum intensity of solar radiation, lower sensitivity threshold at the noise limit of the (statistically fluctuating) photon current, higher density of black-and-white-sensitive rods (for seeing in the dark), etc. But the same is true for all other channels of information.

The *ear* is particularly suited for hearing in air (and therefore not in water like that of fish). It allows for pressure compensation and covers broad ranges of frequency and intensity, its lower sensitivity threshold with regard to sound intensity lies at the informationless noise of Brownian molecular movement and of the blood stream; it identifies the direction and distance of the sound source, thus permitting spatial hearing.

Further examples are the subjective time quantum, subjective time perception (inner clock), the causal interpretation of sequences of events, the expectation of regularities, elementary inferences.

Spatial intuition involves astonishing reconstructive faculties. In a two-dimensional picture we see a three-dimensional

cube. In other instances, too, two-dimensional information from the retina is reconstructed as a three-dimensional object. However, we cannot visualize four-dimensional objects such as the hypercube. But indeed, there are no such objects in our world, either; this world and its objects are only three-dimensional. In this respect, our limited intuition and imagination are completely suited to the structure and demands of our environment.

Congruences

Moreover, in this and many other cases, there is even *congruence* between the world's structure and our subjective reconstruction: we experience the world three-dimensionally; and we know from physics that this interpretation is *correct*. Our experience of time imparts to us a profound difference between past and future; and physics teaches us that this time direction has *objective* character. (However, in contrast to our expectation, this is not due to the laws of nature, but to the initial conditions of the universe.) Subjectively, we give many sequences of events a causal interpretation, but not others; and physical analysis shows that there is *in fact* a difference between regular sequences of events and causal relationships: the transfer of energy.

However, it should be stressed that the fit mentioned above by no means *always* implies congruence. The (psychological, subjective) colour circle is closed and consists of quasi-discrete colours; the visible segment of the (physical, objective) electromagnetic spectrum, in contrast, is open at both ends, completely continuous, and does not contain the "invented" colour purple. Nonetheless, this, too, is an excellent and useful fit, as is the colour circle which, thanks to the principle of complementary colours, makes possible colour constancy, i. e., the fact that despite changing light conditions macroscopic objects appear to us in the same colours, so that we can recognize them more easily. This example shows that no fit, no matter how good it is, *guarantees* the anticipated congruence.

Can This Fit Be Determined Without Circular Reasoning?

Isn't it naive realism to think the world is three-dimensional because it *appears* to us to be so? We have no access to the world except via our perceptive apparatus. How then can we want to compare the world as it is with the world as it appears to us? Do we check a newspaper article, say, by comparing it with another copy of the same newspaper?

But there is indeed an authority which can instruct us as to the structure of the world and corroborate or *correct* our perceptions and experiences: scientific knowledge – in the case of dimensionality primarily physics. It is true that for the testing of physical theories we cannot do without projection and thus without our elementary means of cognition (this is what makes them particularly important to epistemology). Just the same, we can articulate theories and, with our mesocosmic forms of intuition and our categories, we can examine and corroborate them (or find them to be wrong) which *contradict* these very forms of human experience: four-dimensional world models, non-Euclidean gravitational theories, non-causal quantum laws, theories without conservation laws, etc.

Some of these "paradoxical" theories have in fact proved successful, so that we are – for the time being – willing to accept them as correct. Thus, the hypothesis that our world is in fact four-dimensional and that we only experience three-dimensional projections of it, has been frequently considered – without success. There is *no evidence* that physical space has perhaps four or more dimensions instead of three – no contradiction in three-dimensional theories, no fact that could be explained four-dimensionally but not three-dimensionally, no better explanatory success of a four-dimensional theory.

That our world is spatially three-dimensional and contains three-dimensional objects, is thus an empirical fact suggested *likewise* by our spatial perception *and* by all pertinent physical theories. To this degree we can indeed claim without resorting to circular reasoning that our intuition *correctly* reconstructs the three-dimensionality of real objects. The same holds true for all other instances of fit and congruence cited above. Of course, in this question, too, our knowledge remains hypothetical, i. e. basically subject to correction.

Where Do the Subjective Structures of Cognition Come from?

They can be innate or individually acquired. As a rule, it is indeed a matter of a complicated interaction of biologically given dispositions and environmental stimuli in which it is difficult to distinguish between genetic and environmental components. The example of the *imprinting* of new-born animals may be mentioned here: the gosling is genetically *programmed* to *learn* to recognize its mother in a definite sensitive phase after hatching. The imprinting occurs by the first object that comes along which fulfills certain minimum requirements, which moves, for example, or answers the contact call of the young bird. The cognizance of the mother animal is then neither instinctive nor acquired, but is achieved by an intertwining of a genetic programme with environmental data.

Man, too, has numerous cognitive structures, mechanisms of reckoning, algorithms, abstraction procedures, methods of inference, learning programmes, language-acquisition mechanisms, expectations, dispositions, pre-judgments about the world, which are either genetically preprogrammed as a whole, or – and that is presumably the rule – which *mature* according to a genetically determined programme and are dependent on certain environmental data (such that when such stimuli are lacking they can also atrophy).

Innate Cognitive Structures

To illustrate this, a few empirical results may be cited. Innate to man are not only the ability to suck, grip, and stride, smiling and the mimicry of rage, but also motion vision, colour perception, and a sense of time. Innate is spatial vision, i. e., the ability to interpret two-dimensional retina images three-dimensionally, and an aversion to depth. Innate are above all the achievements of constancy, enabling us to recognize objects, to "objectify" the world, to abstract, to form classes and concepts. Innate is the knowledge of human faces (not just of a single face), the visual fixation of a source of sound (even in children born blind!). Innate are the ability to use language and the need to speak, possibly a few fundamental grammatical structures, as well ("universal grammar"). Partly innate are intelligence, musicality, logical structures, e. g., the modus ponens ("if A, so B; now A, therefore B"), biologically realized by the ability to develop conditioned reflexes; elementary mathematical structures, for instance group structures and formation of invariants, possibly causal perception and causal thinking, as well.

The rationalists' and "nativists'" search for "innate ideas" was thus perfectly justified. But not until our century was it possible to specify more precisely what is meant by "idea" and "innate" to a degree enabling an empirically verifiable answer.

It would in any case be completely inappropriate to regard the brain at birth as a tabula rasa or even simply as a computer which is only gradually programmed. Rather, most of the programmes are well installed by the time of birth; the subsequent individual experience merely provides sub-programmes and differing data.

As stressed above, this of course does not mean that all our knowledge is innate. Nor does it mean that all the environmental information that we bring along at birth has to be *correct*. But under normal conditions our innate expectations regarding the environment are in fact quite useful (they "fit") and often even correct (or "congruent").

How Does This Fit Come About?

For every tool there is someone who makes it, picks it out, uses it. Could this also be true of the human cognitive faculty? Can we understand the function and fit of our cognitive apparatus only by making a creator responsible for it? But how else can it happen that the subjective cognitive structures which we bring along fit reality so well and in part are even congruent with it? How can we explain, Kant also asks, that the use of the categories "precisely agrees with the laws of nature, in accordance with which experience makes its way" (Critique of Pure Reason, A 1781, B 1787, B 167-8); and he is surprised at "this harmony of nature with our cognitive faculty" (Critique of Judgment, 1790, A XXXIV).

This typical epistemological question is answered by Evolutionary Epistemology: our cognitive apparatus is a result of biological evolution. Our subjective cognitive structures fit the world because they have evolved in a process of adaptation to this world. And they are (partially) congruent with real structures because only such congruence made survival possible. They are individually innate and in this sense *ontogenetically a priori*, but they were acquired in phylogeny by the species and are thus *phylogenetically a posteriori*.

Traits of Evolutionary Epistemology

The existence and thus the possibility of cognition is an *empirical* fact. Fit and partial congruence between subjective (and in part innate) cognitive structures and objective structures – where they exist – are also empirical facts. These facts can be explained by Evolutionary Epistemology. A person who recognizes the facts but rejects Evolutionary Epistemology is challanged to supply a better explanation.

The history of philosophy shows that the fit mentioned above was seen and taken seriously as a problem. The solutions range from rationalism to empiricism, from pre-established harmony (Leibniz) to occasionalism (Geulincx), from transcendental philosophy (Kant) to transcendental lingualism (Wittgenstein), from conventionalism (Poincaré) to economism (Mach). The answer of Evolutionary Epistemology is not identical with any of them. But of course it owes much to its predecessors, particularly to the philosophy of Kant.

Evolutionary Epistemology interprets the *fit* of our cognitive structures as the result of a process of selection, of an evolutionary *adaptation*. Not only are the sensory organs, the central nervous system, and the brain, products of evolution, but their functions, as well: seeing, perceiving, judging, cognizing, inferring. By this step, the field of epistemological research and argumentation is significantly broadened. Whereas the object of study of traditional

epistemology was intended to be the cognition of every "finite rational being," but *in fact* only that of the *normal, adult, educated European*, Evolutionary Epistemology encompasses many further aspects:

- the individual differences within a human population with the entire range of genetically determined characteristics;
- the differences between human races;
- the cognitive development in the growing child;
- the phylogenetic origins of the human cognitive faculty.

Evolutionary Epistemology is not a discipline of natural science. But it answers epistemological questions via a theory of natural science, the theory of evolution. That alone should be no cause for alarm; after all, in the course of the history of philosophy, this has happened frequently. In the case of Evolutionary Epistemology, however, such a procedure is at times considered *circular*. And indeed, epistemology and empirical science do have a certain reciprocal relationship. But a vicious circle would only be given if Evolutionary Epistemology claimed to provide an *ultimate foundation* for empirical cognition. In fact it is a *virtuous circle*, a productive, self-correcting feedback structure which is neither tautological nor inconsistent, i. e., neither empty nor contradictory.

Evolutionary Epistemology indeed has markedly pragmatic traits, but it does *not* expound a *pragmatic concept of truth*. Evolutionary success can neither define nor guarantee the truth of our innate hypotheses. Evolutionary Epistemology even points to such counterexamples as the colour circle, which is highly adaptive and yet "freely invented." It is thus far from confusing genesis and validity. How, then, does it solve "the" validity problem? If validity means absolute validity, it does not solve it; for then it cannot be solved at all. But if also relative (e. g., hypothetical) argumentations, justifications, proofs are allowed, then Evolutionary Epistemology does certainly contribute to that discussion. To be sure, evolutionary success does not prove that all our innate hypotheses are true, but it does show that they cannot be all wrong.

Prerequisites of Evolutionary Epistemology

Evolutionary Epistemology is not a comprehensive epistemology. Before it can even be articulated, a few preliminary questions must be settled. We need, first of all, explications of the concepts of "cognition," "truth," "objectivity" (cognition is explicated as an appropriate [internal] reconstruction and identification of external objects, hence truth in the sense of the correspondence theory); second, a theory about how cognition comes about (via an interaction of objective and subjective structures); third, a theory on the relationship between the real world and the cognizing subject (this task is performed by the projective model); fourth, assumptions concerning the relationship of consciousness and the brain (an identity theory based on systems theory); and fifth, factual knowledge about the existence, range, and fit, of cognitive systems with subjective cognitive structures (as provided by psychology, physiology, neurobiology, evolutionary theory, ethology, linguistics, and other disciplines of empirical science).

The preconditions of Evolutionary Epistemology include in particular *hypothetical realism* (which is not *significantly* different from critical or scientific realism). Its fundamental assumptions are: the hy-

pothetical nature of all factual knowledge; the existence of a world independent of our consciousness, structured by laws, and contiguous; and the supposition that this world can in part be known and explained by perception, thought and an intersubjective science.

Within the projective model as sketched, not only can various levels of cognition be distinguished; the special task of Evolutionary Epistemology can also be elucidated therein. Above all, it centers on the *cognitive apparatus* onto which the projection is made and which then tries to reconstruct the real structures from the projections. It explains its successes and failures, its range and its limitations. In the process, Evolutionary Epistemology takes recourse primarily to perception and experience and only occasionally to scientific knowledge.

Since cognition is regarded as a function of the brain, Evolutionary Epistemology from the very beginning takes up position in the mind-body controversy on the side of an *identity theory* and thus pursues a consistently naturalistic approach. From a dualistic viewpoint, to be sure, one could refer to an "evolution" of conscious phenomena as well. However, its relationship to biological evolution would then be at best a coincidental analogy (selection can only be effective with material systems); this would not really *explain* the fit in question.

Of course it is possible to include the entire preparatory context (realism, projective model, identity theory) in Evolutionary Epistemology and to call this comprehensive viewpoint "Evolutionary Epistemology." But nothing would be gained by that. It would be far more likely to produce confusion, as evolution is not relevant for all parts of this broadened scope.

The Role of Evolutionary Theory

The theory of evolution is also an indispensable prerequisite of Evolutionary Epistemology; it even gave it its name. However, Evolutionary Epistemology does not depend on every detail of the theory of evolution; but its validity does vitally depend on the following principles:

- the *common origin* of most, if not all, organisms on earth,
- the *phylogenetic kinship* of man with animal ancestors, especially with primates,
- (almost) *invariable reproduction* of organismic systems,
- *inheritability* of anatomical, physiological, behavioural and cognitive characteristics,
- diversity of organismic types through *mutations*,
- differential reproduction due to differing competence, usually called *"natural selection"* (or "survival of the fittest"),
- evolution as a process of development and *adaptation*.

That there are further evolutionary factors, such as isolation, occupying a niche, genetic recombination, may indeed be relevant to Evolutionary Epistemology, but is not crucial. Evolutionary Epistemology would lose its thrust, however, if one of the cited principles of evolutionary theory were false.

In spite of this strong dependence, it would be wrong to consider Evolutionary Epistemology a part of evolutionary biology. Whereas the theory of evolution is an exclusively biological and thus scientific theory, Evolutionary Epistemology, apart from its descriptive and explanatory elements, also contains explicative and normative ones which characterize it as a *meta*scientific discipline. Thus, it far exceeds being a mere "biology of knowledge"

(Riedl) or a "biology of cognition" (Maturana).

How Should Epistemologies Be Assessed?

The ontological, epistemological and empirical premises cited – hypothetical realism, projective model of cognition, identity theory, evolutionary theory – are at least in large part constitutive to Evolutionary Epistemology. Without them, the latter can neither be articulated nor sustained. On the other hand, Evolutionary Epistemology supports these prerequisites. This relationship is not a vicious circle, as no final proofs are intended or claimed. It merely reflects the hypothetico deductive structure even of epistemology.

Evolutionary Epistemology can succeed or it can fail. If it proves itself, this success will provide good arguments for its premises. It must not only prove itself in the face of logical analysis and empirical facts; it must also prove itself by answering questions, solving problems, contributing to the explication of epistemological concepts, recognizing new problems and helping in articulating them, etc. "Ye shall know them by their fruits!" Apart from its inner consistency and compatibility with empirical background knowledge, it is above all its *problem-solving potential* by which an epistemology should be measured.

Evolutionary Epistemology can face the challenge of these assessment criteria without qualms. Intrinsic contradictions have thus far not been found. Its consistency with science is not even disputed by its critics (it rather aroused the suspicion that it is an empirical discipline). Its problem-solving potential can admittedly not be presented in a few words. But we can try to summarize a few questions and answers. The topics which have been raised are almost entirely of an epistemological nature. This in itself is an implicit proof that Evolutionary Epistemology – contrary to the suspicion of a few critics – is in fact epistemologically relevant.

Answers of Evolutionary Epistemology

What role do the subjective cognitive structures play? They are constitutive for cognition, they make cognition possible. Where do they come from? Some of them are innate and are thus results of biological evolution. Why are they (nearly) the same with all people? Because they are in part genetically conditioned and hereditary. Why do subjective structures (of cognition) fit objective structures (of the real world) and are in part even congruent with the latter? Because otherwise we wouldn't have survived evolution. Why is human cognition not ideal? Because biological adaptation never is.

How far does human knowledge extend? First of all, it is adequate for survival, i. e., inasmuch as it is genetically conditioned (perception and immediate experience), it fits the world of medium dimensions, the mesocosm; but it can reach beyond and does just that, primarily as scientific knowledge.

Can intuition serve as a criterion of truth? No, our intuitive faculties are adapted to the mesocosm; beyond, non-intuitive theories can be perfectly correct. Can agreement with our categories serve as a criterion of truth? The answer is likewise no.

Is objective cognition possible? Yes, it probably even exists. Is intersubjectivity a sufficient criterion for objectivity? No, there are also common errors. Is there a necessary criterion of objectivity surpassing intersubjectivity? A reasonable crite-

rion of objectivity is *invariance*, i. e., independence from changes in the conditions of observation. Is there a sufficient criterion of objectivity? No, our knowledge is hypothetical on this question, too. Are there limits to human cognition? Yes, even if we had achieved objective knowledge, we could never be absolutely sure of its truth or objectivity. Is there a priori knowledge of the world? If "a priori" means "independent of all individual experience," yes; but if it means "independent of *any kind* of experience," no; if it means in addition "absolutely true," no. Are there, then, synthetic judgments a priori in Kant's sense? No.

Demarcations

Evolutionary Epistemology does not claim that all knowledge is genetically (biologically) determined. Cognition is rather biologically *conditioned*, but only in part biologically determined, viz., in perception and experience. Our brain indeed did evolve not as an organ of cognition, but rather of survival. But it is in fact capable of more. It enables us to form hypotheses and theories which go far beyond the mesocosm for which it is originally selected.

The decisive step in this was the breakthrough to a descriptive and discursive language. Just as we can construct, execute and evaluate *trial actions* in our imagination before we really act, thus saving time, energy, and risk, we can also *articulate* completely counter-intuitive facts with the aid of language, we can *assume* them for the sake of experiment and *examine* their inferences without having to think they are all true. And thus – quite unlike organisms without language – we can let our theories die in our stead (Popper).

To be sure, the origin of language and the human faculty of speech is biologically relevant and of crucial importance and significance for the evolution of man; but not every use we make of it can be explained by evolution. Scientific cognition, from the standpoint of biology, is a *by-product* of such general abilities as abstraction, generalization, concept formation, logical inference. It would be pointless to try to excavate the biological roots of the theory of relativity, of quantum chromodynamics or molecular biology; they don't exist. But it is possible and meaningful to study cognitive failures as to their biological or mesocosmic origin.

Why is it so hard for us to estimate the long-term growth of capital with compound interest? Why do we have no feeling for the hyper-exponential growth of mankind on our globe? Why do we fail in dealing with interconnected systems? Why do we have so little insight into systems with positive feedback? Why are we at best capable of linear extrapolation? Why do we expect some kind of compensatory justice in games of chance? Why is it so hard for us to adjust to chance events? Why are there often such big differences between objective and subjective criteria of decision? Why could Aristotle's theory of motion and the medieval impetus theory be accepted for so long? Why can't we visualize non-Euclidean spaces, four-dimensional cubes, a finite but limitless cosmos, absolutely accidental events?

These questions can be answered by Evolutionary Epistemology. For apart from its consequences for epistemology, it also has applications in the psychology of research, in the explanation of the history of science, in didactics, in anthropology. For reasons of space, we cannot expand on these far-reaching consequences here.

In spite of its applicability to the history of science, Evolutionary Epistemology should not be mistaken for an explanatory model of theory dynamics. It is concerned with the evolution of cognitive *faculties*, not with the evolution of scientific *knowledge*. The way theories are devised and tested, corroborated or refuted, corrected or superseded, is not a problem of Evolutionary Epistemology, but of philosophy of science. There are at best analogies or structural parallels to Popper's or Toulmin's "evolutionary" methodologies. They are instructive, heuristically valuable, didactically helpful, but that doesn't mean they are identical. Popper's doctrine of three worlds, in particular, is incompatible with Evolutionary Epistemology.

The relationship of Evolutionary Epistemology to sociobiology should at least be touched upon. They have the reference to biological evolution in common. But they are concerned with completely different questions: "What can we know?" on the one hand; "What should we do?" on the other. The subject of Evolutionary Epistemology is our cognitive capabilities; the subject of sociobiology is our social behaviour. In both cases, the question can be raised as to their evolutionary origin, as can that of *philosophical consequences*, in the first case as regards epistemology, in the second, ethics. Evolutionary Epistemology and sociobiology thus form an heuristically productive analogy, but not of a logical implication.

In the strict sense, sociobiology is first of all a "biology of social behaviour (of animals and men)." Just as Evolutionary Epistemology philosophically expands the "biology of cognition" to an epistemological theory, sociobiology may be expanded by a future "evolutionary ethics" to a philosophical discipline. However, the field of study of such evolutionary ethics will be completely different from that of Evolutionary Epistemology.

Finally, what is true for cognitive structures and social behaviour, is also true for the evolution of aesthetic judgments: at first, it will be limited to description and explanation, but then an attempt will be made to draw philosophical conclusions. But here there is as yet not even a "biology of art", so that *evolutionary aesthetics* cannot even begin to be taken up.

Evolutionary Epistemology as an Unfinished Task

Evolutionary Epistemology claims to provide answers of its own to old and new problems. It should be no surprise that in the process it comes into conflict with traditional views. It is thus the task of its proponents and critics alike to examine positions and arguments by making critical comparisons. They can stress the common aspects or the differences. For reasons of space, neither could be done in this presentation.

However, Evolutionary Epistemology is not a complete theory. It is rather a research programme. There is still no complete system of the categories of human experience which is supported by biology and psychology. (Kant's system is certainly *not* adequate in this regard.) There has still been no study of the restrictions to which all empirical cognition is subject due to the projectability postulate, i. e., due to the fact that objects can only be recognized if they *somehow* enter into causal correlations with us. There is still no thorough comparison with transcendental philosophy, with logical empiricism, operationalism, constructivism, pragmatism (there are close relationships in each case). There is no analysis of the feedback between scientific knowledge and epistemology, so important from an historical and systematic point of view. There are as yet no empirically testable and tested hypotheses on the actual evolution of human cognitive abilities.

There is as yet no evolutionary psychology making the concept of evolution productive for psychological problems, as

well. There is no evolutionary theory of education, which doesn't "instruct" or "programme" the child as a tabula rasa, but *challenges and promotes* its natural development. There is no evolutionary didactics replacing cumulative learning models by a contrasting model enabling mesocosmic prejudices to be recognized, discussed, and surmounted.

Such efforts would not only have Evolutionary Epistemology to thank for some ideas, but would also on their part have productive and corrective effects on Evolutionary Epistemology. In any case, there are still many opportunities for scientific and philosophical research.

English translation by Philip Mattson

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