CHAPTER 1

FRACTAL TIME: EXTENDED OBSERVER PERSPECTIVES

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In order to describe a temporal observer perspective, we have to assume two mutually independent temporal dimensions: the depth and the length of time, which respectively correspond to simultaneity and succession. These define the degree of complexity a temporal observer perspective displays. Observer types may be distinguished in terms of their ability to create simultaneous contrasts or to resist contextualization. The setting of the interfacial cut between the observer participant and the rest of the world determines the structure of the fractal temporal observer perspective by assigning rhythms to the observer or to the rest of the world. Misattributions occur when the observer perspective becomes hard-wired and immune to external perturbations, i.e., if only the observer perspective but no external rhythms determine his interface reality.

1. Introduction: One Dimension is not Enough

If we wish to describe the nature and structure of time, we face a Gödel limit. As observer participants, we are already embedded in the subject matter we wish to define: time. We cannot describe temporal structures from an exo-perspective (from an outside vantage point of view), as this perspective is reserved for idealized constructs, such as Laplace's demon, which find no counterpart in the real world. We are limited to an endo-perspective (the view from within), as we are part of the system we wish to describe. The notion of the endo-perspective was introduced by

Otto E. Rössler in his seminal work *Endophysics*[1]. In a nutshell, this perspective is determined by the observer's internal organizaton, i.e., his internal microscopic movements. As Ernst Pöppel pointed out, also our modes of perception act as constraints to the way we generate reality: our models and theories are based on our primary experiences of time, namely, succession, simultaneity, duration and the Now[2]. These primary experiences are based on embodied cognition. On a cognitive level of description (hereafter denoted as LOD), our endo-perspective is also structured by metaphors which arise from the limitations set by the observer's sensory-motor system[3].

As observer participants, we have no access to the *noumenon* and face a limit to conscious introspection of the prerequisites which constrain our perceptions. Given these limitations, a phenomenological approach which focusses on the world-observer interface is a promising starting point. The ideas and assumptions presented in this chapter therefore refer to interface reality – the boundary which embraces both the observer participant and the environment he interacts with. Particular emphasis is given to the notion of the observer's Now, an extended and structured interval which defines the observer's event horizon. As Rössler put it, Nowness is pure interface[4].

The way we generate succession, simultaneity and our Now is not a trivial matter. Our perceptional constraints determine whether we experience a visual, auditory or tactile sensation as one event or as a number of successive ones. An auditory event spans a shorter interval than a tactile or a visual one. So we experience several modes of perception in parallel, as a temporal nested pattern, which forms our Now. The Now is therefore not a point which divides the past from the future, but an extended field, which hosts a structure of temporally nested events – a fractal.

The first person to describe a nested structure of the Now was the German phenomenologist Edmund Husserl[5]. He could not refer to the term fractal, as his treatise appeared 80 years before Mandelbrot's seminal book[6]. Husserl asked the simple question as to why we are able to perceive a tune, as opposed to a series of unrelated notes. He concluded that this must be so because we remember the note we have just heard (retention) and, assuming that this was not all, anticipate the

next note (protention), in our consciousness of the present, the Now. Every Now embeds the preceding one, including its differentiated structure of retentions and protentions, i.e., the memories of the notes that have been played and those we anticipate to follow. This leads to a nesting cascade of Nows, each hosting both retentions and protentions. The current Now forms the framework time into which all previous and expected events are embedded, thus generating a fractal structure. If we were only able to hear successive, uncorrelated notes, no embedding could take place and our Now would not be extended by simultaneous nested structures, i.e., we would not be able to hear a tune or perceive any other time series as a meaningful entity. However, as we *are* able to perceive a tune and not just a succession of isolated notes, we must assume the Now to be extended and provide for *both* succession and simultaneity.

Below, I shall introduce a fractal model of time by means of which we can describe nested temporal structures in an extended Now by differentiating between succession and simultaneity as two mutually exclusive temporal dimensions.

2. Fractal Time

My Theory of Fractal Time adopts Husserl's notion of a nested Now[7,8,9]. It provides a means of quantifying the internal structure of the observer's interface by differentiating between the length of time, $\Delta t_{length,}$ the depth of time, Δt_{depth}, and the density of time, $\Delta t_{density}$. These concepts allow us to describe our temporal interfaces as nested temporal perspectives. Δt_{length} is measured in the number of incompatible events in a time series, i.e., events which cannot be expressed in terms of during-relations (simultaneity). It defines the length of time, the temporal dimension of succession for individual LODs. Δt_{depth} is measured in the number of compatible events in a time series, i.e., events which can be expressed in terms of during-relations. It defines the temporal dimension of simultaneity for two or more LODs. $\Delta t_{density}$ is the fractal dimension of a time series. It measures the density of time, i.e., the relation between successive and simultaneous events.

Δt_{depth} provides the framework times which allow us to structure events in Δt_{length} on individual LODs. Therefore, Δt_{depth} logically precedes Δt_{length}: there is no succession without simultaneity. Δt_{length} and Δt_{depth} are mutually exclusive, i.e., an observer participant cannot generate both at the same time. In retrospect, however, an interval of a time series may be measured in both dimensions and the resulting fractal dimension, which measures the density of time in that interval.

Any multi-layered signal may be considered as an example of a fractal time series. For instance, the least complex frequency ratios of musical notes which are played simultaneously is 2:1. This ratio defines the interval between the notes as an octave. The next overtone of a frequency of, say, 440 Hz (the note A played on an oboe) would have a frequency of 880 Hz, and so on[10]. As the overtones are integer multiples of the fundamental frequency, the overtones generate a nesting cascade whose LODs can be translated into each other. If a temporal pattern displays a self-similar structure, i.e., if the embedded LODs host structures which are identical to those of the embedding LODs, albeit of different extension in Δt_{length}, it is always possible to translate between nestings. In the musical example of nested overtones, this leads to consonance created by overlapping frequencies which are easily translatable into each other in terms of Δt_{length} and Δt_{depth}.

In general, we can say that both temporal dimensions (Δt_{length} and Δt_{depth}) must be assumed in order to explain our perception of a multi-layered signal. $\Delta t_{density}$ is a useful measure for comparing time series. To define a temporal observer perspective, however, the notions of Δt_{length} and Δt_{depth} suffice.

Fractal time is a generalization, as the Newtonian metric of time may be defined as a special case of fractal time metrics. A fractal clock can be imagined as an infinite number of pointers running on the perimeter of the triadic Koch island (a snowflake-like structure with an infinitely complex boundary: see Figure 1), with all pointers ticking away simultaneously[11,12].

So while pointer no. 1 ticks, say, only three times (per lap), pointer no. 2 is ticking 12 times, pointer no. 3 is ticking 48 times, and so on, ad infinitum. If the infinitely nested structure of the triadic Koch curve is projected onto a one-dimensional straight line, it forms a continuum, and

thereby, a Newtonian metric: the set of points generated in this way is the set of rational numbers. Thus, in terms of fractal time, the Newtonian metric may be defined as Δt_{length} of the nesting level ∞, i.e., $\Delta t_{depth} = \infty$.

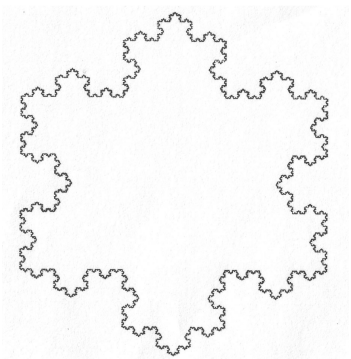

Fig. 1: A fractal clock

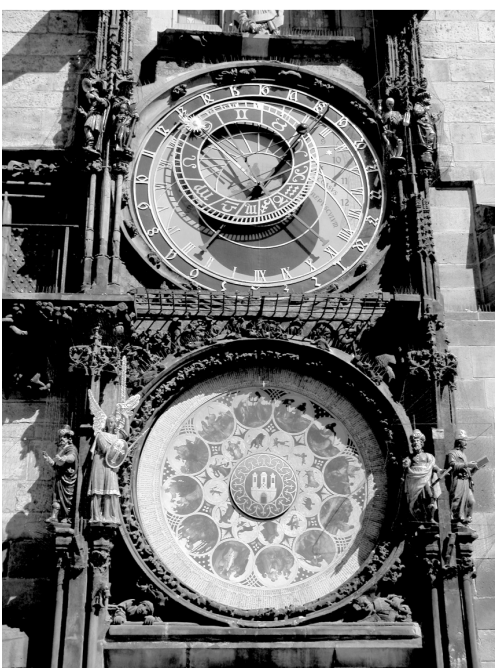

Fig. 2: The Prague Orloj – a fractal clock

The oldest fractal clock is the astronomical clock in Prague (Orloj: see Figure 2), dated around 1410. It shows several nested timescales: minutes, hours, days and months, as well as the night sky throughout the year, the ascent and setting of the stars, the lengths of the days and nights throughout the year, the moon phases and the festive days. It also shows Bohemian time (from sunrise to sunset) and the signs of the zodiac. Underneath this clock is another, divided into 24 sections. It depicts the seasonal changes and corresponding scenes of rural life.

3. The Nested Now: Simultaneity Horizons

The nested structure of the Now is the result of fractal temporal structures within the observer and in his environment. Outside the observer, for instance, tidal rhythms are embedded into seasonal rhythms, which again, are embedded in astronomical ones. Within the observer, for example, neural oscillations are embedded into much slower metabolic ones[13]. Also our sensory perception is fractal: Pöppel[2] showed in his neuro-scientific approach how our perceptual constraints create a simultaneity horizon, at which we perceive audio and visual signals as occuring simultaneously. We perceive audio signals as non-simultaneous if they are separated by an interval of roughly 6 milliseconds. If that separating interval is shorter, we perceive audio signals as being simultaneous. Visual impressions which are separated by an interval of 20 to 30 milliseconds are experienced as non-simultaneous. Below this threshold, impressions are perceived as simultaneous. The simultaneity threshold for tactile impressions lays at approximately 10 milliseconds. Thus we perceive tactile, visual and audio events as temporally nested, since the interval which defines them as one event rather than two successive ones varies for each sensory realm.

According to Pöppel, this temporally nested structure is perceived as one Now if we have a clustering of perception-related experiences which are based on meaningfulness, i.e., perceptual gestalts which are constructed by our brains. He does not refer to a nested or fractal structure, but his examples implicitly describe a fractal perspective. Thus, the extention of the Now depends on the mental capability of the person who experiences an event. The more differentiated and richer the

language, the more complex are the perceptual gestalts a person may construct and the more extended is the Now. An extended Now requires both the identification and integration of perceptual gestalts[2] which, in terms of fractal time, may be denoted as a nesting of meaningful events, and memory, the nesting cascade of past Nows within the current one. The measuring rod for the Now is thus situated within ourselves: the temporal extensions of events, which may be turned into perceptual gestalts by means of integration. Therefore, we may say that a complex observer perceives a complex environment in a decomplexified manner[14,15,16]. The observer participant's degree of fractality determines the temporal complexity of the world he generates.

These observations also support the view that the more complex the observer participant's internal differentiation is, the higher his empathic skills will be, as he is able to simulate and contextualize what happens in the external world.

Contextualization is both an innate and an acquired skill. There are innate correlations such as the female cycle and moon phases, mating seasons etc. On the other hand, there is acquired entrainment, which comes in the shape of adjusting to artificial timetables and other external constraints. However, the ability to contextualize may be impaired for certain observer participants, so these individuals generate simultaneity contrasts which differ from those of observers whose nesting capacity is not compromised.

An example of a simultaneous contrast, i.e., an illusion which some observer types fall for and others resist, is Dakin's experiment, in which individuals with symptoms of schizophrenia and a control group were exposed to a simultaneous contrast[17]. Either an isolated disc (see Figure 3, left margin) or a disc with a high-contrast surrounding disc was presented. Subjects were then asked to report which disc appeared to be of higher contrast. Control group subjects fell for the visual illusion induced by the simultaneous contrast. To them, the central disc appeared to be of lower contrast, as the embedding, larger disc of higher contrast influenced their perception of the embedded disc. Schizophrenics did not contextualize the nested disc, and thus did not fall for the visual illusion because the outer high-contrast disc did not have any impact on their perception of the embedded one.

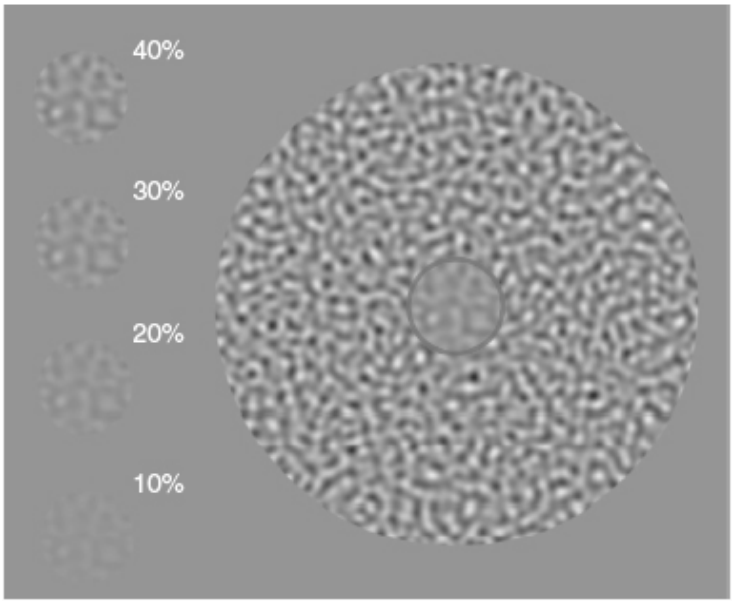

Fig. 3[17] [Reprinted from S. Dakin, et al.] Weak suppression of visual context in chronic schizophrenia. *Current Biology* 15, p. R823 (2005) with permission from Elsevier.

Unconscious nesting performances, such as the one described above, shape the structure of our interface by means of inducing or inhibiting simultaneous contrasts. As Dakin's experiment shows, sometimes an apparent handicap turns out to be a blessing in disguise, when failure to contextualize results in the correct matching of external stimuli on one LOD. Although matching discs is not in itself a useful skill, the ability to resist contextualization in various sensory and cognitive realms can be of advantage when we try to rid ourselves of misattributions. In Chapter 7 of this volume, Gerald L. Clore gives an example of how a misattribution disappears when the true sources of a feeling can be disentangled from a merged cluster of experiences.[18]

4. The Extended Observer

Hitherto I have referred to the observer participant in an unspecific manner, without defining the boundary which limits him. But the

question as to where we may set the interfacial cut between the observer and the rest of the world is crucial for our reality generation game[19,20]. But deciding what we assign as being part of the observer and what as being part of the rest of the world is a tricky matter.

Misattributions are common and often not easily identified as such by introspection or reasoning. Simple conditioning effects can turn individuals into extended observers. The famous example of the rubber hand illusion illustrates this nicely. In 1998, Botvinick and Cohen conducted an experiment in which a person is sitting at a table, with his left arm resting on it[21]. His other hand is screened off from view and a rubber hand is placed in front of him. Next, he is asked to look only at the rubber hand while both the rubber hand and his own hand which is hidden from view are stroked with paintbrushes simultaneously. The visual feedback linked the observer's visual and tactile perceptions, so that after a while, he reported that he felt his own hand was being stroked when only the rubber hand was touched by the paintbrush. The intermodal matching sufficed for self-attribution. This conditioning effect (neurons that fire together wire together) changed his perspective by shifting the location of the interfacial cut between the observer and the rest of the world.

There are also examples of diminished observer extentions. Ramachandran and Blackeslee describe a patient who refuses to believe that his leg belongs to him, although it is obviously attached to his body. Rather than accepting it as being part of himself, he comes up with elaborate explanations why the leg does not belong to him[22]. This condition, which is well-documented under the name "neglect", shifts the observer-world interface towards the observer and sets an interfacial cut within his body.

The other extreme, shifting the interface further and further into the world, well beyond the observer's body, has been described by Metzinger, who reports the case of a patient who spends all day looking out of the window, making the sun move across the sky[23]. The patient is convinced that the apparent motion of the sun is the result of his volitional act. This may be an extreme case, but then many managers and politicians find themselves in a similar situation.

The position of the interfacial cut determines which temporal rhythms are attributed to the observer and which to the outside world. Positive feedback results in hard-wired expectations which give rise to self-delusions. These are next to impossible to dissolve by means of reasoning, let alone lecturing[24]. Our temporal observer perspectives are defined by their fractal structures generated by nestings of rhythms or oscillations. And, as our brain's output controls its inputs, rather than the other way around[13], our fractal temporal interfaces are fairly immune to external perturbations.

5. Conclusion

In order to explain the way we perceive meaningful entities such as a tune or any other time series as a gestalt, we must assume two mutually independent dimensions of time: Δt_{length} and Δt_{depth}. The ability to fall for or resist simultaneous contrasts shapes our temporal fractal interfaces: contextualization generates Δt_{depth}. Thus, our observer perspectives can be defined in terms of the number of nestings at our disposal. The resulting interfacial cut generates our very personal realities.

This cut can lead to advantages or disadvantages. If my interfacial cut is valid for one observer frame only, namely mine, I may, as the individual who has generated this perspective, well be diagnosed as suffering from a cognitive disorder. The same is true for a group of individuals who are embedded in a larger context. They may be branded as suffering from a collective hallucination if their perspective does not match that of the individuals who make up the embedding context. Scientific paradigms are also subjected to and constrained by the interfacial cut set by the scientific community. Scientists who adhere to a scientific paradigm may be falling for a collective hallucination, which becomes hard-wired as a result of positive feedback and results in educated incapacity.

There is no such thing as a pure observer, an exo-observer who does not engage in participation. Neither is there a pure participant, as this state would not allow for an observer perspective. Individuals who approach a state of pure participation would find themselves suffering from oceanic boundary loss or dreadful self-dissolution.

Our knowledge of the world is limited by perceptual and cognitive constraints. We cannot rule out that there may be observer participant extentions we cannot yet assign to a physical or mental cause. Private observer extentions cannot easily be pinned down by external observers, even when we think we can discern an unusual interfacial cut. I shall spare you a long excursion into anecdotal evidence of such phenomena. But, on a lighter note, here's an example of an extended observer participant whose extention we may observe but cannot explain: "... He stands like a statue, becomes part of the machine, feeling all the bumpers, always playing clean, plays by intuition, the digit counters fall, that deaf and dumb and blind kid sure plays a mean pinball ..."[25].

References

1. O.E. Rössler, *Endophysics.* World Scientific, Singapore (1998).
2. E. Pöppel, *Grenzen des Bewußtseins – Wie kommen wir zur Zeit, und wie entsteht die Wirklichkeit?* Insel Taschenbuch, Frankfurt (2000).
3. G. Lakoff and R. E. Núñez: *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being*. Basic Books (2000).
4. O.E. Rössler, Intra-Observer Chaos: Hidden Root of Quantum Mechanics? In: *Quantum Mechanics, Diffusion and Chaotic Fractals*. Edited by Mohammed S. el Naschie, Otto E. Rössler & Ilya Prigogine. Pergamon, Elsevier Science, pp. 105-112 (1995).
5. E. Husserl, *Vorlesungen zur Phänomenologie des inneren Zeitbewußtseins*. First published in 1928. Niemeyer (1928/1980).
6. B.B. Mandelbrot, *The Fractal Geometry of Nature.* W.H. Freeman, San Francisco (1982).
7. S. Vrobel, *Fractal Time*. Houston: The Institute for Advanced Interdisciplinary Research, Houston (1998).
8. S. Vrobel, Fractal Time and the Gift of Natural Constraints. *Tempos in Science and Nature: Structures, Relations, Complexity*. Annals of the New York Academy of Sciences, Volume 879, pp. 172-179 (1999).
9. S. Vrobel, How to Make Nature Blush: On the Construction of a Fractal Temporal Interface. In: *Stochastics and Chaotic Dynamics in the Lakes: STOCHAOS*. Edited by D.S. Broomhead, E.A. Luchinskaya, P.V.E. McClintock and T. Mullin. New York: AIP (American Institute of Physics), pp. 557-561 (2000).
10. J. Fauvel, J. et al, *Music and Mathematics – From Pythagoras to Fractals*. Oxford University Press, p. 27 (2003).

11. S. Vrobel, Fractal Time and Nested Detectors. In *Proceedings of the First IMA Conference on Fractal Geometry: Mathematical Techniques, Algorithms and Applications*. DeMontfort University, Leicester, pp. 173-188 (2004).
12. S. Vrobel, Fractal Time in Cognitive Processes. Paper presented at the *2nd International Nonlinear Science Conference*, Heraklion (2006).
13. G. Buszáki, *Rhythms of the Brain.* Oxford University Press, Oxford, U.K., p. 134 (2006).
14. S. Vrobel, Simultaneity and Contextualization: The Now's Fractal Event Horizon. Talk held at *13th Herbstakademie: Cognition and Embodiment.* Ascona, Switzerland (2006).
15. S. Vrobel, Nesting Performances Generate Simultaneity: Towards a Definition of Interface Complexity. In: *Cybernetics and Systems* Vol 2 (Edited by Robert Trappel). Austrian Society for Cybernetic Studies, Vienna, pp. 375-380 (2006).
16. S. Vrobel, Reality Generation. In: *Complexity in the living – a problem-oriented approach.* Edited by R. Benigni, A. Colosimo, A Giuliani, P. Sirabella, J.P. Zbilut. Rome: Rapporti Istisan, pp. 60-77 (2005).
17. S. Dakin et al, Weak suppression of visual context in chronic schizophrenia. In: *Current Biology* 15, pp. R822-R824 (2005).
18. G. L. Clore, Simultaneity in Emotional Moments. Chapter 7 of this volume, §4: Mood Influences on Judgment.
19. S. Vrobel, Temporal Observer Perspectives. In: *SCTPLS Newsletter*, Vol. 14, No. 1 Society for Chaos Theory in Psychology & Life Sciences, October 2006.
20. S. Vrobel, Ice Cubes And Hot Water Bottles. In *Fractals. An Interdisciplinary Journal on the Complex Geometry of Nature.* Vol. 5 No. 1. World Scientific, Singapore, pp. 145-151 (1997).
21. M. Botvinick and J. Cohen, Rubber Hands 'Feel' Touch That Eyes See. In: *Nature*, Vol. 391, p. 756 (1998).
22. V.S. Ramachandran and S. Blakeslee: *Phantoms of the Brain*. Fourth Estate, London (1999).
23. Metzinger, T. *Being No One: Consciousness, the Phenomenal Self and the First-Person Perspective*. Foerster Lectures on the Immortality of the Soul. The UC Berkeley Graduate Council (2006). http://video.google.com/videoplay?docid=-3658963188758918426&q=neuroscience
24. S. Vrobel, The Extended Observer Revisited. *Systems Research and Cognition.* Vol. 1. G.E. Lasker M. Malatesta (Eds.) The International Institute for Advanced Studies in Systems Research and Cybernetics, Tecumseh, Canada 2007.
25. P. Townshend, Pinball Wizard, *Tommy, A Rock Opera*. Track, Polydor, UK (1969).