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Time, Temporality, Now, edited by Harald Atmanspacher and Eva Ruhnau. Berlin: Springer, 1997. 396 pp. ISBN 3-540-62486-4.

This book is a collection of 23 short essays on "time." I shall first briefly describe each, going through the book chronologically, that is, from front to back. Then I will add a few of my reactions and accompanying comments to some of the essays. Finally, I will take the liberty to express a few of my own thoughts, accumulated over time, about time.

Overall, the emphasis of *Time, Temporality, Now* is that of physicists, physics, and in particular, quantum mechanics. The volume emanates from an international workshop of the Max Planck Society in south Germany from February 26 to March 1, 1996 and contains referee-elaborated manuscripts from that encounter. Seventy percent of the 28 contributors are from physics or strongly physics-related departments or institutes. The remaining minority come from the disciplines of psychology, philosophy, and neuroscience.

Nonetheless the scope is wide and starts off with Part I, Natural Philosophy of Time. Frederick Kronz reminds us of the views of time by Aristotle, Newton, Leibniz, Hume, Kant, and Mach. The current role of empiricism is emphasized. Joachim Klose discusses Whitehead's perception of time. This is seen as epochal, rather than point-like, and as more general than strict empiricism. These two articles should convince the reader to be very humble about his/her own conclusions about the meaning of time, in view of the incredible amount of thought already directed at that question by many of the world's great scientists and philosophers over the whole course of human intellectual history. The third and fourth articles deal with paradoxes related to time in quantum physics. Shimon Malin advances Whitehead's Process Philosophy as a paradigm which can obviate those paradoxes. Eva Ruhnau distinguishes Time (a mathematical construct), Now (a subjective consciousness), and Temporality (between and connecting Time and Now). She concludes that "The continuity of experience is a construct," connected to "value" systems in our brain. Andreas Kull deals with possible connections between time and the self-reference models of Spencer-Brown's book *Laws of Form.* Holger Lyre outlines an abstract theory of information in which time is intimately interwoven with information, as in the physical–philosophical ideas of von Weizsäcker. The position is taken that temporality is a precondition of empirical knowledge just as much as distinguishability is a precondition of knowledge in general. This first, philosophically oriented Part I of the book closes with a very interesting exposition by Carl Friedrich von Weizsäcker of his theories and models in which quantum mechanics gives a better understanding of a continuum time structure than that which could be seen from classical physics.

Part II, Cognition and Time, begins with an account by Ernst Pöppel of the

recent physical experiments (near 40 Hz) which seem to indicate that near that frequency the human brain through neuronal oscillations performs a temporal segmentation process which enables a number of our higher cognitive functions. Next, Elzbieta Szelag discusses the relationship of mentally perceived time to the level of behavioral activity. There is an interesting conclusion of no fundamental difference of temporal integration properties in the left and right brain hemispheres. In a four-author paper, Engel, Roelfsema, König, and Singer address the question of how the brain assembles different attributes (*e.g.,* color and movement) which are processed in different parts of the brain, into a composite action (*e.g.,* how to recognize, catch and eat a prey). I might comment that such studies are also taking place now in the artificial neural network community, it having been found that just using networks of neurons and connections without more biological inspiration built into the model limits the ability to simulate brain-like activities too much. In some sense the next essay by Manfred Euler is related, in that it addresses how conscious perception binds discrete events into mentally meaningful states within a time continuum. Gerhard Dalenoort emphasizes the view of Guyau, that our notion of time derives fundamentally from our notion of space (and motion therein, as in Aristotle's views).

Part III, Relativity and Gravity, features four essays. Jürgen Ehlers takes us back to classical space-time and the needed changes in our concepts of time as caused by the developments of special and general relativity. Julian Barbour argues for a timeless universe. Dirk Graudenz localizes time to the "eigentime" of each observer as he/she travels their worldline. Claus Kiefer looks at how notions of external time and classical time can be approximately recovered from a fundamentally timeless quantized general relativity model.

Part IV, Non-Relativistic Quantum Theory, contains seven essays of a more diverse nature. This part begins with a very pertinent (it seems to me) essay by Hans Primas which emphasizes that we should pay more attention to how we represent facts in our physical theories. A fact is (my words) to be a past event whose validity extends through the present into the future. Actual physical registration of a fact requires the existence of corresponding nonanticipative measuring instruments. Anton Amann argues for a system-theoretic quantum theory in which quantum fluctuations from classical behavior may be characterized by large-deviation entropy. F. Tito Arecchi raises the question of decoherence time, the time interval within which a system stays "fully" quantum mechanical, after which it begins to exhibit quasi-classical features. The role of the environment in reduction of a wave packet is examined. Ioannis Antoniou and Zdzislaw Suchanecki present the Brussels–Austin model for the spectral analysis of resonances and other phenomena of irreversible dynamical systems. This work is highly mathematical and leans heavily on choosing good test function spaces so that their duals (in the sense of distributions *a la* L. Schwartz) capture generalized eigenfunctions which represent the physical event. Harald Atmanspacher examines the possible use of the Kolmogorov-

Sinai entropy of dynamical systems theory to clarify recent issues of temporal nonlocality. That is, the well-established instances of Bell inequality violation and the consequent conclusions of nonlocality of quantum correlations are usually viewed in terms of spatial nonlocality, whereas here attention is directed at the temporal aspects of those situations. Günter Mahler also looks at Bell's inequality theory and numerical experiments and the nature of conclusions about nonlocality that have been drawn therefrom. In the last essay of the book, Basil Hiley and Marco Fernandes revisit the use of Clifford algebras in quantum field theory, emphasizing the use of symplectic structures.

Generally, I found the essays to be well written. Clearly, the readers of this review and the authors whose work I have summarized in one or two sentences must surely know that I have operated here as the very most coarse filter imaginable. Anyone interested in anything I have said about these essays should buy the book to see what is really there.

Now just a few comments of my own, organized chronologically to follow the report above on the book chapters.

First, I thought it would be good to compare, in some systematic way, the content of this book with some literature base. In other words, to provide at least one kind of "grounding" for the book and this review. I happened to have on my desk for another purpose the three relatively recent volumes *Symposium of the Foundations on Modern Physics* (Lahti and Mittelstaedt, 1985, 1987, 1990). These volumes contain of course a huge amount of knowledge but let me make just a few comparisons. I leave further "grounding" of the book under review *via* other comparative material to the reader.

The 1985 *Foundations* volume deals with 50 years of the Einstein–Podolsky–Rosen Gedanken experiment. The contributors are more hard-core physicists than in the book under review, although von Weizsäcker of the book under review is also there (pp. 223–240). Although the hard physical results in the 1985 volume are of course extremely important, the book under review is much more interesting. A valuable outcome of the 1985 symposium is succinctly stated by Sir Rudolf Peierls in his closing words: notwithstanding all the paradoxes and experiments, the quantum theory is still intact.

The 1987 *Foundations* volume was more interesting, as concerns the physics of time. The topic of the Symposium was the Copenhagen Interpretation after 60 years. Both von Weizsäcker and Primas of the book under review were also at the 1987 Symposium. Very interesting is Jagdish Mehra's account of the conceptual struggles with the new quantum theory as seen through the conversations and correspondences among Bohr, Einstein, Heisenberg, Schrödinger, and others. Of course the principle issue then was inherent determinism *vs.* inherent stochasticity in nature, with questions about time in a secondary role, although an unavoidable role due to the uncertainty principle and relativity.

The 1990 *Symposium* concentrated on the Quantum Theory of Measurement and Related Philosophical Problems. This volume should *a priori* have

been much closer to the book under review. However my quick scan of the two Contents pages yielded again only Primas and von Weizsäcker as authors in common. There are of course many relevant articles in this volume, although I will not elaborate them here. Are most physicists too left-brained to be able to deal comfortably with right-brained conceptualizations of time?

Next, let me give you just a few of my own reactions to some of the articles in the book under review. Again for the sake of organization I will order my comments chronologically. I will only comment on those essays which overlap with my own interests or experience.

From Part I (Philosophy of Time) I am struck by the "precious little" that has been given as the facts of Time. We can measure almost anything about Space, in one dimension by a ruler either classical or in terms of the most advanced atomic standards which are maintained at government labs around the world, in three dimensions by GPS (Global Positioning Satellites), and so on. Of course in GPS algorithms, the Kalman filter uses information from previous instants of time, but the measurement goal is position, not time. In spite of all of our curiosity about more interesting meanings of time or a better understanding of those, the only fact of time that we usually use is: the clock fact. The clock keeps us in a frame of continuous three-space and one continuous time dimension. Could Pauli be right in suggesting that we must allow irrationalities into our quantum physical picture? If so, what are the facts of time therein? How do we measure those facts?

A second reaction I had to Part I concerns the work of Spencer-Brown (1969) as discussed by Andreas Kull. Like many others, in the early 1970s I was intrigued by Spencer-Brown's *Laws of Form.* My interest in Spencer-Brown's logic was that it was a three-valued one which seemed to provide possible ways out of paradoxes and also ways to accommodate holistic situations which may not be amenable to conventional two-valued logical consistency. Some years later someone gave me the paper (Schwartz, 1981), my informant telling me that this paper finds that Spencer-Brown's work was not new. As I now take my first look at the Schwartz paper which I happened to file away, I find my informant's capsule-summary over-critical. However, I think it is useful information to add here to that provided by Kull. Schwartz shows that both Spencer-Brown's primary algebra and F. J. Varela's later calculus for self-reference are isomorphic, respectively, to classical propositional calculus and S. C. Kleene's three-valued logic of partial recursion. The conclusion is that the Kleene–Spencer-Brown–Varela logic could be useful in situations of "empirical untestability."

In Part II (Time and Cognition),thirst for more facts of time is partially nourished. All five essays grapple with this issue in their own way. One fact of time which we might focus on here is how we perceive it. In other words, if we are to escape from the confines of time as a left-brained physicist's one-dimensional continuum from to , and if we do not wander off into the multiple time dimensions found among the relativity community, then a good place to find

new facts of time is cognitive science. As every individual cognitizes differently, it would follow that each individual "marches to a different drummer." As related to certain facts of time potentially findable in Part II of the book under review, I would like to point to our paper (Bernasconi and Gustafson, 1998). The point to make from our investigation is that all cognition takes place within a certain context. We found that in most books and other learned treatments of cognition, the term context was missing, or used without a well-defined meaning. In our experiments with quick-modelling by humans, we found an overwhelming need by humans to place a situation into context before they were able to mentally deal with it. It seems to me that psychological/physiological experiments such as those of Part II should always demand a definition of context before they proceed. By the way, our definition of context became: a setting and its meaning.

I was pleased to see that the editors of the book under review did not ignore the importance of the concept of context. On p. 2, I find contextual posed as the opposite to universal. On p. 332, one speaks of contextual exo-description as an empirical concept of reality depending on contexts. In the 1987 *Symposium* volume Primas speaks of contextual quantum objects. There the notion (p. 268) of contextual seems to mean the disentangling of a system from its environment. In the 1990 *Symposium* Bitbol speaks (p. 49) of context as each incompatible experimental arrangement.

A second reaction I had to Part II concerns the sensations and uses of Temporality by our brain as discussed in the papers by Pöppel, Szelag, Engel, Roelfsema, König, Singer, and Euler. I have worked in neural network research during the last ten years. It is safe to say that the interest in spiking-rate information-carry, as contrasted to a more simple engineering-based paradigm of spatial representation of a learned situation by means of weights stored in a computer-like neural network of nodes and connections, has returned to favor after a roughly ten year hiatus. Such findings as the 40-Hz neuronal oscillation frequency domain and the 3-s temporal integration time discussed in the above papers are of great importance to those who want to create artificial neural networks which really mimic the human brain. I should also mention the somewhat controversial work of Richmond *et al.* (1987) in which two-dimensional patterns (*e.g.,* Walsh codes) are asserted to be temporally encoded into their brains by monkeys in controlled experiments. Finally, let me mention my recent paper (Gustafson, 1998) in which I present my view that all neural networks, artificial or animate, which utilize nonlinear thresholds (all the effective ones do...) are subject to an internal local chaotic dynamics which permeates the entire nervous apparatus.

Part III (Relativity and Gravity) is not my cup of tea and I do not want to attempt much personal comment on it. However I must confess to having been a little excited when I noticed in Kiefer' s discussion about time at a fundamental level, that he focussed in on . As sophomoric as it may sound, I have always had uneasy feelings at the glib (and unthinking) use of i by all scientists as they

whiz through their calculations. This unease was not abated when I realized that most of the functional analysis that I was doing and was teaching assumed complex scalars (many of the standard theorems fail for real scalars). In an irreverent way one can say that the subjects of functional analysis, operator theory, quantum mechanics, quantization in general, are just generalizations of . Thus all mathematical tricks and successes of complex variable methods, depend upon the imaginary *i*. In physical terms, I had long ago decided that many mysteries of quantum mechanics were mysteries of phase, *i.e.,* of . The decoherence that Kiefer speaks of in his final section is in my opinion a key concept for a better understanding of time in quantum mechanics, but I wish that he had followed up more on its possible fundamental connections to imaginary phase.

I do not claim to see it all, "the all of *i*." It is a big important secret, in my opinion. The *i* permits the progress from the Schrödinger equation to the Dirac equation. Square rooting needs the *i*. Square rooting is a fundamental symmetry breaking. Square rooting somehow allows causality. The order of time is somehow intrinsically related to *i*.

At this point I took a break from this writing and spent a few hours more perusing the three *Symposium* volumes that I described above. Eureka! In the 1990 volume, p. 425, Herbert Van Erkelens discusses Pauli's attempt to find a unified framework for quantum mechanics and depth psychology. His sources are confidential letters from Pauli to colleagues and friends. These are part of the (generally unavailable to the public, as I understand it, but see Atmanspacher *et al.,* 1995) portfolio of writings known loosely to us as "Pauli's dreams." There was a kind of recurring dream involving a male/female figure Pauli called "The Persian." I go directly to the point (*Symposium,* 1990, p. 435, taken from Pauli's 'Die Klavierstunde,' 1953) and quote:

> At that moment the lady slipped a ring from her finger which I had not seen yet. She let it float in the air and taught me:
>
> *I suppose you know the ring from your school of mathematics. It is the ring i.*
>
> I nodded and I spoke the words: *The i makes the void and the unit into a couple. At the same time it is the operation of rotating a quarter of the whole ring.*
>
> She: *It makes the instinctive or impulsive, the intellectual or rational, the spiritual or supernatural, of which you spoke, into the unified or monadic whole that the numbers without the i cannot represent.*
>
> I: *The ring with the i is the unity beyond particle and wave, and at the same time the operation that generates either of these.*
>
> She: *It is the atom, the indivisible, in Latin....* With these words she looked at me significantly, but it seemed to me unnecessary to speak Cicero's word for the atom aloud.
>
> I: *It turns time into a static image.*

Coming now to the last Part IV (Non-Relativistic Quantum Theory), I was of course gratified to see Primas raise the issue of the meaning of facts. As I said above, Part II already helped by providing some biological facts of time. The concept of facts as entities which are invariant over a time interval centered about Now and extending backward and forward at least locally in time, and

which for their validity require the total ordering of local time, seems to me to be important. For now, let me just say: thank God for the written word. What we can record on paper has a chance of being a fact. What is in our mind is inherently nonstationary. I can do no better than to quote (Wiener, 1948): "Thus the brain, under normal circumstances, is not the complete analogue of the computing machine, but rather the analogue of a single run on such a machine." As I point out in (Gustafson, 1990), this insight creates a tacit sense of a local time within a local time frame for each of us, for example the totality of our total learning and other nervous experience as it evolves through each of our lifetimes.

The discussions of decoherence by Arecchi and entanglement by Mahler address critical barrier issues that are extremely relevant to the possibility of quantum computing (*e.g.,* see Calude *et al.,* 1998). It is important when dealing with individual quantum objects, as Mahler points out, to determine exactly the separate properties of dissipation for suppressing control, as it creates decoherence, and as it may carry information.

Finally, in addition to my comments included in the above, I would like to express some of my thoughts which I have had on time.

First, notwithstanding the fact that I have been quite willing to work with and publish within (*e.g.,* see Gustafson, 1997a) an operator-theoretic paradigm of unitary group reversibility and semigroup irreversibility, I do not really believe it. See Gustafson (1997b) for some of my thoughts on this issue. Basically I believe that virtually every process is dissipative or accretive and never quite balanced if we can look close enough or small enough or large (*e.g.,* out to or beyond the boundary of wherever we have been considering a situation) enough. I do not believe the "heat bath" models or open system linear models (*e.g.,* see Davies, 1976) either, nor the formulations of instruments therein. I must place here a great joke from Japan in 1995. After I gave a lecture there, at dinner some bright young physics professors from the University of Tokyo asked me: "Do you believe in God?" I hesitated and then replied: "Maybe." They said no, the correct mathematician's answer is: "Yes, up to unitary equivalence!" I was not quick enough to state it then, but I guess I do not believe that unitary equivalence exists for any truly physical process. But for many applications it is close enough to use in our mind-models.

Second, I have developed a habit of going to the dictionary when I find myself in rhetorical encounters in which others purport to know better than me the true "essence" of something, or its "deep" meaning. I have become an agnostic about such things: I do not think anyone has the final answers to such core value truths. As one of my colleagues from the English Department who found himself spending years without end on a campus curriculum core value committee quipped to me when I asked him what the goal was, "Why of course, the goal is to impose my core values on you...." Let us go to the dictionary (Websters, 1971). I find 15 elaborated concise meanings to the noun Time, five to the verb, three to the adjective, more than one full small-print

column of attempted explanations from the highest authorities on the English language. Then of course dictionaries in other languages will have their own established interpretations of the usages of their versions of the word Time. Unless you have absolutely no humbleness in your soul, I think that such exercises should convince you to become agnostic about such core truths, too.

Of course such agnostic-like realizations are not unique — we all have them if we are at all awake in life. Such awakenings can induce a mental malaise, a languor of helpless realization that there are no final answers, an acceptance of the fact that each of us is a relatively coarse observational filter upon a world far more complex and rich than our perceptions will ever allow us to know.

At this point we have a choice: probably many choices, but let us keep it to two choices here. We can head off into philosophy and a study of meaning and even the meanings of meanings (see the excellent book Brent, 1993, about Charles Peirce, and semiotics). We may realize that, having undergone this transformation to a better understanding of the limited nature of who we really are and what we may really comprehend, we are free to do our best, to take decisions and actions for the common good as best we can, knowing that there is neither ultimate good nor evil that can come from our deciding to get back into the game.

I go back to the dictionary with my heart saying go ahead, just quickly scan and force your filter to respond to a single predominant frequency, and it did. Meaning 2a states: "time: a point or period when something occurs: the moment of an event, process, or condition." Let us fine-tune this to just "time: the moment of an event."

May I assert that this definition is in excellent correspondence with the title of the book under review? Time is time, moment is Now, event is Temporality.

Third and the last of my personal observations here about Time, is offered as second-hand testimony to the fact that virtually everyone realizes time as an inescapable essential nonunderstood presence in our lives. Often I cook breakfast for my son Garth (age 26) and myself on Saturday mornings. My son is viewed by his peers as extremely terse and very sharp even though he never exhibited much interest in secondary education and even less (he chose not to go) in university education. On the other hand when he was five years old, he asked me why we did not go flying off into space and I told him "gravity" but that no one had the final answer on that. When he was ten years old he decided to do a school project on helicopter flight and he figured out for himself all aspects of those dynamics. I mentioned this review project as we shared pancakes and I asked him what his "definition" of time would be. There was a moment's hesitation as he realized he could not just shrug it off. He replied, "The constant we use to label the unfolding of the universe. Probably it is not really constant, it is just a tool we use. (Pause) The question is, if you go back in time and do something, like kill someone, do their descendants just wipe out, or do they continue in their own bubble? (Pause) If anyone ever figures out what

time is, we are in big trouble. I do not want to think about it anymore, it makes my head hurt."

My head does not hurt but I choose (Free Will) this moment (Now) to bring (Temporality) this review to an end (Event). I thoroughly enjoyed *Time, Temporality, Now,* and I recommend its essays to anyone who wants to think more about Time.

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Biology Revisioned by Willis W. Harman and Elisabet Sahtouris. Berkeley, CA: North Atlantic Books, 1998, xxvii + 290 pp., $14.95, (p). ISBN 1-55643-267-4.

In *Biology Revisioned,* Elisabet Sahtouris and the late Willis W. Harman present a philosophical discourse on concepts that they suggest should underlie a new approach to the sciences, using examples drawn from biology. In their vision, a reductionistic approach to understanding the universe is necessarily incomplete, since entities cannot be fully understood without also knowing their inter-relationships. While this view is perhaps most familiar in ecology, the authors suggest that it can be applied to all the sciences. For example, they suggest that physicists' interest in finding fundamental particles is misplaced; by definition, such a particle has no relationships to anything less complex or less organized. When entities (holons) are understood in relationship to the holons they join to form and those they are formed by, that is, understood within a holarchy, these particles (if they exist) become aberrations rather than models for understanding the whole of nature.

Harman and Sahtouris then present a definition of life (credited to biologists Humberto Maturana and Francisco Varela) in which the ongoing process of self-organization, or autopoiesis, is key, rather than specific material components (cellular membrane, nucleic acids) or particular events (birth, reproduction). This definition encompasses known life from the most simple one-celled, non-nucleated organisms through the most complex, largest mammals. In the authors' view, it also extends to stable whirlpools (p.118), to the Earth as a whole (as in James Lovelock's Gaia hypothesis), and to stars and galaxies. With the concepts of holarchy and autopoietic life in place, the authors put forth what may be the most challenging premise in the book: consciousness is not found only in certain holons (such as humans), but rather permeates the entire holarchy of living things. Further, under the definition of life they propound, everything from bacteria to the universe itself may be seen as conscious, with intention and purpose. It follows that questions of intent and meaning, of why, are as appropriate for research as questions of mechanism, of