# EPISTEMOLOGY, UNCERTAINTY AND SOCIAL CHANGE

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## Abstract

While uncertainty has always been a part of human experience, scientific results in our current age imply that a unifying theory is out of reach, probably forever. If we are to survive the dangers of resurgent irrationality and accept that we have reached the end of ideology, than we will need to recognize a 'new rationality', a pragmatic and critical approach based on relative certainties. The plausibility of this approach is strengthened by recognizing its roots in the evolution of human thinking patterns. Application of this 'new rationality' and its concomitant systems literacy is illustrated by examples drawn from global computer information networks.

Beyond the overall message treated as a modernized heritage of a long philosophical continuity the paper delivers three uncommon ideas. First, this work relates different views of uncertainty to the endeavors of various unification theories for explanation the world's existence, correspondences and changes; second, treats disciplinary ways of thinking i.e. logic and probability as metapatterns and third, suggests basic shifts in roles of philosophical disciplines as epistemology and ontology.

The stimuli for the above conclusions originated in computer science and artificial intelligence research.



**Key words**: epistemology, ontology, uncertainty, logic, rationalism, patterns, computer science, education.



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Invocation: To say the truth, true and not true.
(Shakespeare: Troilus and Cressida, I.2.101)

**Epistemology takes on a new role in the modern age.** We can characterize "modern" in many ways, the concept is uncertain and therefore as context-dependent as many others. Our context here relates to the present era, often dubbed the "Age of Uncertainty." Uncertainty has become a key feature of our ways of thinking and our relationship to Uncertainty (now capitalized) is seen as an important feature of many epochs' ways of thinking. To be more fashionable, we might say a feature of many paradigms. The formulation and application of an "epistemology of uncertainty" has become a crucial task.

## 1. A long history of Uncertainty -- in brief.

**Uncertainty has always been present in the human mind.** Its existence was more recognizable in the experience of earlier men than has been the case in our times. Uncertain outcomes were the regular experience of everyday life, in contrast to our present era, when uncertainty is usually considered an exception. This everyday experience of uncertainty stimulated a generalization toward a unified view. Thus, Uncertainty was not really detached from Certainty and, as a result, the whole world was seen as being controlled by a marionette-like mechanism of spirits, gods, or strange, supernatural beings. The indigestible experience of death contributed to this marionette-model unification, which put all knowledge of events under one uncontrolled branching framework of mythologies. Whatever man could know was at the mercy of the gods.

Hence it was not by chance that the philosophers of Antiquity bypassed the problem of Uncertainty. However, even in the syllogisms of Aristotle we find two modalities beyond the certain or necessary (*anangkion*): the possible (*dünaton*) and the contingent (*endechomenon*), both of which express uncertainty. We should not neglect the relevance of paradoxes in thinking about logic, expressed mostly by the Stoics, that also refer to Uncertainty. Nevertheless, these kinds of Uncertainty could be easily put into the outlined mythological framework, and were less a source of headaches than expressions of a joy in playing with concepts. Lucretius was one of the rare exceptions who went deeper; significantly, he also had the intellectual and political courage to refuse the divine hypothesis.

This pattern for dealing with Uncertainty by means of a globalized supernatural concept continued for centuries. Beyond the divine unification, i.e.
the step by step replacement of local and individual gods by one Supreme Being, the role of spirits, holy ghosts remained similarly.

In parallel with this view of Uncertainty, the human endeavor to get a "rational" picture of the world grew stronger. This was the result of progress in science, as man started to get structured knowledge of certain phenomena and learned that these structures would reiterate predictably, or could even be reproduced at will. We will return to an interpretation of these structures, which were mostly conceptualized as mathematics and logic. The relationship of mathematics to logic tended to be a rather subjective issue: whether one was a part of the other or whether, in the end, both were the same thing. The argumentation on these issues was partly epistemic, i.e., relating to the alleged meanings, and partly practical, relating to how various questions were treated. In any case, the result was the gradual development of a world-view based on observed regularities which could be formulated as rules.

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**The rule-based view** (as it is called in the vernacular of artificial intelligence) required a reinterpretation of the supernatural conceptual structure. The new idea also originated with Greek Antiquity, where God was endowed with the attribute of Primary Mathematician, the Great Geometer, one who designed a perfect, rule-based World Order. Man's most challenging task would be to recognize these "Laws of Nature." To become aware of God's miraculous laws would lead to a deeper awareness of God himself. Not only Thomas Aquinas, but most of the great logico-theological thinkers of the Middle Ages, including Abelard, Grosseteste, William of Ockham, Roger Bacon, and Raymond Lullus, shared this belief.

These same ideas of rule-based order became the philosophical bridge between the Enlightenment and earlier results and beliefs and led to the popular belief in several, perhaps infinitely many worlds of Creation (including the Leibnitzian "best of all possible worlds"). While the supernatural framework remained, the roles of God and Man began to shift. As man became increasingly impassioned by the seemingly unlimited possibilities of science and technology, the idea of God as Divine Orderer took a back seat to the idea of Mankind and Science.

One of the most revolutionary ideas characterizing a new look at the world's functioning was Darwinian theory. Instead of a planned, structured development, a random dynamics became the vehicle of change for the generative and the survival processes (i.e. for mutation and selection). Natural selection, however, turned out to be but the tip of an iceberg.

## 2. The new Uncertainty

**Discovering "black holes" of knowledge** was the next revolution. (And here we use the word "revolution" in its original sense, as a "turning," not something to be overly dramatized.) The view of rule-based regularities had worked quite well for an extremely long time; as an inevitable consequence, it failed. Several essential results marked this failure, notably the success of the probabilistic interpretation of quantum mechanics, and Gödel's final refutation of the ambitious Hilbert-Russell enterprise to create a complete and consistent logico-mathematical foundation and unify both fields, which led to the concept of non-computability. The possibility of infinitely interpretable logical models (characterized by Skolem and Loewenheim), the Uncertainty principle of Heisenberg, and many other achievements of science, led to the conclusion that researchers were exploring the outer limits of science.

Computers played an important role in this process, one similar to the earlier course of the human mind. The machine's fantastic computing capabilities -- several billion operations per second, handling even more vast amounts of stored information -- were supposed to be (once more) the final instrument to solve previously unsolvable problems. The true picture was discovered in a new discipline of mathematical computer science: algorithmic complexity theory. This field revealed the limits of computation, as related to any imaginable and physically realizable device created by existing technology and design principles. The classes of non-computable complexity start with "simple" NP problems, i.e., those that cannot be solved by a sequence of polynomial expressions of the data, components, agents, or states involved. Anyone can imagine the terribly high number of computational steps in the case of even polynomial expressions -- consider only the hundredth power of one hundred! Non-polynomial problems are of much higher complexity. The combinatorial explosion starts very fast and reaches numbers which exceed the number of milliseconds since the Big Bang, or the number of atoms in the Earth! Similarly to set theory, which differentiates among the levels of infinity (e.g. countable, which can be ordered by real numbers, and higher orders of

non-countability) NP classes were found which require not only an NP number of operations, but also an NP number of storage places.

Some NP problems can be reduced to computable ones, and some reliable approximation methods, which can be well estimated, were found. However the "Bad News" -- as people working in this field refer to it -- is the result of a recent proof that several important problems cannot even be approximated with reliably estimated errors. These are metaphoric generalizations of broad classes of practical problems mostly related to complex graphs, i.e., to optimal solutions of highly complex interrelationships.

We have other problems with interpretation models. These too belong to lower complexity levels. Mathematical modeling of social-economical processes have shown, that in case of multi-objective optimization, i.e., satisfying several different objectives simultaneously, we often cannot find a good compromise. Some objectives have to lose, if we want others to win, that is, progress in a necessary way. Thus models assisting decision-making were also subject to uncertainties.

Last in our enumeration of Uncertainty relationships we return to a more immediate sense of the term. Just as the concept of enlightened Certainty developed, the mathematical-philosophical treatment of Uncertain events started with clearly defined models: coins and dice used in games where the chances could be calculated on the basis of firm statistics. The close marriage of statistics and probability started that way. Jacob Bernoulli, one of the pioneers in that field, connected this with the idea of "moral expectation," which is nothing but Bentham's concept of utility. This hinted at further uncertainties in decision-making, as mentioned above. The hint was ignored for a long time, perhaps due to an unconscious psychological horror of conceptual vacui, a fear of real Uncertainty.

Uncertainty, viewed as probability based on objective facts, was questioned by many philosophers. John Venn may have been the first in the last decades of the 19th century. Frank Ramsey and Bruno de Finetti, in the 20s and 30s of this century, referred to the subjective view of these phenomena and to the relation of these concepts to psychology.

The seminal effort of Kolmogorov, who established the firm theoretical framework of classic probability theory, marked the last attempt to treat Uncertainty as a well definable and generic mathematical-philosophical concept. Similar to the story of the Hilbert-Russell effort in mathematical logic, this axiomatic foundation gave new impetus to a critical view, the

clear definitions of the axioms generating both doubts and investigations of their validity and limitations. We now see an explosion of competing models for Uncertainty: the Bayesian, the Dempster-Shafer method, fuzzy, possibilistic, and other approaches. All have some validity and some intuitive basis, but no one can dissolve the uncertainty of Uncertainty in any final way.

For the time being, at least, we have to face the fact that no finally certain knowledge exists and that there are problems which are, in the end, unsolvable by the human mind forever.

### 3. Dangers and new approach

**A changed view of the world.** As awareness of these "black holes" of knowledge spread through the culture, the emotional and philosophical outcome was a profound alteration in the way people viewed the world. People lost a firm belief, a grip on their uncertain lives. Many returned to previous beliefs: religions, myths, simple superstitions. But this return could not really happen, there was no way to step back into the same river. Modern life, and "modern" in this context means our technologically defined everyday life, can not be stuffed back into the Certainty of previous beliefs. We can observe that most fundamentalist societies, after a nightmare of victorious reversal, start to compromise with the achievements of the Age of Reason. Even a relatively moderate, but strongly conservative, organization such as the Catholic Church has to confront the changes caused by progress in medical science, such as contraception and improved infant mortality, as well as the resulting societal changes in women's roles.

**Fundamentalists refer to adamant first principles** and apply a strict logic for any further conclusions, but first Principles are under steady revision. The idea of going back to first principles and redefining them according to up-to-date knowledge has been an unbroken theme of human beliefs and efforts. We could rewrite the history of human thinking by listing the sequence of such redefinitions. It is a natural desire to have some fixed and simple cornerstones to start off from and an apparently realistic hypothesis. It is natural for us to believe that the interactions of infinite events has, at root, a very small number of basic actors and types of interaction. Physics and biology supply much evidence for this idea; it is equally reflected in the representation of final components and infinite interactions seen in modern art. An open problem for modern ways of thinking is just how we can overcome the limitations of primary human representations, such as this desire for first principles.

Geometric shapes, motion, and time are the most important everyday experiences and reference patterns. These have been questioned, to some extent, especially by modern physics. In spite of this trend and an intention to replace these with the more subtle metapatterns of mathematics (and even this subtlety is limited by the boundaries of these original patterns), the current models of First Principles are somehow bound to the same limits of our imagination.

In this way First Principles can be useful hypotheses for thinking, and further experimentation, but should never be taken as idols. This was and is still the danger of the traditional idea of First Principles. Believing that a set of principles is the first is equal to *fundamentalism* (the word impeaches itself). Any reference to principles being fundamentally and unchangeably first justifies the right to do anything which can somehow be logically derived from those principles, whether it is true or false according to some other view, another set of principles. Science has started to get rid of ultimate First Principles, but this is not yet true for the everyday man or everyday social relationships. Having First Principles as fixed dogmas is an intellectual convenience and an invitation to intellectual indolence.

The essential difference between ways of thinking before our age and those which will come after is that we have lost the possibility of a Unification Theory, be it a primitive myth, a sophisticated religion, or a firm belief in science. We have to face a thoroughly new way of thinking: a long, maybe for mankind eternal, coexistence with relative certainties. It is this fact of life which forces us to reconsider the role of Epistemology. One approach to this coexistence is a pragmatic assessment of the risks.

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**Pragmatism** is the practice of our everyday life. We are conscious of the fact (for example) that any kind of commuting carries with it a certain risk of accident. We may even know the statistics on one or another transportation method or route, and yet we still commute. On the other hand, having knowledge of this uncertainty, as private persons and as communities we try to decrease this uncertainty further -- in several cases with good, but never complete, success. Similar situations can be found in any event and experience of everyday life; these are (and always were) the starting points of many subtle philosophies.

The lesson of the pragmatic approach is well illustrated by the example of algorithmic complexity. The given problems have no really generic solutions, but cooperative efforts by

mathematicians and domain experts can reduce the problem by introducing delimiting background knowledge, contextual interpretation, which can help to reach a rather appropriate solution for a given task. This result can often help in other analogous problems (this is the power of the experienced specialist), but *can not yield a solution, which is valid in each similar case*, one which will be certainly true under any, even slightly different, circumstances.

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**We have reached the *end of all ideologies*** if we accept this conclusion. Ideology is understood here in a Platonic sense, analogous to what was earlier called a "unification system," or "globalized supernatural concept," i.e. a General Ruling System of the Universe, or at least of a microcosm. It marks, as well, an end to a belief in a Final Truth, whether it be a divine doctrine, the excluded middle of logic, or a belief in salvation by means of certain social institutions. The end of *great narratives* is a similar notion, often found in the philosophy of Postmodernism.

The situation holds a real danger of causing devastating confusion. If Reason fails, every kind of irrational (i.e. phylogenetic and ontogenetic instinctual) belief can take a ruling position. That has been the major lesson during the whole Twentieth Century. As noted, this effect cannot persist over too great an historical span (otherwise it destroys the system, as we have seen in several examples, even in our century), but the process can be long, and perilous for more than one generation.

Having awareness of limits to knowledge, we should not abandon what we have already achieved to date. One of the best examples of this is the status of medical science, with all of its open, unsolved problems on one hand, and with wonderful results on the other. Charlatanism in the form of pseudo-medical fads is the cause of suffering and death for many, who could be cured by up-to-date professional methods. The same risk of losing real benefits to irrational and unjustifiable beliefs can be found in many related professions and activities.

With the death of all past ideologies, a new approach is needed. We might call it a "*New Enlightenment*," or "*New Rationalism.*" It would drop the last belief-like features of human thought, and by that process, put the entire responsibility for action under uncertain circumstances not on the shoulders but on the critical *mind* of man.

In reaching toward an understanding of the epistemic situation of relativity, or, perhaps better, the contextual sensitivity of knowledge, epistemology has taken on its new role. In Unification Theories of previous epochs, ontology had the primary role; other branches of philosophy, i.e. epistemology, ethics, and esthetics, were derived from the essential view of Being.

## 4. Changes in philosophical implications

**Ontology, in this new view, is shifted to the realm of theology**. It can deal with questions of belief. But, from an epistemic point of view, if we don't encounter a real, reproducible experience of e.g. revelation (as all religions believe), then we cannot treat the problem in any scientific way. The final questions of the nature of being are hidden in the final Uncertainty of self-reflection. Paradoxes of logic like the Liar paradox and the Russell paradox -- even, in some sense, the Meinong paradox[1]-- are excellent metaphors for the problem, which cannot be approached in a metaphoric way alone, precisely because of its translogical nature. (I use the word "translogical" here, which is used in cognitive psychology in a somewhat different sense, in order to avoid the word "metalogical," which in my sense would refer to an interpreter for different kinds of logic, similar to the idea of a "metalanguage" for mathematical or computer languages).

The problem of being could only be treated by metabeings, beings other than mankind, who do not have the same experience with being that we have: birth, human desires, aging, and death. This is why the concept of a Supreme Being was not only instrumental in resolving Uncertainty, but also an answer to ontological problems. It is also the reason why we can now (finally) shift these issues to the realm of theology without any comment, since another realm will have different values and different rules for the estimation of validity.

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**Epistemology thus becomes a kind of manual, a set of instructions for the use of knowledge**, a series of steps to the ideal place from which we may govern human thinking. The idea of tools of thinking (*organon*) was also found in the thought of the Peripatetics, of course, but in a very different way. If everything is to be treated in a critical way, because all

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[1]Liar paradox: A Cretean says "all Creteans lie".
Russel paradox: The only barber of a village says " I shave here everybody who doesn't shave himself".
Meinong paradox: reference to and conclusion on non-exiting objects.

knowledge is context sensitive and these contexts vary from time to time, from situation to situation, in the light of differences in the relationships of knowledge chunks, then all other issues of human judgment should undergo the critique of relational thinking. Ethics and esthetics are no longer absolute attributes of Being, but considerations related to Knowledge. This emphasizes the increase of responsibility, which no longer can be shifted to the Supreme Being of any ontological theory. The ideas outlined here are, of course, not new; they have their origins, in one or another ways, in the whole history of philosophy. But to take them as a more or less general conclusion about epistemological practice is an idea that, for the reasons discussed above, holds unique relevance for our times.

As I have tried to discuss in detail in my book *Computer Epistemology*,[2] epistemology, as related to the computer age -- or more precisely, to methods of computer modeling, knowledge representation -- is now the essential practical tool for the unavoidable, continuous critique of any human decision, activity, application limits, and expected outcomes, once again recalling Bentham's "moral expectation."

The contrast of attitudes between an epistemology that recognizes uncertainty and the older, more rigid assumptions of certainty can be represented by the differences between an enlightened (but still human) American physician, who shares his view of the situation and the odds on the success of various therapies with the adult patient, and the traditional European practitioner, who tends to treat the patient as a child who should be protected by "trust the oracle" stories.

If we coexist with Uncertainty, with the sensitivity of knowledge to all kinds of varying contexts, then this general attitude, and its commitment to continuously updated techniques of epistemic criticism, becomes the first priority for judging and doing anything. According to my view, this means that a basic knowledge of all major epistemic approaches should be the key requirement for civil participation, much like literacy used to be in the classic Enlightenment. A rough list of such approaches might include, e.g., some system dynamics, statistics, uncertainty techniques, logic, linguistics, and, of course, a holistic attitude to problems. We might call this basic knowledge a "literacy of processes." We will return to this issue as a major lesson and task for the future.

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[2]T.Vamos: Computer Epistemology, Singapore: World Scientific, 1991.

**The Scientific attitude to knowledge must change in a parallel manner**. Philosophy of Science was recently the focus of much attention, precisely because the relativity of knowledge was recognized. The last philosophical school in defense of absolute scientific values was positivism, which made unquestionable basic achievements. Positivism had -- as mentioned earlier -- a role somewhat similar to the quest to formulate a logical foundation of mathematics. Later development shifted to the other extreme, a total questioning of any kind of scientific truth and relegating science to a solely social group of contexts, which is an important, but *one* selected viewpoint only.

The pragmatic approach to scientific validity can be seen as analogical to the development of the logic of relationships and uncertainty calculations. Truth is replaced by usability (not only profitability; this is understood in a very broad sense, i.e. usable for communication, usable for further considerations, etc.). Usability means that a result can be successfully reused. This is a weaker replacement of reproducibility, weakened only by the addition of limits. These limits can be the statistics of the reproduction, the measure of deviations, and similar limits, but all, including the lack of evidence or provability, are to be defined and described well, or in the same fashion. I could describe these conditions as the weak, but sincere types of the Popper criteria.

The procedure of reproduction is a relevant subject of this usability definition process. This means that the criticism of any experiment, whether a conclusion reached in a material experiment or a theoretical result as a thought process, should be enhanced by all possible information about the context, in a fashion similar to any conditional, uncertainty related logical statement. The result is never a Final Truth as expected in classical logic and Rationality, a "Law of Nature," or of any other discipline-defined process, but rather a weaker or stronger hypothesis, where we are more or less aware of the measure of its strength. Just as in our practical example of commuting: if we sit in a car and want to reach some point via a certain highway, we have a working hypothesis about what time and in what condition we might arrive or not arrive there. All our decisions and actions are subordinated to these considerations. The pragmatic approach to scientific truth is essentially no different. This way of thinking includes the steady observation and weighing of compromises, changing and correcting the initial hypothesis.

The philosophy of "New Rationalism" is no more, and no less, than this! Experience with the frequency of events, with similar features of situations, are ways of conditioning that have a strong background in modern computer science, where the tasks of massive, critical

knowledge representation and knowledge-based reasoning first became a focus of interest. The phenomenon of massive representation and usage is relatively new, just because of the novelty of technology in general and especially of the novelty of computer technology. In this fashion, earlier views of logic became weaker, but the treatment of uncertainty became stronger, due to the reunification of the two.

For a deeper understanding of what was going on, consider a rather new (albeit with a long prehistory) approach to the knowledge-acquisition/representation process. The idea of patterns as fundamental representations was supported by Platonic idealism and many following schools. The evolutionary process of patterns was surprisingly clearly summarized by the economist-philosopher F. A. Hayek, in his *Law, Legislation, and Liberty*.[3] In mathematical thinking I refer to the stimulating book of Polya: *Patterns of Plausible Inference*.[4] This latter was an extremely profound considerations on scientific methods, their subjective ways of creativity, a wonderful documentation of those problems of human creativity, which are believed to be most suitable for mechanization.

## 5. The evolution of thinking

**Our mechanisms of thinking are fixed in given schemes.** The story starts with the survival-reaction abilities of living systems. In most primitive organisms we find the basics of identification of some external effect (light, chemical, mechanical), a memory for storing these, and a reaction mechanism which helps to give the best answer for survival, i.e. whether to react to the stimulus with intake, rejection, or by multiplying.

An ensemble of these external effects is considered a pattern and the same concept can be applied to the answering mechanism: sensing a pattern, another pattern is fired (stimulated, put into action). Some recent findings in biology indicate that even unicellular organisms have such mechanisms. They can combine two different inputs (e.g. light and movement in the fluid environment) and react in a way that provides an appropriate answer for the two simultaneous, but otherwise disparate effects.

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[3]F.A. Hayek: Law,Legislation and Liberty, Vol. 1. Rules and Order. London:Routledge and Kegan Paul,1973.
[4]G.Polya: Mathematics and Plausible Reasoning, Vol.II.: Patterns of plausible inference, Princeton, N.J.: Princeton University Press, 1954.

When we consider the corresponding biological structures of any higher level organism, we find the entire complex entity is made of these primitive components, structured and specialized, however, in very complex ways. This suggests that the pattern concept can and should be used for higher intellectual activity as well. If we consider our ways of thinking, we find it based essentially on *memorizing* patterns, i.e. images of objects, living things, other people, situations, all of which have some coherence, and *joining* these patterns of recognition with action patterns that have proved to be appropriate from the most basic points of views of individual and group survival, or that are somehow, but easily, deduced from these basic survival criteria. Humans have the richest visual sensory apparatus, so it is not surprising that most of our patterns are more or less related to visual images. The highest intellectual activity, intuitive creativity, is essentially pattern based, even in such subtle subjects as chess or mathematics. This fact has been well documented by investigations in cognitive psychology.

All generalizations and theoretical methods of reasoning, have similar origins. The experience of consequences leads to combination rules for patterns, e.g. to logic or concepts of statistics, the two rather shabby basic mechanisms of reasoning. In the framework outlined above these are *metapatterns*, i.e. patterns of pattern behavior, combinations. Emotions are now well-detectable as chemical switches for pattern bias. Appreciated mechanisms like creative intuition or superior performance in critical situations are controlled by emotions as well. The process functions as an increased ability to elicit required, but hidden, background patterns both for identification and reaction.

The mysticism of numbers is a good example of how our "conceptual machine" works in creating metapatterns. People create "meaningful" patterns of numbers, and their combinations (like magic or Latin squares, etc.). A wonderful twist on this process is the usual form of mathematical thinking. The metaphoric archetypes of geometry and mechanics lead to the highest, sophisticated, abstract concepts of mathematics. The creative mathematician works mostly by analogies of formulae, problems, and solutions related to these mental schemes. The cited book of *Polya* presents a gold mine of these examples. We see similar paths of discovery in theoretical physics and biology, the metaphor of the double helix was only one of the striking examples.

Other high level mechanisms, schemes of thinking, are similarly based on these seemingly primitive but complexly organized components. The virtual principles of teleology and

causality have the same origin: a retrospective, human-conceptual view of pattern interactions, evolutionarily selected survival techniques.

The pattern view and the concept of metapatterns as a representation method for our ways of thinking helps in accepting the attitudes of the New Rationality. We can finally abandon the earlier view of initially defined structures and instead look at the structures as representation patterns in our mind. On the one hand, this is a useful representation that not only helps us to survive, but also to make circumstances more agreeable. But on the other hand these are only representations, created by a long process of phylogenetic biological evolution of the mind, and thus hold no claim to be a complete picture of what is really going on. The situation is similar to computer representation, in that a computer has its own representation mechanisms and the model, what we have in the computer, has its limitations defined by the limitations of this representation mechanism.

Another, related caveat concerns the concept and mechanism of *teleology*, a useful, but anthropomorphic idea in 18th and 19th Century physics. A certain pattern teleology is always at work in our mind. The connections of patterns, even the semiconscious patterns of our behavior, were and are developed in a certain teleological way that proved to be useful. But this partially fixed teleological mechanism can be inappropriate, obsolete in a new situation, and the adaptive ability of the brain is admirable, but limited. This means that the conceptual structures which proved to be excellent in one environment can be harmful, or at least false, in another. *Emotions* are often a large scale result of long imprinting frequencies for certain patterns and thus metapatterns. Biologically generated emotional forecasts of weather, some maladies, some kinds of anxieties, all of these were extremely useful, when there were no other means of obtaining an early warning. Now they are mostly burdens. The same is true for feelings of sympathy for what is similar and antipathy for the strange -- a situation illustrated all too graphically in these days of inter-ethnic violence.

This mechanism for the fixation of conceptual and emotional patterns is both phylogenetic and ontogenetic. The phylogenetic part can be a difficult burden, but we should concentrate more now on the ontogenetic part of the phenomenon. As is true in other brain structures (e.g. motor, visual, auditory, etc.), all have a certain fixed imprinting period in life, usually very early. This is seen clearly in the case of language acquisition, and explains why people who learn a language after their teens are often unable to avoid an accent. The last imprinting phase is that of the *structures of thinking*. This happens perhaps in the late teens to early twenties. Requiring more the building of brand new structures than the consolidation of

experience, those abilities tend to flourish most in that period of life. The bursts of creativity seen then are not seen as frequently in later years. A list of prodigies in such fields as mathematics, theoretical physics, music, and chess supports this point.

This fact is another important clue to the issues raised above concerning relativity, usability, and limitations on knowledge, but it is also a clue to the issue of education related to the New Literacy.

## 6. Implications of Global Information

**The Revolution in information technologies requires a new look at the relevance of epistemology.** In *Computer Epistemology* I outlined some important features of this revolution, such as the fact that on two occasions, four major revolutions have changed human circumstances. The first group was related to tools (primitive manual tools, mechanisms, powered machines and *electronics*), the second to communication (verbal, written, printed, *electronic*). For the first time now, both tools and communication have produced significant changes by the same means. The relevance of these changes to the dramatic decreases in time and geographical distance, to ways of working and other activities, have been discussed by thousands of authors. I focus attention here on the lesson these changes hold for the increased relevance of epistemology.

The first effect we encounter is the abundance of information. For a long time in science, one book was considered to be fundamental: whether the Bible, the Koran, perhaps a few canonized authorities in a field. Instead of *One Book* world we now face a *Global Library*, a source of practically unlimited information, available on everyone's network-connected personal computer displays. Everybody can issue information the same way. The selection, the navigation of this ocean of information, made easy by such powerful tools as hypertext and hypermedia, is a critical task for the future. Practically nothing is done beyond the creation of these excellent instruments of technology. The user of global systems has no defenses against information monopolies' imposed criteria of selection, nor against being overwhelmed by the insurmountable abundance. While no general panacea can be suggested, a free, but ethically controlled market of information processing (in this sense) can be the only feasible system, similar to a political democracy or an economic marketplace. The problems are analogous. A healthy relationship among information producers, mediators (the

people who provide navigation, selection, and surveying services) and the users can only be established on a relatively high level of New Literacy, the kind of awareness mentioned here.

A second and related issue arising from the globalization of information is the presence of different cultures. In the previous world, some cultural interactions were always present. Sometimes they were slow and mild, sometimes dramatic and forceful. But continuous coexistence as an unavoidable condition of cooperation was never a de facto rule. Societies were basically unicultural, and structurally intolerant of any other cultures. By "culture" I mean to emphasize here the point of view of typical ways of thinking,, the usual metaphors (patterns and metapatterns), and the traditional range of values.

Values can only be preserved in a critical way: a changing world, a changing history mark changing values. The previously mentioned relativity of thinking sees another aspect to this globalization of information. People must be accustomed to meeting other cultures, must learn a conscious empathy for them, an ability to accept, or at least understand, the other's values.

As a pioneer of global discourse, computer science has collected some experience in this area. Cooperative, distributed computation via networks have developed some very useful principles for layering activities according to the depth of content of the cooperation. Working together not by a simple distribution of tasks (e.g. producing different, but matching components), but on common intellectual activities (e.g. telediagnosis, teleconsultation, common project development) requires a full mutual understanding of the partners' vernacular, very clear definitions, and highly sophisticated protocols of information exchange, negotiation, and agreement. This process has a certain historical precedent in all professional activities where this sort of global cooperation was required (transport, trade, financial activities), but it has not been implemented in a broad sense. It was mostly restricted to specific fields and not generally available for the population-at-large. The man of the future will need to meet this task in an unusually versatile environment.

Several problems in these processes of globalized information raise questions of how much should become global and what should remain local, or even continue to grow in a locally autonomous way. The dangers of global uniformity are clearly detectable as are a number of aggressive answers to that as well. The desirable development would and could be a parallel one, the ample possibilities of global cooperation should create freer, more self-enriching individuals and societies.

## 7. Challenges for the future

**A New Literacy based on an advanced view of Epistemology** is my recurring answer. This is, of course, only one of the answers needed. A culture of relativity, of coexistence has essential economic and social background issues. Many of these are culture-related, as discussed above. Because the rather early imprinting periods for ways of thinking, a pluralistic intelligence should be started early, in the most sensitive learning periods of life. Several experiments in mathematics, arts, and languages have shown that children's brains are capable of far more adaptation than was expected earlier. This is less a matter of the volume of knowledge, than the breadth and diversity. Some potential subjects were mentioned above -- system dynamics, statistics, uncertainty techniques, logic, linguistics, holistic approaches -- but the task should not be sketched out in any superficial way. The design of such an educational curriculum is a most demanding and responsible agenda for the future. Some experience suggests that the concepts and the related ways of thinking can be translated in quite a wonderful way into the perceptual language of children of every age.

Structures of thinking may be fixed early, but if more than one structure is fixed at an early age, this can later function as a multivoiced instrument, a creative device for new combinations. It will help to prepare a responsive brain for new types of problems.

Not surprisingly, flourishing concentrations of talents in one or another region, population, and time have mostly been connected with essentially multicultural influences, arising on the borders of different cultures, of periods of historical values, of regions and groups engaged in cultural transfers. One of the latest phenomena displaying these effects was the sudden emergence of so many multifaceted Jewish talents in the region of Central and Eastern European during the few decades before and after the opening of the 20th Century.

Karl Popper's ideal of the Open Society can only be approximated by an open-minded population. Facing a goal which has never existed before, namely a global, polyphonic society closely connected in real-time, all trends toward simplistic unification are disastrous. This is the reason why mankind either becomes able to develop the kind and level of New Literacy required, or the continued development of technology, the unavoidable presence of increasing complexity and uncertainty, becomes catastrophic.

One last comment: several civilizations, the Europeans first of all, have started to abandon their cultural heritage, especially in education. Reflecting what has been said above, I feel this is a great mistake, the loss of a common language and a common key for the understanding of historical-cultural processes. We refer only to Thomas Jefferson's historical principles of education for the American people -- it should be updated, of course, but not the cardinal principles of the message. Innocence of a cultural heritage opens the door for the return of confused myths. Once again, we must relate the historical-cultural patterns of our living past to those of other cultures by a standard of reference such as the New Rationalism, the New Literacy. Both are methods by which we can learn to live with the inevitable Uncertainty of the world. The revival of millennia old problems of epistemology in computer science, and the essential, practical relevance of an epistemic-critical view to such problems is only one demonstration of the continuity and validity of that view.

**Remark on references:** A comprehensive bibliography is given in the cited book: T. Vamos: *Computer Epistemology*, Singapore, World Scientific, 1991. The ideas of this paper refer to those, as a long continuing development of science and views on scientific methods. In this paper I referred only to two further books, and this is the reason why they are quoted specially in footnotes.