Sheer Simultaneity: Fractal Time Condensation

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Abstract

The structure of time is presented in a phenomenological approach as a fractal. This fractal structure is generated by nesting levels of description, i.e., by embedding time series simultaneously on parallel levels of abstraction. The notion of a Temporal Natural Constraint is exemplified by the concept of the Prime – the smallest temporal extension in a scaling nesting cascade – whose indivisibility results from the fact that it cannot host any further nestings.
Within the framework of my Theory of Fractal Time, which differentiates between $\Delta t_{length,}$ Δt_{depth}, and $\Delta t_{density}$, the notion of condensation is introduced. If the Prime of a temporal structure is set as a constant, the lengths of time Δt_{length} are condensed on all levels of description to varying degrees. Large intervals of Δt_{length} shrink to a fraction of their original temporal extension. The congruence of nested intervals comprising the Prime Structure Constant (PSC) causes a change in perspective on the observer's interface, his Now: if condensation is induced, the observer seizes at a glance the PSC on intervals of varying Δt_{length}.
Against the background of this theoretical framework, experimental results in synchronization and psychoacoustic phenomena (e.g. the missing fundamental) are discussed. It is suggested to consider interpreting intervals of temporal scaling patterns as partial or full condensation. The notion of sheer simultaneity is defined in terms of successful contextualization which manifests itself as a condensation scenario.

Keywords: fractal time, levels of description, temporal natural constraints, condensation, sheer simultaneity

Introduction

In this paper, I shall try to show that multi-layered, nested signals trigger perceptions of simultaneity and succession which depend on the structure of the observer's temporal interface. After summarizing the phenomenon of the missing fundamental, I shall try to interpret it against the background of my Theory of Fractal Time. The notion of the Prime as a Temporal Natural Constraint and the concept of condensation are described. It is suggested that the observer's temporal fractal perspective determines his perception of the outside world in terms of succession and simultaneity. Multi-layered signals are interpreted as simultaneous by fractal observers if they display the same scaling structure as the observer's interface. Sheer simultaneity is defined as complete congruence between the outside world and the observer's internal differentiation as manifested in his world-observer interface. In

this context, the missing fundamental phenomenon and synchronization are interpreted as observer-induced condensation.

The Case of the Missing Fundamental

A sound wave is a periodic compression of air, water or any other medium. While its amplitude determines the volume (intensity), its frequency is related to perceived pitch: The higher the frequency, the higher the pitch perceived. A human adult is able to perceive frequencies between 15/20 and 20,000 Hz.

When a note is played on a musical instrument, we hear not just one sinusoidal wave (a pure tone), but also its overtones. (This is true for all naturally produced tones). If these are integer multiples of the fundamental frequency, they are referred to as harmonics (see Figure 1). However, not all overtones are harmonic: some musical instruments produce overtones which are not integer multiples of the fundamental frequency. These inharmonic overtones are referred to as partials.

The superimposed frequencies form a harmonic series if the overtones are integer multiples of the fundamental frequency:

440Hz	fundamental frequency	first harmonic
880Hz	first overtone	second harmonic
1320Hz	second overtone	third harmonic

(en.wikipedia.org, 2006)

If the fundamental frequency is removed and only the overtones are played, the listener hears the same pitch as he would hear if this fundamental were included. Even if one takes away not only the fundamental frequency but also the first overtone (plus the second, third, etc.) this does not change the perception of pitch. This phenomenon is used to trigger the perception of low frequencies which are physically non-existent, such as in stereo speakers which do not produce low frequencies, to generate a bass sound the speakers cannot physically produce. In telecommunications, only the higher frequencies are transmitted, as the listener can hear the missing fundamental and the first few overtones, even though they are physically not present in the signal.

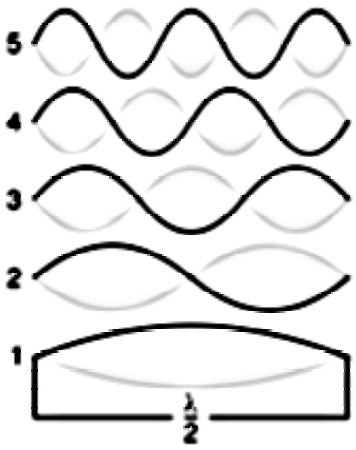

Figure 1: overtones
(en.wikipedia.org, 2006)

A widely accepted explanation for this phenomenon is that our brains calculate the difference in frequency from the relations of the overtones and thus calculate the lower overtones and the fundamental frequency. Below, I shall try to show that it is conceivable to

interpret this completion process performed by our brains as a result of creating simultaneity from a multi-layered signal such as a cascade of overtones.

Fractal Time and Temporal Natural Constraints

If the component frequencies of a wave are integer multiples of the fundamental frequency, this multi-layered signal may be described as a self-similar temporal fractal. The individual levels of description (LODs) are defined by the different frequencies. As high and low frequencies are present simultaneously within a signal, this arrangement may be described as a nesting cascade of waves. The overtones form a temporal scaling pattern, whose LODs are translatable into each other by multiplying the respective frequencies by an integer.

In order to describe the relation between the simultaneous and successive waves which make up this scaling cascade, I suggest differentiating between the length and depth of time, as proposed in my Theory of Fractal Time (Vrobel, 1998).

In a nutshell, this theory differentiates between temporally compatible and incompatible events. Compatible events may be perceived simultaneously, whereas incompatible ones generate succession. I have defined the terms $\Delta t_{length,}$ Δt_{depth}, and $\Delta t_{density}$ to describe this differentiation:

Δt_{length}, the length of time, is the number of incompatible temporal extensions in a time series. It measures the succession of events on one LOD. Δt_{depth}, the depth of time, is the number of compatible temporal extensions in a time series. It measures simultaneity and provides the framework time which allows us to structure events in Δt_{length}. $\Delta t_{density}$ is the temporal density of a time series, the fractal dimension of time. Successive, i.e., incompatible events have to be arranged on one LOD. This LOD, however, must first be defined in terms of Δt_{depth}. Therefore, epistemologically speaking, Δt_{depth} logically precedes Δt_{length} – there is no succession without simultaneity.

In a temporal nesting cascade, there is a structure on the innermost nested LOD which does not host any further nestings, e.g., an overtone which sets an upper limit to the frequency spectrum, i.e., there are no further overtones of a higher frequency. Below, I shall define this smallest frequency as the Prime of a temporal nesting cascade which is indivisible in the sense that it cannot host any further, smaller frequencies (hosting means embedding a shorter time interval such as the one generated by a smaller frequency).

When our brains disentangle, e.g., an air pressure wave, we differentiate a multi-layered signal into a frequency spectrum, thus creating a cascade of LODs defined by these different frequencies (Vrobel 2006c). If the signal is self-similar (e.g., if the overtones of the fundamental frequency are integer multiples of the latter), the temporal structure is perceived as harmonic.

How can this translation between LODs which is performed by our brains be interpreted? I shall try to show that a time condensation scenario would be a viable interpretation of this performance. It also allows for an interpretation of the missing fundamental.

First, however, it is necessary to take a closer look at the structure of the Now – our only window to the outside world.

The Extended Now's Nested Structure

This paper focuses on phenomenological objects as they manifest themselves on the world-observer interface. The notion of the Now as pure interface goes back to Otto Rössler (Rössler, 1995). An observer who wishes to define simultaneity and succession is, of course, already embedded in his object of study: time (Vrobel, 1997). As he cannot describe the system he is nested in from the outside, he is confined to the view from within, the endo-perspective (Rössler, 1998).

The idea that the Now is not a point but has extension and a fractal structure generated by the observer and the world around him is not a novel one. Although he could not have chosen the concept of a fractal to describe his idea, the German philosopher Edmund Husserl described what may be interpreted as a nested structure of the Now (Husserl, 1928). He illustrated his idea by pointing out that, when we listen to a tune, we hear a succession of musical notes. But what we perceive is not just a succession of unrelated notes - we hear a tune.

We are able to do this because we internally connect the note we have just heard with the present one and the tone we anticipate to follow it. But we don't connect them in an arbitrary way: we remember a tone (*retention*) and anticipate the next tone (*protention*) within the consciousness of the present, the Now. As we do this over and over, we create a nested temporal pattern within the Now.

It is our ability to connect the memory of the preceding note, which still lingers on in our consciousness of the present, with the note we anticipate to follow it. This ability enables us to perceive a meaningful entity, a tune, as opposed to a succession of uncorrelated, isolated notes. Therefore, we must assume the Now to be extended (in order to host retention and protention).

As this process continuously generates new nestings of retention and protention, we must assume the Now to provide for *both* succession and simultaneity. This succession and simultaneity of retention and protention within the consciousness of the present, the Now, generates a nested, fractal structure. In order to explain our ability to perceive a tune or any other time series as a meaningful entity, we have to assume the structure of the Now to be a nested, fractal one. My Theory of Fractal Time briefly outlined above takes account of the nested fractal structure of the Now by differentiating between Δt_{length}, Δt_{depth}, and $\Delta t_{density}$.

A fractal observer is capable of observing events on a number of LODs. As a result, he is in a position to generate a Temporal Fractal Perspective, observing succession and simultaneity of events directly, in real time (Vrobel, 2002). A non-fractal observer can perceive only isolated notes in a tune or isolated events in a time series. Succession, simultaneity and memory formation would be unknown to him, as he would not be able to generate a Temporal Fractal Perspective through continuous nesting. The non-fractal

observer would live in an eternal succession of unconnected Nows, in which no learning or reflection could take place.

Temporal Natural Constraints

A fractal observer who has learned to differentiate LODs of a multi-layered signal has generated a Temporal Fractal Perspective and is thus capable of registering and identifying scaling structures in real time. Such structures, which appear on various nested LODs, abound in nature (Olsen et al, 1987). These natural scale-invariant intervals are usually limited – self-similarity exists only in certain domains over a limited interval of time (such as overtones of a fundamental frequency). They are also confined to a limited number of levels of description: There is an "outer" LOD, which hosts the structure covering the largest interval in Δt_{length} and an "inner" LOD, at the top end of the scaling cascade. This smallest structure covering the shortest interval in Δt_{length} is a limitation on the structurability of time by the observer, and may be regarded as an *atom of time*. It is a Temporal Natural Constraint (TNC) (Vrobel, 1999).

This smallest structure which recurs on all levels of description I have denoted as the Prime. There are other TNCs, such as Feigenbaum's number, which is a transition rule in Δt_{depth} (the Prime is a transition rule in Δt_{length}). The Prime is the most basic temporal unit within a scaling system. It is extended like Husserl's Now but indivisible in the Bergsonian sense, which implies that it cannot contain further nestings. TNCs such as the Prime allow us to relate the nested LODs to each other through their recurring structure. This may be done by setting the recurring structure of the Prime as a constant. This Prime Structure Constant (PSC) would act as a translation tool between the LODs within scaling intervals (Vrobel, 2006a).

Fractal Time Condensation as Sheer Simultaneity

If the Prime of a temporal structure is set as a constant, the lengths of time Δt_{length} are condensed on all LODs to varying degrees. Large intervals of Δt_{length} shrink to a fraction of their original temporal extension. The congruence of nested intervals comprising the PSC causes a change in perspective on the observer's interface, his Now: Condensation is induced – the observer seizes at a glance the PSC on intervals of varying Δt_{length}.
A non-fractal observer would not be able to induce condensation, as he lacks a basic prerequisite: nested LODs. A fractal observer, who has generated nested LODs, is in a position to identify correlations between both successive and simultaneous events in real time. After registering and identifying a Prime, he may set it as a constant. This will modify the structure of his interface (his Now), which will then contain the PSC, allowing him to observe a condensed version of originally long intervals in Δt_{length} (Vrobel, 2005).

A new kind of relativity can be said to result: for the observer, time is distorted with respect to the PSC. TNCs act on a system like temporal gravitational lenses on the observer-world interface by inducing a condensation scenario (Vrobel, 2000).

Condensation may be measured in condensation velocity, v(c) and condensation acceleration a(c). If LOD2 ⌒ LOD1 (⌒ denotes *nested in*), the quotient of Δt_{length} of LOD1 and Δt_{length} of LOD2 equals the condensation velocity v(c). This presupposes, however, that the LODs involved may be translated into each other by means of a PSC. For scale-invariant structures, v(c) is identical with the scaling factor. Multifractals would be defined by $a(c) \neq 1$ (Vrobel, 2006b).

Familiar and Non-Familar Phenomena Reinterpreted

The phenomenon of the missing fundamental is well-known and is applied in the construction of musical instruments and telecommunications. It is usually explained as being the result of our brains calculating the difference in frequency from the relations of the overtones and thus calculating the lower overtones and the fundamental frequency. This performance may, against the background of my Theory of Fractal Time, be interpreted as an observer-induced condensation.

As an observer with a temporal fractal interface is in a position to relate to the outside world in terms of the PSC (the sinusoidal wave recurring on all levels of description in the nesting cascade of his Now), he may extrapolate from multi-layered signals and complete the interfacial nesting cascade. This results in the observer hearing the missing fundamental as well as the missing overtones, although they are physically not present. This occurs although his temporal window to the world, his Now, is only extended far enough to host the overtones, not the embedding fundamental frequency (which covers a much larger temporal interval than the nested overtones). As this larger interval of the fundamental frequency is generated by the observer within the smaller interval of the overtones, he has included temporal extensions which exceed the temporal interval of his Now in Δt_{length} (generated by the overtones). The observer therefore catches a glimpse of his immediate temporal environment – the lower end of the nesting cascade – by inducing condensation. To induce condensation is to generate sheer simultaneity by translating nested scaling structures in Δt_{depth}. Condensation is a non-temporal access to embedding intervals. The observer's brain extrapolates from the condensation velocity and thus generates the missing frequencies.

An experimental result which shows that fractals such as representations of the Mandelbrot set are more efficient in evoking neural synchrony and binding than other stimuli, such as Kanizsa figures (which make the observer perceive illusionary contours as a result of a completion correction process), may also be interpreted as a condensation scenario.

Erimaki et al investigated EEG responses to complex fractal stimuli (Erimaki et al, 2006). They showed that there is an increased synchronization of the EEG activities over the parietooccipital areas (compared to synchronization occurring when the subjects looked at a simple overlapping pattern and a Kanizsa figure). Synchronization Likelihood (SL), a measure of linear and non-linear interdependencies between EEG channels, was used to compare results. Not only for gamma-1 and gamma-2 bands was an increase in SL observed, but also for broadband SL, which points to a frequency-independent, more complex pattern of interdependencies.

These findings of frequency-independent interdependencies may also allow the interpretation of binding and synchronization as being the result of observer-induced condensation. This interpretation, however, is far more speculative than that involving the missing fundamental, as mere correlations between neural activity and cognitive performance do not necessarily imply a causal relation. Moreover, the Mandelbrot set does not display an exact scaling structure: its self-similarity is rather intuitive. Possibly, this intuition is a result of the structure of the observer's fractal temporal perspective, which even takes into account self-similarity without an exact scaling structure (as is present in the example of overtones and the missing fundamental), as it has been exposed to natural self-similar structures occurring in natural patterns. Furthermore, the observer's internal structure and dynamics also display scaling structures (Olsen et al, 1987).

Erimaki et al also suggest that the increased synchronization they observed when subjects were exposed to an image of the Mandelbrot set may provide a neurophysiological basis for the observation that aesthetic perference is given to fractal images (as opposed to non-fractal ones). This suggestion supports the idea that an observer's temporal fractal perspective, which has been shaped as a result of a selection process as well as of individual experience, generates a decomplexified version of the world if exposed to fractal patterns (Vrobel, 2006d). If the observer's interfacial structure matches that of an incoming multi-layered signal, he may be able to disentangle this signal simultaneously on several nested LODs. This would result in the generation of a higher degree of simultaneity than the perception of events on one LOD, which have to be stretched out in Δt_{length}, thus creating succession. If the brain can calculate the condensation velocity, the perception of a multi-layered, nested signal takes less time in Δt_{length}. It happens in the dimension of Δt_{depth}, thus generating simultaneity. Sheer simultaneity would be experienced by an observer whose fractal temporal interfacial structure is in a one-to-one mapping with the outside world.

Conclusion

Against the background of my Theory of Fractal Time, phenomena such as the missing fundamental and findings in synchronization may be interpreted as being the result of observer-induced condensation. Generating simultaneity by nesting congruent structures allows the observer to catch a glimpse of his immediate temporal embeddings. This widened perspective resulting from a condensation scenario is usually limited to a self-similar domain in a time series (a limited nesting cascade such as the frequency spectrum of a musical note). It is conceivable, however, for the observer to structure his temporal fractal perspective to the point of total congruence with the outside world.

A condensation velocity which equals the scaling factor is the most promising congurence candidate. It would induce sheer simultaneity – a non-temporal access to the world. However, even limited self-similar domains and fractals which do not display complete self-similarity may trigger a limited condensation scenario, if the observer's temporal fractal interface matches the LODs of the multi-layered signals perceived.

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