CONTEMPLATIONS ON A KNOWN UNKNOWN: *Time*

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Abstract: This essay is a short review of the concept of time as seen from a logical point of view. It refers mainly on the work of the philosopher and logician Gotthard Günther whose oeuvre has hardly been recognized by the mainstream of the scientific community, although his *Theory of Polycontexturality* (TPC) has to be considered *the* formal basis of any modern cybernetics or systems theory in which subjectivity becomes a part of scientific investigation. Besides poly-contextural logic (PCL), which is a parallel interwoven calculus, TPC also encompasses Keno- and Morphogrammatics and the theory of qualitative, i.e., polycontextural numbers. In the present essay, however, the formal theory is not outlined. Instead we try to introduce the idea of polycontexturality in a more semantic way using the well-known concept of a Turing machine (T*M*) and its principal limitations in modeling mental processes. The concept of a polylogical machine (PL*M*) will be discussed, which is an ensemble of single T*M*'s where the function of the total ensemble of T*M*'s is no longer a T*M*. It turns out that within the concept of a PL*M* it is no longer possible to distinguish between soft- and hardware, since they have to be considered as a dialectical unit, as PL*M*.

> "Time has usually been considered by logicians to be what is called "extralogical" matter. I have never shared this opinion. But I have thought that logic had not reached that state of development at which the introduction of temporal modifications of its forms would not result in great confusion" (CP 4.523).
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> *Charles Sanders Peirce* (1839-1914)

In the antiquity and in the middle ages *computus* designated both number and calendar. Later this term denoted measurability and standardization (Borst, 1994). Today the term appears – although with a slightly different meaning – in our word *computer*. The question arises, what is the relationship between number and time, between counting and calendar if considered from a computer age point of view? It would be a big mistake to understand such a question only in the context of philosophy. Since the 21st century has been declared the century of brain research this question becomes a topic not only in natural sciences but also in computer sciences. It is not surprising to see that nowadays nearly all new and exciting ideas concerning the topic *time* emerge from the natural sciences and scarcely from philosophy. Who does not know the work of Prigogine (Prigogine, 1982) and his collaborators about the correlation of time and entropy? An interesting contribution was made recently by Schommers (Schommers, 1997) in his book »Zeit und Realität« where he discusses a system-specific spectrum of times – a so-called *t-spectrum* – for the description of biological systems. Barbour's book »The End of Time: The Next Revolution in Physics« (Barbour, 1999), on the other hand, represents a sharp contrast to Schommers' idea of a time structure, of a manifoldness of times in biological systems. Last but not least the book by

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Atmanspacher and Ruhnau (Atmanspacher and Ruhnau, 1997), together with Varela's (Varela, 1999) contribution, should be mentioned in the present context, both of which cover problems of time and causality that appear not only in physics but in neurophysiology, biology, and cognitive sciences. However, these contributions concerning our understanding of time and the causality of time and space should not be considered as the beginning of a possible scientific revolution gathering on the scientific horizon – a change of the scientific paradigm à la Thomas S. Kuhn where, for instance, subjectivity has been included within scientific descriptions. These contributions as important as they are, still remain on the path of the classical scientific paradigm in which any subjectivity has been strictly excluded from the very beginning. From a philosophical point of view it appears as if everything has already been said by Heidegger in »Sein und Zeit« (Heidegger, 1962) published first in 1927, so that it seems that nothing new can be said on this topic by the camp of academic philosophers or social scientists.[1] For the majority of scientists *time* as a scientific subject does not exist or is still seen to be a matter for philosophers. This was acceptable in the past when the classical natural sciences such as physics and chemistry were dominant, but today it is absolutely unacceptable for the entire branch of biological or life sciences as well as for modern research in Artificial Intelligence (AI). Indeed, such an attitude presents a scientific misunderstanding, if not a scientific lack of understanding as will be demonstrated in the following sections.

It is not surprising that the mainstream of AI research has not yet even discovered or reflected McCulloch's short paper »A heterarchy of values...« (McCulloch, 1945), a study that already points towards a transclassical concept of time. The situation becomes even worse when considering the work of the American-German philosopher and logician Gotthard Günther which has been successfully ignored by the scientific mainstream. His essay »Logik, Zeit, Emanation und Evolution« published in 1967and his study »Time, Timeless Logic and Self Referential Systems« from 1967represent the background of the present discussion (Günther, 1967a, 1967b; Günther and von Foerster 1967). Günther's philosophy and his efforts to extend our Western scientific thinking towards a theory of subjectivity have scarcely been noticed by the majority of the scientific community.

Hamlet: "The time is out of joint..."

Computers and the Brain: a TIMELESS subject with variations

The scientific conceptions of the subject of *time* nowadays are somewhat antithetical. The following passages about the nature of space and time will demonstrate the contradictory ideas behind them. Let's first quote from a typical text book on Artificial Intelligence (Nilsson, 1998):

> Time: Processes (including computation) occur in time, and computer scientists and AI researchers have developed various techniques for describing and reasoning about time. Special *temporal logics* [...] used in the analysis of computer programs have certain important aspects of time built into them. AI people have tended to

[1] It was Niklas Luhmann who even eliminated subjectivity from the social sciences and replaced it with the term "system", a piece of "scientific progress" which still is celebrated by the community of his imitators (see also Walter L. Bühl's critique (Bühl, 2000)).

> handle time in two other ways [...]. First, explicit mention of time can be ignored altogether by referring instead to *situations*, which are ‘snapshots’ of the world at unspecified times. Situations are linked by actions that transform one situation into another. [...] Second, time and time intervals can be included among the entities that are explicitly reasoned about. As an example of the formalization of a concept needed for commonsense reasoning. [...] C_1

Here from a logical point of view *time* is considered an existing entity, otherwise one could not talk about a temporal logic where "time has been built into" the calculus. In AI research, temporal processes are often described, as mentioned in the above quotation, with reference made to the temporal logic of Arthur Prior[2]. According to AI researchers, this logic describes the phenomenon *time* sufficiently. In this conception, however, *time* is only introduced semantically and consequently presupposed to be an existing entity or as an ordering parameter.

In his book, »Shadows of the Mind«, the mathematician and astro-physicist Roger Penrose writes (Penrose, 1990, 1994):

> In fact it is *only* the phenomenon of consciousness that requires us to think in terms of ‘flowing’ time at all. According to relativity, one has just a ‘static’ four-dimensional space-time, with no 'flowing' about it. The space-time is just *there* and time 'flows' no more than does space. It is only consciousness that seems to need time to flow, so we should not be surprised if the relationship between consciousness and time is strange in other ways too.
>
> Indeed, it would be unwise to make too strong an identification between the phenomenon of conscious awareness, with its seeming ‘flowing’ of time, and the physicists’ use of real-number parameters t to denote what would be referred to as 'time coordinate'. In the first place, relativity tells us that there is no uniqueness about the choice of the parameter t, if it is to apply to the space-time as a whole. Many different mutually incompatible alternatives are possible, with nothing particular to choose between one and any other. Second, it is clear that the precise concept of 'real number' is not completely relevant to our conscious perception of the passage of time.... C_2

Although this statement does not answer the question regarding the nature of *time*, one can however consider it to be in diametrical opposition to the philosophy of AI research.

Things become rather interesting if one examines the results of the modern brain research. In his book, »Das Gehirn« (Linke, 1999), the physician and neurophysiologist Detlef Linke summarizes this point lucidly when he writes:[3]

[2] Arthur Prior (1914-1969) undertook pioneering work in intensional logic at a time when modality and intensional concepts in general were under attack. He invented tense logic and was principal theoretician of the movement to apply modal syntax to the formalization of a wide variety of phenomena.

[3] The original text is in German and was translated by the authors.

> There are indeed functioning complexes [in the brain] which reveal their own characteristics of time where the corresponding processes cannot be extended or shortened arbitrarily [...] It seems inadequate to understand the brain like a clock for which particular quantities of time can be extracted, ...
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> [...]
>
> No pacemaker could be found for the basic rhythm of the brain's currents. Instead, a complex interplay between various control loops had to be supposed for its origin whereby very different EEG-frequencies could be realized. The brain-electrical correlatives to cognitive processes are extensively independent of the basic rhythm of the brain currents. Therefore time results as a complex phenomenon similar to the function of the brain itself. C_3

The experimental results in neurophysiology have at least two interesting aspects: on the one hand, when describing the neurological processes in the brain it is evident that one does not find a central clock, or a clock unit like in any known computer. On the other hand, it is evident that there are processes with different time characteristics, i.e. a spectrum of times or several times, or however this might be expressed.

As Schommers has shown in his book, »Zeit und Realität« (Schommers, 1994) by defining a time operator it is possible to introduce systems that are characterized by various differing times. This indeed is an interesting fact because here the demand for a system-specific time is made which is essential for all living systems, since life is a process and not a state. Whether this model solves the problem of 'Mehrzeitigkeit' in biology is another question. But Schommers as a theoretical physicist is substantially more critical than, for example, his colleagues in the AI research community when he writes[4]:

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[4] Note added in proof: The quotation has been taken from »Zeit und Realität« and was translated by the authors.

Although the meaning of $f(E, t, \boldsymbol{p}, \boldsymbol{r}) = 0$ should be evident, we will comment this relation shortly.

A physical system can be defined by the (possible) changes of energy E with other systems, i.e.,

$$\frac{dE}{dt} = \sum_i \xi_i \cdot \frac{dX_i}{dt}$$

This relation can be written as

$$dE = dE(X_1, X_2, ...) = \Sigma_i\, \xi_i \cdot dX_i \qquad \text{(F1)}$$

The left hand side of this equation reflects the changes of the total energy E of the system which equals the sum of different forms of energy such as mechanical ($\boldsymbol{v}\cdot d\boldsymbol{p}$), heat ($T\cdot dS$), or chemical energy ($\Sigma_j\, \mu_j \cdot dn_j$), etc. – forms of energy which the system under consideration is able to exchange with other systems and which therefore describe and define a physical system. What can be measured is, for example, the change (the difference) of the energy between state_1 (given by a constant value $E=E_1$=const) and state_2 (with $E=E_2$=const) or the differences of the corresponding physical variables X_i, ξ_i. A physical state with E=const simply means that $dE = 0$, i.e., the state can be defined by a state function $s(E, X_{i=1}, X_{i=2}, ...)$ which has a constant value in a corresponding state space, i.e., all state variables $E, X_1, X_2, ...$ are constant and independent of time t, or more general: every physical state is independent of time. This is expressed by $f(E, t, \boldsymbol{p}, \boldsymbol{r}) = 0$ in C_4.

The symbols used above have the following meaning: E: energy; t: time; $\boldsymbol{p}$: momentum; $\boldsymbol{r}$: space position; $\boldsymbol{v}$: velocity, T : temperature; S : entropy; μ : chemical potential; n : quantity

The variables E (energy) and $\boldsymbol{p}$ (momentum) [...] belong to the (fictitious) reality, the quantities t (time) and $\boldsymbol{r}$ (position) on the other side are the variables which model the image of the reality. In order to produce such an image, the reality and the describing image have to be linked together, i.e., the variables E, $\boldsymbol{p}$, t, and $\boldsymbol{r}$ are related to each other, which generally is expressed by $f(E,t,\boldsymbol{p},\boldsymbol{r}) = 0$. [cf. footnote 4] C_4

It is hardly astonishing to see that in the meantime AI researchers have also recognized the importance of the topic *time* in their own field. Research about *time-encoded information*, that is, the temporal sequence of the neural signals is now being undertaken (Maas, 1999):

How do action potentials represent sensory states? How is information contained in the firing patterns of action potentials stored and retrieved? These are old questions that have been the focus of much research, but recent advances in experimental techniques are opening new ways to test theories for how information is encoded and decoded by spiking neurons in neural systems. C_5

Unfortunately, this concept does not deliver much more than the conventional models of the neuro-computing – a concept of adaptive (non-linear) data-filters that is quite useful for solving certain technical tasks, but one that does not bring us any further in our search for models to describe mental processes. In other words, these neuro-computing approaches are completely insufficient when considered as models for neurophysiology. Even worse, they might create a misconception of the actual problem.

It is in principle unlikely that anything can be learned about mental processes from the sequence of individual neural signals, just as it is impossible to learn about the nature of a running program from the corresponding sequences of signals (0 or 1) in a computer. At the level of zeros and ones it is no longer possible to distinguish between a program and its data.[5] Zero and one only gain a meaning in the context of a program, but this should be first explored. In other words, AI research has a

(in mol); ξ : generalized symbol for intensive physical variables; X : generalized symbol for extensive physical variables. Eq._F1 is denoted sometimes as Gibbs function (see for example: Callen, 1960; Falk and Ruppel, 1976; Falk, 1990).

Example: For a mechanical system (e.g., a pendulum) eq._F1 can be written as,

$$dE = \boldsymbol{v} \cdot d\boldsymbol{p} + g \cdot h \cdot dm$$

where the first term on the right hand side gives the energy of movement and the second term the gravitational energy (integration yields the well known kinetic energy $E_{kin} = \frac{1}{2} m \cdot v^2$ and the so-called potential energy $E_{pot} = g \cdot h \cdot m$). The variables are: g the gravitational constant, h the distance between m (the mass) and for example, the surface of the earth. The physical state is given by $dE(\boldsymbol{p},m) = 0 = \boldsymbol{v} \cdot d\boldsymbol{p} + g \cdot h \cdot dm$ which describes the energy exchange between two reservoirs as it is required for any oscillating system. Such a system (here an oscillating pendulum) is independent of time t and if no further energy exchange occurs it is oscillating eternally.

5 Note added in proof: This is the essence of the message which can be extracted form the model of so-called non-trivial machine discussed by Heinz von Foerster – a machine that can be constructed on the basis of serial logic circuits like any classical computer.

blind spot in the most proverbial sense: AI research is unable to perceive perception and consequently is unable to think thought.

To put it into the context of the present paper, only when AI researchers have understood that *time* represents a conceptual construct of our mind and consequently *time* as a category of description can only be thought within the process of reasoning as a process in time, will they be in a position to define the goal of their own research: the design of intelligent artifacts.

Only then one will recognize that the question *what is time?* is completely misplaced. One will perhaps then recognize that the question should actually be:

> *How can processes of living and/or technical systems (algorithmically) be modeled so that these models are able to produce their own time, their own temporality ?*

> Die aristotelische Logik, soweit sie Theorie des Denkens (manifestiert in der menschlichen Sprache) ist, ist also eine Logik ohne ein Subjekt, das denkt oder spricht.
> *Gotthard Günther* (Günther, 1967a)

CONTEXT-FREE *languages* – TIMELESS *machines*

In order to define the extent of this discussion, some statements will be presented. Some of these statements are so obvious that they hardly need to be justified. Others, however, need some explanation.

1/ Every experimental measurement is based on the mental concept of a linear time axis, i.e., an ordered sequence of (time) points.

2/ All processes which can be modeled with an ordered sequence of time points — a linear time axis — are isomorphic with the (function) model of the Turing machine (T*M*).

3/ All hierarchically described process sequences are isomorphic with the (function) model of the T*M*.

4/ Physics primarily deals with the description of states. Physical states are timeless (this can be seen in the formula: $f(E,t,\boldsymbol{p},\boldsymbol{r}) = 0$ in Schommers' equation C_4 – more on this point see footnote 4 and (von Goldammer, Paul and Kennedy, 1996).

5/ Basically all descriptions of physical-chemical processes are transitions between different states and can be mapped on a linear time axis.

6/ All currently known models in computer science, in artificial intelligence, in neural sciences or neuro-computing can be represented in principle by the (function) model of the T*M*.

7/ Models in which several system-specific times are introduced, with each having an independent meaning, are always isomorphic with the (function) model of the T*M* if (and only if) the total of the processes can be described as hierarchically structured (cf., Mattern, 1989, 1999; Charron-Bost, Mattern and Tel 1996; Li, Zhou and Muntz 2000).

8/ A living system can be defined by the necessity to synchronize with procedures and processes in its environment. This is one of the prerequisites for life. The system should be able to recognize its environment, i.e. it must be a cognitive system, if cognition is understood as the ability of a system to distinguish between itself and its environment (by its own effort!).[6]

9/ Mental processes, like learning or the interpretation of the context dependency in natural languages, can never be mapped onto the classical model of a T*M*.

Points 1–5 are straightforward. Basically, the isomorphism between the model of a linear time sequence and a T*M* is founded on the sequentiality of the counting process, which is ultimately the basis of the linear, or more precisely, of the sequential time model as well as the model of the Turing Machine. The Peano numbers represent, as everybody should have learned at school, a sequential row, i.e. every number – except for the zero – has exactly one predecessor and one successor. Since Aristotle, at the least, numbers and the way we count have formed the basis for our understanding of *time*.[7]

Considering point 6, neuro-computer scientists have always emphasized that one does not work on the basis of the T*M* model but rather on the basis of much more complicated connectionist models. In fact, all current artificial neural network models run on normal computers, which are nothing but classical T*M*s, and no one has yet reported on models with non-sequential *times* – about models characterized by *Mehrzeitigkeit*.[8]

6 It should be mentioned that the term "system" has been used as a generalization in order to describe living system as well as technical systems, which do not exist yet. It also should be recalled that 'living systems' have been characterized by their cognitive abilities, a necessary condition but not the only one (cf. Maturana, Varela, etc.)

7 Note added in proof: All physical processes are transitions between physical states (cf. footnote 4). These transitions can be considered as an infinitesimal number of intermediate states each described by a time point of an ordered set of time points t_i, viz.,

$$\ldots < \ldots < t_i < t_{i+1} < t_{i+2} \ldots < \ldots$$

From a logical point of view the transitivity law strictly holds, which says that "IF (t_i is a time point earlier than t_{i+1}) AND (t_{i+1} is a time point earlier than t_{i+2}) THEN (t_i is a time point earlier than t_{i+2})", i.e.,

$$(t_i < t_{i+1}) \wedge (t_{i+1} < t_{i+2}) \rightarrow (t_i < t_{i+2}) \qquad \text{(F2)}$$

Processes where the transitivity law holds are hierarchically structured. This is, so to speak, the definition of a hierarchical process structure. In other words, all physical processes, and all processes that can be modeled in the sense of the Church-Turing thesis, or by use of differential equations, etc. are based on the validity of the transitivity law in the sense of relation (F2) and therefore they are hierarchically structured and *vice versa*.

8 Note added in proof: Here we use the German term "Mehrzeitigkeit" and not poly-temporality for the following reason: If we have a look to the similar term "polyphony", then we find that polyphony can be translated in German in two ways: "Vielstimmigkeit" or "Mehrstimmigkeit". Although many Germans do not know the different meaning, a difference exists. In German one can say that the singing of birds is "vielstimmig" (many-voiced) but not "mehrstimmig". However, a cantata of Johann Sebastian Bach is "mehrstimmig" and not "vielstimmig". The difference results form the fact that Bach's polyphonic music is based on rules, i.e., it is not chaotic. The birds' singing, however, is without such rules. An analog argumentation holds for the term "Mehrzeitigkeit", a term which will be explained below.

Statement 7 was included here because today, as mentioned above, models with several times are discussed in the literature. However, from a structural point of view, such models are nothing exceptional. They are already known in parallel processor structures or in distributed systems, e.g. in computer networks. Technically speaking, it is common to have only one clock unit in a computer, i.e. one central clock. In principle, computer structures would also be possible without such a common global central clock, as it is the case with computer networks in which every computer in the net has its own clock (see also: Mattern, 1989, 1999; Charron-Bost, Mattern and Tel, 1996; Li, Zhou and Muntz 2000).

A program (or process) that can be split into different parts which run in parallel on different computers or processors could also be presented sequentially on a T*M*. This point is important since it states that all currently known parallel algorithms could also be represented sequentially – i.e., in the model of the universal T*M*. This point will be discussed further later in this paper.

Statements 8 and 9 are not very obvious. They imply self-referential processes, which in principle cannot be presented sequentially and therefore cannot be mapped onto the model of the T*M*. It should not be necessary to repeatedly state why a cognitive process is self-referential and hence, from a logical point of view, is circular. This has been discussed on many occasions in the past and could be read in the literature (cf., Varela, 1979; Zeleny, 1981; Kaehr and von Goldammer, 1988, 1989; Priest, Routley and Norman, 1989; von Goldammer, Paul and Kennedy, 1996; Bühl, 2000; and many others), nevertheless we will focus on some aspects in the supplement of the present paper.[9]

Considering the background of the statement in point 9, the present article deals primarily with the following questions:

a) How can we imagine *time* as a category of description within the (mental) process of thinking as a process of time ?

and

b) How should mental processes be modeled algorithmically so that systems or models can be implemented which produce their own time, their own temporality?

In order to develop a category of description like *time,* it is clearly not sufficient – as mentioned in point 8 – merely to ask for cognitive capabilities. More is still needed, for example a memory. What should be discussed is the conceptual idea of memory, which is nowadays still influenced by the concept of the classical

Since the term "Mehrzeitigkeit" has nothing to do with chaos theory but with logic we would like to make a clear distinction. Chaos is a metaphysical term and not physical or a logical one.

9 Note added in proof: In the revised version we added a supplement because it turned out that the authors' ideas concerning the scientific-logical meaning and the consequences for any modeling <u>and</u> implementation of self-referential processes differ considerably from the referees' meaning on these items.
A somewhat longer discussion that deals with paradoxes, logical circles, diallels, etc. within the context of McCulloch's *heterarchy of values* and Günther's logic of place-values can be found in www.vordenker.de (von Goldammer, Paul and Newbury, 2003).

computer. A memory is normally conceived as a data storage or even as an information storage. Today, from a cybernetical point of view, both ideas are totally obsolete.

An information storage does not exist, since one could ask, what is actually being stored? The data on a CD, for instance, acquire a meaning only in the context of a special application program and on the basis of the formatting used (with reference to the program), i.e. as a sequence of video-pictures with sound, or whatever. Without the context, the data on the CD do not mean anything and therefore do not represent any information. For an Eskimo living in his igloo the CD would be of no use. Presumably, he would not even know what a CD is. So, data and signals only gain meaning in a given context. This is actually quite trivial but, nevertheless, we still talk nowadays about storing information.

Furthermore, it is already well known that our mind does not work like a simple data storage device, as with computer-RAM, hard disks, CDs, etc. In this context one should refer to the work done by Heinz von Foerster (von Foerster, 1967). In his article »Time and Memory« von Foerster calculates with quite elementary means that during a film-sequence (with about 25 pictures per second) the brain as a data storage device would overflow after only 15 minutes. He pointed out that the concept of data storage is inadequate to describe the function of the mind due to its limited storage capacity. It is necessary to mention that the concept of data storage as it is used today is from a structural as well as conceptual point of view based on the concept of the T*M*. This is an essential point because no mental processes – and recall (*Erinnern*) is such a mental process – can ever be represented by the model of a T*M*. This also holds for the mind (*Gedächtni*s), as will be shown in the following.

- *What does it mean, or what is it exactly, to talk about time? What are we measuring if we observe chronologically or temporally changing procedures or processes?*

When defining *time*, as it is called, we are dealing with a counting-process which then has to be brought in relation with another one, namely the observed process. In the following, P_1 refers to the counting process and P_2 refers to the process that is being observed. In general, P_1, i.e. the way we count, is realized by a clock. This might be a pendulum movement or oscillating atoms (atom-clocks) or any other kind of clock. P_2 could be a moving car, or put more abstractly, a moving body of the mass *m*. Mathematically speaking, P_1 already represents a relation. Since the difference between an initial and a final state has to be determined, the result is usually a length or an angle or simply a certain number of oscillations. In turn, this relation will now be placed in relation to a time concept. That is, the lengths, the angles, and the number of oscillations will be transformed into seconds or minutes or hours, etc. This process, in which one relation is knowingly put in relation to another relation, occurs only in the human brain and not in a clock. With regard to the example mentioned above of a moving body (process P_2), the result will be a description, in a physical sense, of the observed variation of P_2 using a term that will now be called time *t*.

So, one relation will be put in relation to another relation and so on in order to finally talk about a temporal variation of P_2, the process being observed. Here, the act of "putting-in-relation of relations in the brain" is naturally also a process and in fact a mental process, which – at least in physics – remains unnoticed. Moreover, this mental process cannot even be measured in the same way we measure the speed of a moving car. It is crucial however to note that the process to be described, P_2, is in the meantime an already observed process and therefore a process which already belongs to the past. In other words, the process of "putting-in-relation of relations in the brain" requires memory – TIME *AND* MEMORY!

What we are trying to describe here with "putting-in-relation of relations in the brain" is part of what is generally subsumed under the term consciousness. This represents the ability to recognize and interpret signs, terms, or whole sentences in different contexts whereby they become information. In other words, from a mathematical point of view, the context-dependency of signs, terms, or sentences could be considered a process to form "*relation of relations of ... relation of data*". Therefore, the function of the needed memory cannot be just to store data but obviously to store and process "relation of relations of … relation of data", i.e. to be able to remember.

- *What constitutes the actual problem?*

It is well known that the actual scientific understanding of the world is totally shaped by the classical natural sciences. This also applies for computer science! This understanding of science is characterized, however, by the idea that it is totally free from any subjectivity. The idea of a totally objective science is dominant – whatever might be understood by *objectivity* – and, consequently, not only *subjectivity*, but also all mental processes are eliminated from the very beginning.

It is quite interesting to raise the question as to how subjectivity and mental processes are being excluded during the process of concept formation in the natural sciences and what is actually being eliminated.

This question can be illuminated by the concept of *time*. Generally, we try to define scientific terms or concepts in a context-independent way in order to generate a context-free scientific language. This is done ideally through the use of mathematics. The concept of the physical time, which has often been modified throughout the history of physics, is the result of the development of a mathematical-metric conception[10] whereby the mentioned formation of "relations of relations … of relation of data" inside our brain has been eliminated. *Time* results as a *parameter* which receives its meaning in the respective physical context. In our daily spoken language, however, *time* paradoxically is very often referred to as having quantitative features. At a sporting event, for example, where time is very important, we hear that someone has "lost time" or "some time left", etc.

This is not only due to the fact that the Newtonian philosophy still substantially dominates our way of thinking, but also that our present understanding of science is

[10] A discussion on the metric and ultrametric space in mathematics and physics can be found in »Ultrametricity for Physicists« (Rammal, Toulouse and Virasora, 1988). It easily can be shown that the principle of (ultra)metricity corresponds to the transitivity relation in logic.

exclusively made on the basis of quantities and not qualities – a theory of qualities does not exist and cannot exist on the basis of the present mathematics and logic.[11] Physics is therefore not only a science of quantities, of something that is higher, longer, faster, etc., but also the science of dead objects. It is simply not a science of qualities and of life.[12] This is, for instance, expressed in the quote (C_4) by the relation $f(E,t,\boldsymbol{p},\boldsymbol{r}) = 0$.[13]

Both context-independence on one side and the restriction on formal scientific descriptions of quantities (of objects) on the other side presuppose each other. A theory of qualities never can be based on a context-free scientific language. Such a theory has to be able to model standpoint (viewpoint) dependencies – this however is not a matter of physics or chemistry. Consequently, the question about the objectivity of science has to be raised anew and in a totally different way. In other words, any theory of qualities or context-dependent theory has to *include* and not exclude *subjectivity*. This is rather trivial to understand and without the need for any further justification.

And in fact, all natural sciences as well as computer sciences deal exclusively with quantities and dead stuff and not with qualities and life. This is also true for the so-called bio-sciences, where the prefix "bio" should merely suggest that they are dealing with living systems. *Life* is not their primary subject of scientific investigation – *life* is presupposed as an already existing attribute!

In computer science, too, context-free languages are being exclusively used. Consequently, one is trying to search for a universal conception of a language, a *lingua franca*. This is an attempt to develop a concept of general language using the context-free conception – a *contradictio in adjecto*.

Why is it so and what are the difficulties?

> The disciplines of artificial intelligence and artificial life build computational systems inspired by various aspects of life. Despite the fact that living systems are composed only of non-living atoms there seems to be limits in the current levels of understanding within these disciplines in what is necessary to bridge the gap between non-living and living matter.
>
> *Rodney Brooks* (Brooks, 2001)

The INTELLIGENCE of *Turing machines*

The answer to this question is relatively simple. The solution, however, is more complex. Context-dependency cannot be consistently formulated using classical logic and mathematics. Other attempts to develop suitable concepts in intensional logic will not bring about any changes, as shown by the temporal logic example. In other words, today it is still impossible to represent the process of forming "relation of relations of … relations..." on a computer. One can even go as far as claiming

[11] A minimal requirement for any 'theory of qualities' (or a 'theory of life') is the inclusion of subjectivity and not its exclusion. This point will be discussed further within the supplement.

[12] It cannot be expected that *life as a process* can be described by means of a theory which only allows to measure and to model transitions between states, i.e., which only delivers tools for a description of states.

[13] It should be mentioned that there are some frontiers in physics where a context-free representation of the physical world was not completely successful. One famous example is the Einstein-Podolsky-Rosen phenomenon.

that the actual problem of formally describing such processes, which are necessary for the development of an algorithm that helps to model the context-dependency – or more generally, mental processes – on computers; these scientific-logical tasks have been at best marginally recognized by the mainstream of the scientific community.

It would be naive to believe that the problem "relation of relations..." (or context-dependency) could be tackled mathematically in the following way:

$$f(x) = \sin[\cos(x)] \tag{1}$$

where the cosine of *x* is calculated first and the resulting value is passed to the sine function to determine the final result. If it were so easy then the formal processing of "relation of relations…of relations..." would have been no problem at all.

It is also impossible to solve a relation in the sense of the predicate calculus of second or higher order either, such as:

$$\exists f[f(\cos(x))] \tag{2}$$

The model suggested by Prigogine and his colleagues doesn't lead us anywhere. It presents time as a function of entropy, i.e. time as an operator $\underline{\mathrm{T}}$ of a hyper-operator $\underline{\mathrm{M}}$ of entropy:

$$\underline{\mathrm{O}} = \underline{\mathrm{M}}(\underline{\mathrm{T}}) \tag{3}$$

There is not much to say about (1) and (2). Regarding (2), however, it is believed in the current AI research that it would be possible to represent mental processes using meta-linguistic elements. What is normally not considered – and this generally holds for all intensional logic variants such as modal or temporal logics, and also for fuzzy logic and whatever else – is, that at the end, all developed algorithms can be represented within the (function) model of a universal T*M*.

The time conception, symbolized by (3), introduces the so-called time-arrow into physics, i.e. the parameter *t* now acquires a direction based on the entropy law. From a structural point of view, one can state that here physics catches up with computer science, since an algorithm also runs only in one direction. From a logical point of view, one can easily see that relation (3) has the same structure as relation (2) (von Goldammer, 2003) and it can (at least in principle) be represented within a universal T*M*.

When considering the T*M* one has to keep in mind that every process that can be modeled in the sense of a T*M* belongs to the category of the so-called *positive-linguistic* scientific representations. This simply means that in the case of the T*M*, the algorithm will run until a (positive) result is reached and then will end. Or in other words, any differential equation describing a physical process represents the transition between two physical states – that's all. For a living system, however, this would mean death, as no more physical and/or mental processes would run. Here, one could argue that living systems could be modeled using several T*M*s that run in parallel so that some process-models would be still running. In this case, one should ask about the interplay and the interrelation of these parallel T*M*s. In the framework of a positive-linguistic logic[14] it can be shown that interactive, i.e. interrelated parallel T*M*s can always be represented by only one (universal) T*M*. In other words, different single processes, each running on one T*M*, can always be presented sequentially as an overall (hierarchically structured) process and therefore they can be represented on one T*M*. This then is to say that *the sum of the parts is equal to the whole*.

In this way, however, neither mental processes, nor context-dependency could be modeled. One can even say that the T*M* does not only represent the mechanical model of our present computers but rather symbolizes the context-free concept of computer science. The main problem today in AI research and/or cybernetics is to recognize this and to start making necessary changes.[15]

In order to model context-dependency, a T*M*, or better said, an algorithm should be able to organize itself, i.e. change itself (on its own). This cannot, however, work in the model of the T*M*. The minimum required is to have parallel T*M*s (algorithms) that cannot be reduced to one T*M* – so, the sum of the parts is something different than the whole. In other words, the sum of the T*M*s is, in a classical sense, no more a T*M*. When talking about single processes that are running on the respective T*M*s, one can state that *the sum of the single processes is qualitatively different compared to the overall process*.

How could this be technically realized?

> Die Lebendigkeit eines lebenden Systems bestimmt sich dadurch, dass es simultan komplexe Unterscheidungen trifft und sich zugleich zu diesen verhält. An jedem Ort der Unterscheidung ist zumindest eine doppelte Unterscheidung im Vollzug: die Unterscheidung zwischen sich selbst als Unterscheidendem zwischen sich und der Umwelt und sich selbst als Unterscheidendem zwischen anderen Unterscheidenden, die zwischen sich selbst und ihrer Umwelt und anderen Unterscheidenden unterscheiden und dabei sich selbst als Unterscheidende kreieren.
>
> *Rudolf Kaehr* (Kaehr, 1993b)

.... Relation [of Relations (of Relations ...) ...]

The problem could be clearly described using, for instance, the definition structure of verbs (von Foerster, 1985):

[to strike → {to knock, to beat, to pulsate} →
{(to strike, to beat, ...) (to hit, to thresh, to fight, to wrestle,
to punish, ... , to court) (to strike, to pulsate, to swing,
to stamp, to shake, to push, ...) } → etc.] (4)

[14] Note added in proof: In the revised version we have added a supplement where we are discussing in the context of heterarchical process structures the meaning of positive-lingusitic logic. See also »Heterarchy and Hierarchy« in www.vodenker.de (von Goldammer, Paul and Newbury, 2003).

[15] The picture provided here of the Turing Machine (T*M*) could, of course, be extended through sensors and actuators, as is being discussed, for instance, in the model of persistent T*M*s by Wegner (Wegner, 1998). Sensors and actuators are necessary in order to interact with the environment. Their implementation, however, does not pose any principal or scientific-logical problems so this aspect can be ignored in the further discussion.

This cannot be modeled using a meta-linguistical hierarchy for instance, in the form of:

$$R(x) = R^{(1)}[R^{(2)}[R^{(3)}[R^{(4)}[R^{(5)}[...[R^{(n)}(x)]]]]] ...] \qquad (5a)$$

As presented in example (4), it is not even possible to clearly specify the sequence of the individual relations, i.e.

$$R^{(1)}[R^{(2)}[R^{(5)}[R^{(3)}[R^{(4)}[R^{(1)}[...[R^{(n)}(x)]]]]]] ...], \qquad (5b)$$

or

$$... R^{(1)}[R^{(2)}[R^{(5)}\{R^{(5,1)}(R^{(5,2)}(R^{(5,3)}(\underline{x}^{(1,5)})))\}[R^{(3)}[R^{(2)}[...[R^{(n)}(\underline{x}^{(1)})]]]]] ...]... \qquad (5c)$$

would present a description of the definition structure from example (4).

In other words, relation (4) cannot be represented as a tree structure in the sense of Plato's pyramid of concepts – it represents a *network structure* which is very often related to heterarchical structures which have to be assigned to the mental processes that occur in our brains and which cannot be experienced or measured by physical methods (cf., our supplement: THE UNDISCOVERED HINT).

Certainly, what has been said about the definition structure of verbs does not solely apply for verbs. The context-dependency of statements can be seen in every good joke. For instance the joke of the blueberries, which are red, because they are still green, etc.

Although the concept of heterarchy was introduced in 1945 (McCulloch, 1945), most scientists today have not yet discovered the intellectual challenge of »A heterarchy of values...«. And as far as Günther's contributions for the design of an operational dialectics and his *Theory of Polycontexturality* are concerned, this work has totally ignored by the mainstream of the scientific community, even within the cybernetical circles. Günther's theories, however, simply form *the* theoretical basis for any formal treatment of the mutual interplay between heterarchically and hierarchically structured processes (for more details see: von Goldammer, Paul and Newbury, 2003). Such an interplay of processes is the most characteristic of all living systems, organisms, and organizations of living systems (cf. »Cognition and Volition«, (Günther, 1979a)).

The problem of achieving a context-change, i.e. the formation of "relations of relations…", is a heterarchically structured process in which a machine has to be able to simultaneously execute logical active processes (logical operations) in parallel and to analyze every single step of these processes and finally correlate the results of the analysis with the steps of the processes in order to correct them, if necessary, i.e. to change them.

We will call such a machine a ***P****oly-***L****ogical-***M****achine (PLM).*

It should be clear, at this point, that any heterarchically structured processuality can never be modeled on the basis of a classical Turing Machine (T*M*). A Poly-Logical-Machine, a PL*M*, is a machine that models the interplay of heterarchically and hierarchically structured processes, as they are characteristics of all living systems. A classical T*M* is, in principle, unable to change its own algorithm through its own effort, i.e., the changes should not be pre-programmed by the designer of the program.

What is required, therefore, in order to realize a self-organizing machine is an ensemble of simultaneously parallel interacting T*M*s (or algorithms) which – and this is important – are no longer reducible to a sequential string of instructions as is necessary for modeling algorithms on the universal T*M*.

The construction of a PL*M* is the problem which has to be solved in order to algorithmically model processes of living and/or technical systems in a way that these models are able to produce their own temporality.

To repeat it again, this problem is equivalent to the much quoted statement, which says that in living systems or in organisms the whole is 'greater' than the sum of its parts.

> Although we usually think of time as a *dynamic* phenomenon, a little reflection reveals, perhaps surprisingly, that, after all, we do write and communicate our ideas of time in terms of *static* sentences, like those in a paper or book.
> *Lars Löfgren* (Löfgren, 2000)

Emergence of ... kronos *and* kairos ***... kenos***

The PL*M* model introduced above consists of a set of parallel interacting T*M*s that should be able to exchange data among each other. This means that the T*M*s should somehow be physically connected with one another. Obviously, these connections turn the set of single T*M*s into a construct, the so-called PL*M*, which should, as a whole, no longer be a T*M* in the classical sense – this was the requirement.

This means, however, that the totality of the T*M*s – i.e. the PL*M* – cannot be presented mechanically anymore, since otherwise it would be a T*M*. In other words, the individual T*M*s could be presented mechanically but the entirety could not.

On the other hand, the respective connections between the single T*M*s are undoubtedly of physical nature and so the whole is a (parallel) computer that consists of some matter, i.e. hardware, and therefore represents a *bona fide* object which always can be represented by means of classical logic, i.e. within a positive-linguistic language framework. Thus it also can be constructed mechanically.

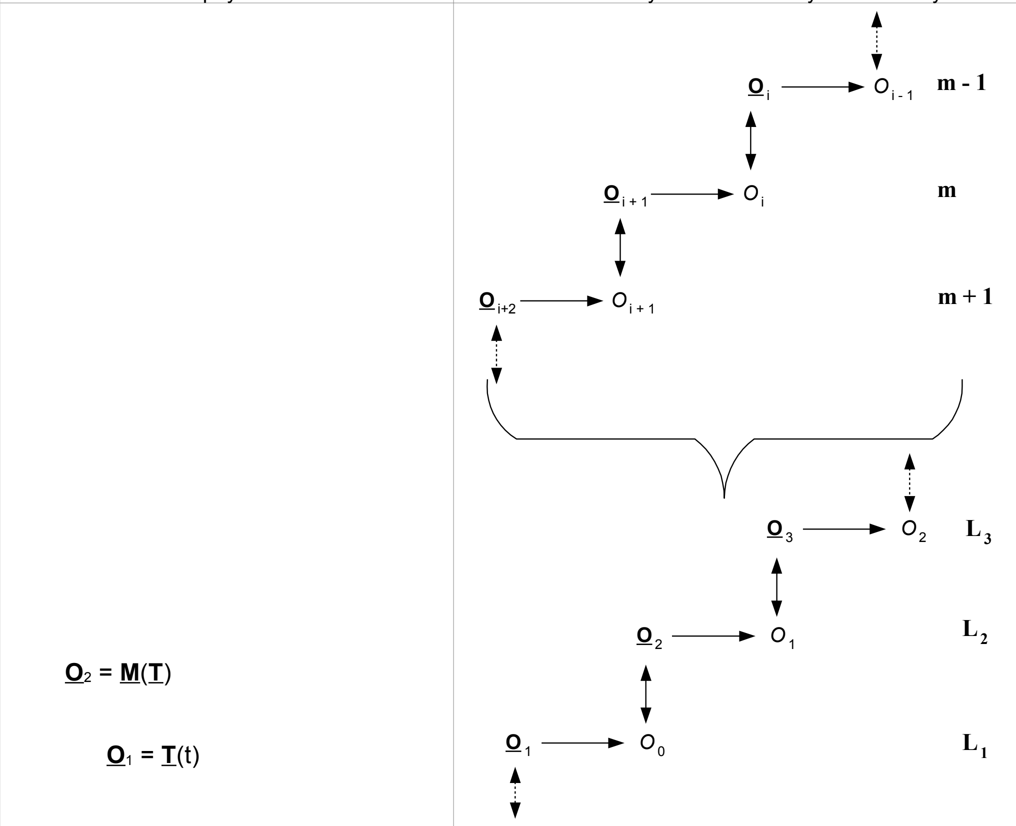
The dilemma here is that we are used to thinking of hardware and software as two separate entities and this is exactly what is no longer possible with a PL*M*.

- *Software and hardware represent a dialectic entity — the* PL*M.*

Dialectics cannot be considered a state but only as a process. A dialectic process is not an action, it exists only in our thoughts, and thinking itself is a process and not a state in the sense of physics, a fact that cannot be pointed out often enough: *Thinking and dialectics only occur in time.*

Following the facts stated above, it should not be difficult to understand figure_1_b, which was originally developed by Günther (Günther, 1979a, 1979b). This figure will be interpreted using the model of a parallel T*M*.

mono-contextural representation	poly-contextural representation
the positive-linguistic world of physics	the negative- and positive-linguistic world of modern cybernetics and systems theory



(a) (b)

Figure_1:
(a) time operator: $\underline{\mathbf{T}}$ and entropy-hyper operator $\underline{\mathbf{M}}$ due to *Prigogine et al.* [Ref.2]
(b) "relation of relation of ..." in a polycontextural representation
$\underline{\mathbf{O}}$ (operator or relator), *O* (operand or relatum),
$\longleftrightarrow$: exchange relation, $\longrightarrow$: order relation

Figure_1_b shows a three-place (m = 3) relational structure represented as three (logical) levels. Each level has to be considered a logical domain – a logical contexture (or a compound of contextures). A contexture is a logical domain in which all the classical logic rules are strictly valid. In the language of the polycontexturality theory, classical logic as well as all its intensional variants, for instance modal-logic and time-logic etc., represent mono-contextural logical conceptions. There is always only one contexture, one logical domain. In polycontextural logic, new operators have been introduced, for instance transjunction, which controls the transition between different contextures, or global negation operators, which negate whole contextures. In addition to global negation there exists inside a contexture common negation, i.e., intra-contextural, (local) negation. The crucial point is that single contextures are related to each other through operators and do not stand unmediated side by side or one over the other.

In figure_1_b, the symbols **O** and O are being used for operator and operand respectively.[16] The individual contextures are symbolized by L_1, L_2, L_3 etc. For more details, please refer to the literature (Kaehr, 1978) and for a somewhat broader introduction (von Goldammer, Paul and Newbury, 2003).

Every mono-contexturally describable process (algorithm) is being represented using the T*M* model. One can simply say that a contexture corresponds to the model of a T*M* and the set of all connected contextures, through which the whole process is being described, represents the PL*M*.

As can be seen here, one is dealing with a parallel interwoven calculus. What is still missing, however, is the indexing of single contextures, as well as the indexing of groups of contextures, which are – depending on the respective application – "related" to each other. The sequence of Peano numbers would not be especially useful in this case since they would again lead, due to their sequential order, to a hierarchization of all contextures in the sense of Russell's theory of types.

Besides the place-values *m* (cf. figure_1), which as symbols still stand for something (an existent value), there is the so-called *Kenogrammatik* as a grammar of the *Leerschriftstellen(sprache)*, the *Morphogrammatik* as a grammar of the patterns resulting from the *Leerschriftstellensprache*[17], the theory of qualitative numbers, the theory of negative languages, and the cycles of negations which together form the *Theory of Polycontexturality* and which are necessary for the management of contextures (Kaehr, 1979, 1981).

In figure_2, the 15 morphograms are represented which can be derived from the 16 logical functions of the bivalent logic by value abstraction.[18]

---

[16] Note: An operator (relator) always belongs to a logically higher type than its corresponding operand (relatum), which explains the notion of the indices.

[17] *kenos*: empty, void; *Grammatik*: grammar; *leer*: empty, void;
Schrift: system of writing; *Sprache*: language; *morphe*: form, shape, structure
Both terms *Leerschriftstellen* (script of the places of the void) and *Leerschriftstellensprache* (script of a language of places of the void) can hardly be translated as a single term. The German language has the advantage (or disadvantage – depending on the standpoint) to allow constructions of substantives that describe different contexts. In English this possibility does not exist which might be one of the reasons why there was no such development as the speculative idealism in the English speaking culture.

Gotthard Günther in »Time, Timeless Logic and Self-Referential Systems« (Günther, 1967b): "We, therefore, introduce a new type of symbol which we shall call a "kenogram". Its name is derived from the term "kenoma" in Gnostic philosophy, which means ultimate metaphysical emptiness. An individual kenogram is the symbol for a vacant place or ontological locus that, in conjunction with other kenograms, may form a pattern without regard to possible value-occupancy. An individual kenogram may or may not be occupied by one value at a time. To provide for the accommodation of many different values at the same time, we may introduce as many differently shaped kenograms as we choose. As symbols for values, we use positive integers. We further stipulate that a context of individual kenograms shall be written as a vertical or horizontal sequence. This affords us two possibilities. We may either repeat a kenogram of the same shape until the predetermined length of the sequence is filled; or we might choose differently shaped kenograms to fill our vertical columns. A kenogram may remain empty within the context of a calculus, or it may be occupied by a value."

[18] It should be mentioned that these patterns are not restricted to four symbols (kenos).

The structures on the left side of figure_2 are presented using only two (!) symbols and result directly from two-valued logic. On the right side, the structures are completed by the introduction of two more symbols. Since it is not the single blank symbol which is of significance but rather the structure of the whole morphogram (in the present case with four kenos, resp.), structure-equivalent morphograms can emerge that are shown in the lower half of figure_2. In other words, structurally different morphograms are presented in the upper half of figure_2 while the structurally equivalent MGs are shown in the lower half (Günther, 1979c).

	1	2	3	5	6	8	9	10	13	14	15
	✱	✱	✱	✱	✱	✱	✱	✱	✱	✱	✱
	✱	✱	□	✱	□	□	△	✱	△	△	□
	✱	□	✱	✱	✱	□	✱	△	△	○	△
✱	□	□	□	✱	✱	✱	□	□	□	□	✱
✱	□	□	□	✱	✱	✱	□	□	□	□	✱
	✱	□	✱	✱	✱	□	✱	△	△	○	△
	✱	✱	□	✱	□	□	△	✱	△	△	□
	✱	✱	✱	✱	✱	✱	✱	✱	✱	✱	✱
	4	2	3	5	7	8	12	11	13	14	15

Figure_2: The 15 morphograms resulting from the binary logic

It is impossible here to go into all the details, however some remarks should be made. The keno-structures form a three-dimensional grid, that is, a structure in which the bivalent logic systems, i.e., the contextures, can be inscribed without any coincidence[19]. According to the differentiation between iteration and position in a sequence, three fundamental keno-grammatical distinctions emerge, which are denoted as proto-, deutero- and trito-structures (cf., Günther, 1967a, Kaehr, 1979, 1993a). The size of the morphograms is herewith not restricted to four kenos (symbols of the void).

On the basis of these keno-structures a keno-arithmetic (Kaehr and Mahler, 1994) and a theory of qualitative numbers (Kronthaler, 1981) have been developed. These are areolar numbers where the structure rather than their value is of importance. In general, these numbers do not have only one successor but normally more than one. In the trito-structure the position of the keno-symbol within a morphogram is of importance. In the deutero-structure the number of the different kenos and the number of the same kenos inside a morphogram is of importance. In the proto-structure only the number of the different kenos within a morphogram is considered. In other words, with the help of deutero-structures and with morphograms of equal length, contextures of the same type can be grouped together as a compound contexture, and the same is true for the relation between deutero- and proto-structures.

What is essential is that individual contextures can be indexed with the help of qualitative numbers. These are, as described above, numbers where the respective structure, i.e. the *pattern*, is of importance and not its value, as with Peano numbers. In that sense, the contextures themselves now become an arithmetical

[19] Gotthard Günther: "…the projected system of many-valuedness will form what we shall call an ontological grid which determines the relations of the various contextures to each other" (Günther, 1979d)

object and, consequently, "relations of relations of…" can be tackled arithmetically. Moreover they also can be stored or remembered, i.e. *rechnend speichern und speichernd rechnen*.

Transitions between different contextures (cf. figure_1) – the inter-contextural transitions – are caused by global negations. They do not represent affirmations, thus what one is speaking of here is a negative-linguistic representation of a process. These inter-contextural transitions make sense for only the description of non-physical processes – they are not appropriate for the description of *bona fide* objects. States and transitions between (physical) states can only be described within a contexture (intra-contextural), i.e. within the framework of positive-linguistic logical representation. In other words, the *bona fide* objects in physics are being described intra-contexturally while mental processes are being described inter-contexturally. Intra-contexturally, i.e., within a contexture, the principle of identity holds rigorously in the classical sense. However, inter-contexturally, i.e., between different contextures, the principle of identity acquires a quite different (non-classical) meaning.

In an inter-contextural sense, one could talk about *distributed identity*, a concept that from a classical logical point of view does not exist and would be absurd. Intra-contextural descriptions of process structures are always hierarchical, while inter-contextural transitions provide heterarchical process-structures.

In other words, only the *Theory of Polycontexturality* (Polycontextural-Logic, Kenogrammatik, and Morphogrammatik) forms the scientific logical basis for the formal description of the interrelation between heterarchically and hierarchically structured processality as is needed for the processing of context-dependency or for a theory of qualities in general.

Certainly, the *polycontextural conception of time* contains intra-contexturally any possible physical conception of time. The inter-contextural transitions and the resulting heterarchical (non-transitive) structures of processality are the ones that lead to a conception of time which is generally known in philosophy as subjective time or temporality, a term that must be quite vague for an engineer. In Günther's conception, time gets an extended and, above all, precise conceptual meaning since the process of exchanging operator and operand, i.e. the inter-contextural transition, leads directly to an extended conception of time:

> In a polycontextural description, time can be interpreted as a change of designation from the pseudo-objectivity of mental processes toward the domain of bona fide objects (cit. Günther): "Time, from a structural-theoretical point of view, is nothing else but the activation of a discontextural relation between the past and the future". (Günther, 1980).[20]

Finally, one point still needs to be clarified, namely what Prigogine's conception of time, as symbolically shown in figure_1a, does or does not have in common with the polycontextural conception of time. In figure_1 one can notice a certain similarity between the two conceptions. A relation of relation emerges in the Prigogine's conception, as can be seen in figure_1a, in other words, the relation of

[20] "Discontexturality" stands for the inter-contextural transition between two contextures.

one operator to another operator and operand. This similarity is however only superficial since the inter-contextural transitions which are absolutely necessary for a heterarchical process modeling are missing. The relations, or more precisely, the operations in Prigogine's model are defined exclusively in a mono-contextural manner and correspond, from a structural point of view, to the situation shown in eq. (2), however as regarding their content with a totally different interpretation.[21] The same is also true for operators as they are known from quantum mechanics or from statistical physics. The result of Prigogine's concept is the physical parameter time *t,* which has now gained a direction.

Due to practical reasons, several points could not be discussed in the present contribution. It can be shown that within the polycontextural conception of time even non-causal processes, for instance the neuro-physiological processes studied by Benjamin Libet (Libet, 1989, 1992), find a rational explanation like the *Mehrzeitigkeit* and *Polyrhythmie* of biological processes in general.

Tolle numerum omnibus rebus et omnia pereunt.
Isidorus von Sevilla (um 600)

Supplement: *The Undiscovered Hint*

In his paper »A Heterarchy of Values Determined by the Topology of Nervous Nets« W.S. McCulloch wrote (cf. McCulloch, 1945):[22]

"Because of the dromic character of purposive activities, the closed circuits sustaining them and their interaction can be treated topologically. It is found that to the value anomaly, when *A* is preferred to *B*, *B* to *C*, but *C* to *A*, there corresponds a diadrome, or circularity in the net which is not the path of any drome and which cannot be mapped without a diallel on a surface sufficient to map the dromes. Thus the apparent inconsistency of preference is shown to indicate consistency of an order too high to permit construction of a scale of values, but submitting to finite topological analysis based on the finite number of nervous cells and their possible connections. ...

... It requires one diallel in the plane. Its three heterodromic, branches link the dromes so as to form a circle in the net which is distinguished from an endrome in that it is not the circuit of any drome but transverse to all dromes, i.e., diadromic. The simplest surface on which this net maps topologically (without a diallel) is a tore. Circularities in preference instead of indicating inconsistencies, actually demonstrate consistency of a higher order than had been dreamed of in our philosophy. An organism possessed of this nervous system – six neurons – is sufficiently endowed to be unpredictable from any theory founded on a scale of values. It has a heterarchy of values, and is thus internectively too rich to submit to a *summum bonum.*"

McCulloch has already hinted to a non-classical concept of logic in connection with a trans-classsical concept of time. First is his idea about the diallel, and second the fact that the law of transitivity can no longer be applied to the description of

[21] The relation between an operator and operand $\underline{\mathbf{O}}_1$(O) or between an Operator and Operator/Operand $\underline{\mathbf{O}}_2$($\underline{\mathbf{O}}_1$(O)), is managed in physics by a projection between non-mediated meta-levels from level into a lower one.

[22] Emphasis by the authors

heterarchical structures. This has to be interpreted in terms of logic and not with the help of images of circles, loops, or paradoxes. From the idea of diallels one can immediately infer that heterarchical structures can never be observed in the world of physics, i.e., heterarchy obviously can only be assigned to processes and not to the states of *bona fide* objects. One can further deduce by logical thinking that the nature of heterarchical processes cannot be attributed to the transitions between initial and final states as they occur in physical-chemical sciences. Physical-chemical processes – in the sense of state transitions – can be described (since the time of Newton and Leibniz) by differential equations.[23]

If we take a short look at hierarchical structures, we realize that even those structures only make sense in the context of processes. For example, if we use a tree for the presentation of a hierarchical structure, then the tree is a symbol for the process which it represents.[24] Every transition from an initial state *A* (symbolized by a node in the tree) to a final state (node) *B* can be described by an ordered set of (time)points: t_1, t_2, t_3, ..., t_n for which the law of transitivity strictly holds and therefore can be applied, viz.,

$$R(t_1, t_2) \ \& \ R(t_2, t_3) \rightarrow R(t_1, t_3) \qquad (6)$$

where the predicate R(..., ...) has the meaning of "...earlier (or smaller) than..."; $\rightarrow$ stands for the implication (IF ... THEN) and & stands for the conjunction. (...AND...). Relation (6) then reads:

> "IF t_1 is a time(point) earlier than t_2 AND t_2 is a time(point) earlier than t_3, THEN it follows that t_1 is a time(point) earlier than t_3".

If we use graphs to symbolize heterarchical structures as is done in the majority of publications in this field, we can move from one node *A* to another node *B* and so the transitivity law can be applied in order to describe the time dependency of such a process, namely the transition from state *A* to *B*. This even holds if we move along a closed circle.[25] In other words, graphs or circles are inadequate symbols for the representation of heterarchical process structures. If taken as symbols for processes, graphs always represent exclusively hierarchical process structures. Therefore McCulloch points very strongly to the idea of diallels and he gives us the hint that for heterarchical structures the law of transitivity cannot longer be applied.

The arguments given above are not a surprise since the law of transitivity always yields a sequence of time points, i.e., a hierarchical process structure. Therefore any foundation of a theory for modeling the interplay between heterarchical and

[23] The concept of differential equations does not – and cannot – include the concept of diallels and if the transitivity law cannot be applied the whole idea of time dependent differential equations is meaningless.

[24] We are comparing this symbol with processes which we have experienced in the past because we are surrounded by hierarchically structured processes which can be detected and described very easily. All physical processes (transitions between two or more states) are hierarchically structured.

[25] This is no surprise because Euler (Leonhard Euler, 1707-1783) introduced the concept of graphs into mathematics in order to solve the so-called "Königsberger Brückenproblem" which he was asked to do by his friend Immanuel Kant (1724-1804).

hierarchical process structures is primarily a serious scientific-logical problem and cannot be solved by celebrating paradoxes and/or circularities of all different kinds.

The belief in a *summum bonum* and thinking in terms of hierarchies obviously dominates Western culture so strongly that even within the second order cybernetic movement, where the *circulus creativus* has been celebrated for decades, McCulloch's hint still remains an undiscovered, an unreflected puzzle. In »Cognition and Volition« and »Das Janusgesicht der Dialektik« (Günther, 1979a,b), which were published in the early seventies, Günther analyzed on the basis of his place value logic the interplay between heterarchical and hierarchical structures. Here we will point to one aspect that Günther discusses in »Cognition and Volition«: It is the use of circles as symbol for heterarchical process structures.[26] The following figure, which we have taken from »Cognition and Volition«, depicts two circles with three values. While the number of values is not limited to three (it could be four, or five, or whatsoever) it would be pure nonsense to use circles or knots or networks without any values. This follows already from the title of McCulloch's paper »A heterarchy of values…«. The question arises about the meaning of these values, or numbers. It is not surprising that Günther describes in »Number and Logos« his nightlong discussions with McCulloch concerning the nature of numbers.

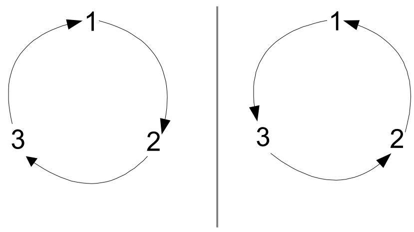


Figure 3:
figs. 15 and 16 of Günther's *Cognition and Volition*

The arrows always point to the preferred number.

In Günther's interpretation the three values stand for logical places (e.g., standpoints, situations, etc.) which are represented by at least one logical domain (contexture). If a heterarchy of values is required then at least two circles are necessary where the transitions between the different values have to be imagined clockwise and counterclockwise according to the arrows in figure 3. What is more important, however, is that the clockwise and anticlockwise movement has to be imagined simultaneously in parallel and not sequentially. Both processes which represent the heterarchical structured processuality cannot be separated. The reason for this demand is quite simple: If we state that the standpoint 2 is preferred to standpoint 1 (symbolized by $1 \rightarrow 2$) and so forth, then we introduce a preference – *a hierarchy of values*. As long as we use our natural language and/or any other positive-linguistic framework of a formal theory (like mathematics or the truth-definite logical systems) there is no other way to express a relation between different standpoints, i.e., one has to enumerate the different standpoints and one has to express in words or as a formula a relation between the different standpoints. A heterarchy of values requires an equivalence of all values (standpoints).[27] This

[26] Günther uses the symbol of a circle only in two or three of his studies. In »Cognition and Volition« it is only a very short comment while his study »Das Janusgesicht der Dialektik« is dedicated to Hegel's 'circle of circles'.

[27] An equivalence of standpoints can be interpreted in different ways:

can only be achieved as long as a parallel simultaneous (clockwise and anticlockwise) movement occurs within our model of circles. This is, so to speak, the situation of a system that has to make a decision and therefore has to weigh all possible standpoints before any decision can be made. At the end of such a process when it comes to a decision a designation of one of the standpoints or a rejection of the whole situation will be the result, this will be the end of the heterarchical processuality. The heterarchical processuality itself is a non-designating process. A heterarchical process never occurs as an isolated process. It is always an interplay of heterarchical and hierarchical processes, a processuality of processes. In other words, figure 2 or in general all circles, knots or similar symbols are inadequate for the description of an interplay of heterarchical and hierarchical process structures. This can easily be seen if one tries to figure out the way in which the two parallel simultaneous processes are interconnected, or if one tries to imagine two parallel simultaneous (clockwise and anticlockwise) movements. This corresponds to the problem which has been nicely described by Gregory Bateson (Bateson, 1972) in the metalogue *How much do you know ?* (in*:* »Steps to an Ecology of Mind«) where he puts the problem in the daughter's mouth: "I wanted to find out if I could think two thoughts at the same time. So I thought ‘It's summer’ and I thought ‘It's winter’. And then I tried to think the two thoughts together. ... But I found I wasn't having two thoughts. I was only having one thought about having two thoughts." Although we are not able to think two thoughts simultaneously this does not mean that parallel simultaneous processes do not occur within our brains.

> " …I vividly remember a conversation with Dr. Paul Lorenzen of Bonn in 1949 in which he expressed the view that Europe had had more geometry than was good for it. Of course geometry was an essential basis for modern science, but it did have the bad effect for inducing too ready a belief in abstract timeless axiomatic propositions of all sorts supposedly self-evident, and too willing an acceptance of rigid and theological formulations…"
>
> *Joseph Needham*

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a) All standpoints are equivalent in the sense that they can be submitted to a *summum bonum*, i.e., to one single standpoint. This corresponds to a *hierarchy of values* and we are back in the world of natural sciences, we are back in the world of truth and false of good and evil.

b) Some standpoints are considered to be equivalent in comparison to others. This situation demonstrates the shortcoming of the use of natural numbers for an indexing of different standpoints. If standpoints are different but are considered as equivalent in comparison to others simply means that a system judges a situation by its individual standpoints. Here we are entering into a scientific world which is characterized by a *heterarchy of values*, a world of individuals, a science of subjectivity and individuality.

Note: All self-referential processes can be considered as standpoint depending processes. For example, cognition as a process means that a (living or technical) system has be able to make a distinction between itself and its environment (by its own efforts). Here we have a system and its image and the environment and its image. These are already four different logical places (standpoints) from which six different relations can be discussed.

The belief that self-reference can be modelled by the Calculus of Indications is a kind of superstition. The Calculus of Indications represents the form of the classical two-valued logic, i.e., the world of truth and false of good and evil, and therefore it is a hetero-referential calculus which has been declared as *the* calculus of self-reference. This corresponds to the famous wooden iron or as it is usually called to a *conctradictio in adjecto*.

CONCLUSIO**n* ***ratio

If we cannot think two thoughts at the same time then we cannot express simultaneous parallelism of processes in spoken or written terms regardless whether we use our natural language or a formal mathematical language or any other symbols. At this point it should not be a surprise that Günther's negative language has to be considered as complement to our well known positive-linguistic formal tools of thinking in the same way as heterarchy only makes sense if considered as complementary category of description of hierarchy and *vice versa*. It is the interplay between heterarchical and hierarchical processes which Günther calls the *Janus' face of dialectics* which characterizes life as a process, life as a processuality.

It was Ludwig Wittgenstein who in his »Tractatus Logico-Philosophicus« wrote: "Whereof one cannot speak, thereof one must be silent". More than eighty years thereafter and with the intellectual heritage of Gotthard Günther, Wittgenstein's argument should become: *whereof one cannot speak, that possibly can be calculated*.

New opinions are always suspected, and usually opposed, without any other reason but because they are not already common.
John Locke (1632-1704)

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Note: The references marked by (*) are available on w^3 at:
http://www.vordenker.de or http://www.thinkartlab.com and/or RK-Archive

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