ES GIBT NICHTS PRAKTISCHERES ALS EINE GUTE THEORIE

(Nothing more practical than a good theory, quoted by: Alessandro Volta, Immanuel Kant, Gustav Robert Kirchhhoff, Albert Einstein, Kurt Lewin, Theodor Karman, etc.)

Hypotheses non fingo, Newton[1]

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Abstract

Good and practical theories are generative, i.e. they stimulate hypotheses and research for new phenomena, new relations. Some examples, e.g. generative linguistic theory, the Darwinian evolution, analogue ways of thinking, the broad world of geometric metaphors.

A relevant feature of these generative theories is their unification power for creating relations among specific theories. The general scheme of epistemic progress is discussed in the cited frame and, the final check of validity in practice is emphasized.

1. Good and practical theories are generative

In order to see the real messages of these two well-known statements, we have to analyze the diachronic and synchronic contexts. In the first, Es gibt nichts Praktischeres als eine gutte Theorie, we emphasize the attribute *gute*, i.e. *not all* theories, only the good ones, those proven to belong to that sensitive class. The other, the Newtonian citation, according to R. Kalman [12], the founder of modern control theory, is a reference to typical compilations and confused, not proved speculations.

Theory in our age and the way we see it is always a well-proven hypothesis, a generalization of earlier experience and/or a strong evidence of coherence among phenomena and concepts. These concepts themselves are hypothetical and proven unification of cognitive phenomena. This means theory, in this view, is an advanced credit to a strong hypothesis.

Good and practical theories are generative. They can generate new facts, the existence of non-discovered phenomena and further connective interactions. This is the real meaning of practical, not or not only the instant solution of a related problem, mostly far from an instrument for immediate profit. According to G. H. Hardy, the great British mathematicians of the 20th century:

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[1] Latin for *I feign no hypotheses*, is a famous phrase used by Isaac Newton in an essay *General Scholium* which was appended to the third edition of the *Principia*.
It was his answer to those who had publicly challenged him to give an explanation for the *causes* of gravity rather than just the mathematical principles of kinetics. a translation of the passage containing this famous remark:

> *I have not as yet been able to discover the reason for these properties of gravity from phenomena, and I do not feign hypotheses. For whatever is not deduced from the phenomena must be called a hypothesis; and hypotheses, whether metaphysical or physical, or based on occult qualities, or mechanical, have no place in experimental philosophy. In this philosophy particular propositions are inferred from the phenomena, and afterwards rendered general by induction* [18]

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We may say, roughly, that a mathematical idea is ′significant′ if it can be connected, in a natural and illuminating way, with a large complex of other mathematical ideas. Thus a serious mathematical theorem, a theorem that connects significant ideas, is likely to lead to important advances in mathematics itself and <u>even in other sciences</u>. [9]

2. The paradigm of generative linguistic theory

With those introductory remarks we arrived to the selected examples, to the role of being generative for a certain theory. The illustration starts with the *generative grammar* theory of Noam Chomsky [3]. The background is also illustrative: the almost contemporary advent of genetic engineering with the discovery of the genetic code by Watson, Crick and Franklin published in 1953 and Chomsky's most influential publications in 1955-57.

Much is revealed in the wording: the Greek word γενναω (gennao), to give birth, is the stem of Genesis, gene, generative and generation, i.e. it expresses the search for the origins and secrets of all further developments. This is the general scheme of theories: discovering and setting the elementary constituents and creating hypotheses about the rules, the effects of evolutionary processes and a search interpreted as the causal representation of the investigated effects. The concept of causality is treated with care and should not lead to the philosophical problem of the factual existence of causality and, as a consequence, teleology, the hypothesis on the purpose of the world.

The Chomskyan hypothesis supposed a certain inherited brain function, an elementary grammar that enables mankind to adopt those highly variable languages and infinite expressive variations that have still some basic structural properties common. The elementary genetic code structures generate an infinite variety of living creatures from the same few biochemical compounds. Behind the two generative hypotheses stood the analogy of the newly-developed computer organizations, the mathematical-electronic generative theory of computation and the materialization of the mathematical theory of logic-based automata and computer languages, those that enable us to formulize the infinite realm of knowledge.

The story of computer languages continued almost uninterrupted. In spite of many lucid attempts to deviate from the main road of development, the fundamental structural ideas survived an increase of apprixunateky ten orders of magnitude, and an explosion in memory and speed of operation. Computer language families have grown over at least five generations and manipulate global networks, multimedia presentations and previously unimaginable devices and applications. In spite of this real revolution, anybody making an in-depth sutdy of the original mathematical and physical bases can easily follow and understand and admire all these wonderful developments.

The following unfortunately unprovable hypothesis is even more daring: If Panini, the great Sanskrit linguist living around 500 BC [13] or Aristotle one and a half centuries later, could be resurrected and received a few months' of education on the interim progress, they would be able to understand everything about computation and its linguistics and, maybe, give us good advice, how to proceed.

The argumentation as an example of a very good theory, namely that there are hypotheses developed on the soundness of that theory, demonstrating its scarcely surpassable practical essence. On the other hand, no proof exists for the uniqueness of thit theory, not even from a practical point of view. Quantum computation [10], standing on the horizon of realization, offers completely new theories, mathematical methods hardly differing from those used in logic based computation. Although we cannot speak with certainty of an advent of that new paradigm, the theoretical possibility is proven and several realization hypotheses of and of realizations deadlocks are available.

The characteristics of a good theory, hypotheses and practical realization are well demonstrated using this single but highly relevant and transparent examples.

3. The story of generative evolution theory

The story of the generative evolution theory is no less instructive. The still mysterious origin of life has always been a fundamental problem for mankind. All ancient civilizations solved this problem by referring to divine miracles and this reflects the levels of civilization during of written traditions and social-political relations. Literary refinement is a mark of those who contributed to the canonization of the scripts. Scientific theories, in our sense of science, started only after the twin developments in freedom of thinking and methods, instruments of research related to anthropology and history of nature.

The *Darwinian Theory* [4] is still one of mankind's most revolutionary and influential theories. One and a half centuries later evolution is a well and increasingly proven theory in its original field of science and a source of several stimulating hypotheses in various kinds of research applications, investigations such as humanities and development of large-scale systems [5], [11].

This paper omits the non-scientific ideological attacks and anti-hypotheses that pertain until recent times, propagated mainly for political purposes. The intelligent design hypothesis also belongs to this non-scientific class, as do all others that cannot demonstrate factual discoveries, and therefore cannot compete with the Darwinian version.

The theory that could really compete was the earlier Lamarckian hypothesis of life-long genetic adaptation. In this context we must affirm Darwinian ingenuity as being less dogmatic that that of some of his followers. The dogmatic rigidity of any theory usually works against the original theory, and this could also be traced in our previous example about computer science and its changing relations to several branches of uncertainty calculation. The dogmatic interpretation of probability theory and randomness changed only slowly due to subjectivity and infinity of situations and conceptual worlds.

This obscure dogmatism was to become the tragedy of the theories and hypotheses of the abusers, pseudo-followers of Karl Marx, leading to mass tragedies in the 20th century. Recent anthropological findings, refined microanalysis methods of analyzing them and especially dramatic progress in biology indicate the essential truth of the Darwinian evolutionary mechanism and the minor but relevant effects of some not yet completely understood Lamarckian adaptation due to environmental circumstances and random internal coincidences. The Darwinian mechanism of genetic variations receives a microbiological experimental background. After nearly a century of strictly deterministic results of individual genetic codes, the role of the not directly coding genetic structures was revived. Their internal mobility of genetic codes and several discovered code-interactions indicate a much greater freedom of opportunities for individual destiny than previously hypothesized.

We quote these examples in order to show our view on theory and hypothesis. The difference is emphasized not in the least out of definitional snobbery but because it has relevant epistemic consequences, outlined later, as the lesson of this paper.

4. The hypotheses generating analogies

Another interesting epistemic relation is the role of analogy assumptions in creating hypotheses. The analogy of computer-mathematical code and the biological-genetic was obvious, and expressed also by the word: code. Further leading analogies concerning the mechanisms of the brain and structural-functional parts of computers and the mind are also instructive. The early structural simplicity of computers could not reflect the distributed nature of the brain [16-17]. Now, in the age of temporarily connected large computer grids, multicore chip organizations and embedded, hierarchical software structures, the original analogy is more fruitful. Even the linguistic distinction of brain and mind reveals the combating differences of related hypotheses. The development of learning-adaptive systems and their branch-and-cut and Monte Carlo style random search strategies in the infinite space of possible and impossible solutions is a typical evolutionary process based on analogue thinking, looking for computational similarities of everyday human search and adaptation activities.

It may be said that these analogies are simply nice speculation games, but their relevance of those is much more profound. Analogy is the main road to creative thinking. Narrow analogies may sometimes be trivialities but they help to extend the use of common devices and methods. The really ingenious analogies are the conceptual correlation of distant thoughts. If we rethink the origins of the most revolutionary scientific ideas, we find that epistemic hypothesis to be valid. The world of dynamics created by Galilei, Kepler, Newton, Leibniz and Descartes (and further many others, like Laplace and Hamilton) is their vision on different views of motion, characteristics of fixed geometries and step-by-step changing states of objects.

The interaction of non-Euclidean geometry and the relative states of the material provided answers to some of the strange behaviors exhibited light and formed the Einsteinian theory. The ancient observations on different wave behaviors and elasticity-related transformation mathematics contributed to the solving of the original problem. Final elementary components and forces united the theories of quantum physics, these last two in some respects competing, and the theory of relativity and of quantum physics, two in some respect competing, and non coherent theories created the current world of elementary phenomena and cosmology, the sciences of the extreme small and extreme large. The two extremes meat in some final respects, and of course, in analogical hypotheses about the development of the Universe [24].

Analogical reasoning reflects the developmental road of thinking. The brain works from given material, given as sensory objectives and of hierarchically abstracted concepts from the same, just as evolution has created the hitherto most complex biological entity, the human brain, from chemical compounds to be found in the most primitive living creatures. Evolutionary theory and the mathematical philosophical theory of complexity, computability and realizability are related, the analogy is a conceptual and factual reality.

5. Geometry, a most fertile analogy model

Probably the most fertile analogy is the ever renewing marriage of geometry and mathematics and, that line of evolutionary thinking is the base of practically all mathematically modelable sciences to date. At the very beginning geometry was the science, that is to say geometry and numbering, the origin of all science theories. This is science as understood in the current Anglo-Saxon nature-related meaning of the word, and as metaphors for philosophical considerations about world orders.

Geometry was always the representation of the space of observation and events. The Euclidean theory can be considered as the first scientific theory in our modern sense, the visual, metrical discipline of premissae and their logical consequences, the theorems and their proofs. Non-Euclidean geometry, as J. Bolyai probably understood first in his enthusiasm, was really the discovery of a new world of still highest abstraction of spaces and their metrics as further developments of Riemann and his ingenious present-day followers [7].

These abstracted spaces are not only the really understandable metaphors and calculation models of modern physics but also provide viable modeling possibilities for biological, psychological, sociological and economic phenomena. The space-time conceptual entity is one of the most powerful theoretical instruments, used more and more for practical views in computational problems not feasible for scientific analysis until recently [1].

In the same sense the methods of uncertainty calculations develop. The long story of uncertainty was always blurred by the last arguments concerning extraterrestrial mystic forces; it was the evocation of destiny [8]. Probability and statistics, according to Savage [20] were never clearly related disciplines due to the differences of the frequentist and Bayesian views. These classic theories could be applied only under very strong, and in many practical problems unrealistic, conditions. The addition of hypothetical and experimental models for the behavior of the investigated uncertain phenomena could lead to feasible solutions [22]. The practical approach of theories in approximation calculi created the hulls of possible expectations, multidimensional space-time representations of hypothetical events [2].

6. Unification theories

Some great theories cover more and more unified perspectives of apparently previuosly unrelated and therefore not computable events. In addition to the aforementioned great theories of physics we have to consider the modern general Hamiltonian theory of motion and Maxwellian theory of electrodynamics. If we look at these two families of equations, we can immediately see the analogy, namely the dynamic balance of naturally transforming entities, both related to the concept of energy. The various but basically unique manifestations permit the incorporation of the two into the final balances of physics. Balance and lack of balance are very good examples of analogies originated in simple visual impressions. In their power of unification these great theories now serve in many transformational translations as practical computational algorithms in the design and control of engineering systems [21].

All these examples were closely related to the evolution of computer science. It is difficult to find any major achievements of computer practice that neither were nor anticipated by revolutionary novelties of basic science. Electrical and related electronic engineering is still based on the Maxwellian theory, (1865) decades before any major applications. Semiconductor- and laser technology developed in the late forties and thereafter are all non existing without the early 20th century revolution of physics, quantum theory, theory of solid state materials. Computer science and everything relevant in artificial intelligence is offspring of the long development of logic, Boolean algebra, representation theories of Frege, and others, all in the 19th century and further in the first decades of the 20th century, by Turing and Neumann. Neumann is the father of the non-

Neumann-ian neural nets and founded game theory in 1928. The other pillar of computer science is uncertainty theory, probability, fuzzy and other related theories included, started with Pascal, in the 17th century and followed by many others, let us mention Bayes, from the 19th and Markov, from the 19th century, creating the bases for data mining. Nonlinear dynamics as a computational theory for aerodynamics, turbulence, fractals, chaotic phenomena and so for most problems of dynamics in nature found its still valid origins with Ljapounov and Poincaré at the turn of the 19th and 20ty century.

Some software developers can say, oh, these are historical figures but our technology could solve all these without the sophistication of elegant, highly abstracted mathematics and theoretical physics. The truth is the contrary. All pragmatic developments are direct offspring of these theoretical pioneering in ways of thinking. Without that continuity no pragmatic solution is possible like no deus ex machina exists in natural evolution. We can state this just in the light of the fantastic developments in micro- and nano-electronics and in computational- mathematical applications for large scale systems, real life phenomena of global nature and microbiology.

7. The cognitive scheme of knowledge acquisition

These examples comprising very large areas, refer to the connections and differences of hypotheses and theories. Both serve in the feedback loop of epistemic practice. That loop is represented in the Figure (Fig. 1) [23] about the continually self-correcting mechanism of regular goal-oriented thinking in general, and of scientific knowledge acquisition in concreto.

The scheme has two essential features. The first is the priority of observations. Observation is also a critical issue. For a long time observation meant only personal sensory observations, mainly those of the person whose mind executed the whole knowledge acquisition process, with the addition of those observations he/she considered to be from reliable sources. The visual and auditive observations later proved to be fallible and limited**;** the great revolutionary periods of scientific thinking were always bound to the revolutions of sensory instrumentation, especially those of visual and visualizing tools. Remember the first astronomical instruments of special orientation, navigation, the microscope and telescope revolution of the Renaissance and the previously mentioned instrumentation technology explosion of the past one and a half centuries.

All this means the relative and evolutionary progressive strength of observation. *Evolutionary progressive* must be emphasized: the critics of the earlier, long experienced false observational facts, e.g. about the shape of the earth and its relation to the solar system, can be put into the wider frame of the advanced view and, despite their apparent theoretical failure, can be successfully applied in those situations that frame the earlier theoretical environment. A long list of primitive medical observations can be cited that now have totally contradictory explanations from the contemporary view but are still remarkable in the now scientifically accepted observation frame. This remark also has no absolute validity; it refers only to the different nature of observations within the knowledge acquisition loop.

I suppose the role of other items in the scheme needs no further discussion, not even the thought experiment. A distinction should be made between the role of hypothesis and theory, the first as an daring forecast of some connections and interdependencies, a research program in the Lakatos sense [15]. The theory is a well-formed model proven, without contradictory observations, until its revision by additive statements or its being refuted by a new theory. The definition roles somehow lie between the strength of the Popperian thesis [19] and the liberal view of the Lakatos interpretation.

8. Grau, teurer Freund, ist alle Theorie und grün des Lebens goldner Baum?

Why should these definition distinctions iterated after so many accepted and debated works of science philosophy? I can refer only to Goethe on the dubious problems of philosophical definitions: *Grau, teurer Freund, ist alle Theorie und grün des Lebens goldner Baum* [6]. Adding to that enigma, this was given into the mouth of Mephistopheles.

In this context the difference in definition underlines the liberal evidence nature of hypotheses, being creative initiatives for further research, and the relative strength of theories, proven exclusively until the present day. In this view theories are not immortal but are highly respectable. This great respect refers to the Kirchoffian statement of our motto, to the proven practicality of theories, i.e. basic science and its generative, fertile, practical importance.

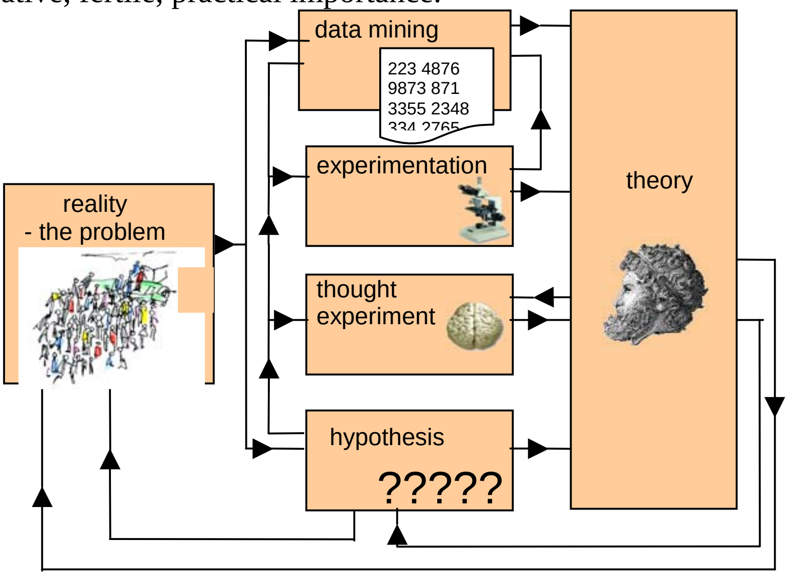

Figure 1. The epistemic scheme

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