Adaptive Tension Systems: Fields Forever?

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Abstract

After all, how could it be possible that all cognitive functionalities of holistic nature (from associations to consciousness as a whole) were explained in terms of hierarchic data manipulation and filtering only? Still, this is what the contemporary neural and cognitive models propose. In the framework of Adaptive Tension Systems, however, there emerges yet a higher level: it seems that the orchestration of neuronal activities gives rise to *fields* that reach over the underlying physical system, making it perhaps possible to explain *resonance* among the activated structures. Matched vibrations seem to exist everywhere when living systems interact.

1 Introduction

Many beliefs from 500 years ago seem ridiculous to us — at that time, alchemy was a hot topic; divine explanations were just as valid as (proto)scientific ones. Still, the human brain has not changed, those people were just as smart as we are now. In fact, they had more time to ponder, and, really, in many cases thinking at that time was deeper than what it is now.

How about *our* beliefs as seen 500 from now in the future? Even though we know so much more than the medieval people, it is difficult to imagine what we cannot yet imagine. And, indeed, because of the new measurement devices and research efforts, the number of "non-balanced" observations and theories is now immense. There are many fallacies and logical inconsistencies in today's top science — many of these paradoxical phenomena are related to the seemingly clever orchestration and control of complex processes. What comes to very elementary chemical systems, there already exist plenty of mysteries:

> There are as many different functionalities of proteins as there are genes. How can a protein do what it does as there is only the electric charge field visible to outside environment, with only attractive and repulsive net forces? How to explain the decrease in activation energies caused by the enzymes, and how to explain protein folding? Further, what is the nature of coordination in reaction chains that are involved in gene transcription and translation processes?

How can a molecule implement the "lock and key" metaphor when there is no pattern matching capability whatsoever available — it is like a blind person trying to recognize a face of an unknown person by only using his stick?

All of the above phenomena can of course be reduced back to the properties of molecules and the nature of bonds therein, but one is cheating oneself if one thinks that today's quantum mechanics can ever truly explain the complexity. One needs "emergent level" models. What this means, what is perhaps the nature of such higher-level models, is illustrated in what follows.

2 Case of molecules[1]

In the previous paper in the series (*Adaptive Tension Systems: Towards a Theory of Everything?* in this Proceedings) it was observed that the framework of *adaptive tension systems* (also known as "elastic systems") (Hyötyniemi, 2006) can perhaps be employed to model molecular orbitals. That model is so simple that further analyses become possible.

2.1 Protein folding, RNA splicing, etc.

All genetic programs are manifested as proteins being products of a complex process of DNA trancription and RNA translation. The proteins are used either as building blocks themselves or as enzymes catalysing further reactions. The DNA, and after that RNA, only

[1]As noted before, these studies of the quantum realm are somewhat heuristic; perhaps they still illustrate the possibilities of the "new science"

determines the linear sequence of amino acids, the formation of the three-dimensional structures taking place afterwards. It is the physical outlook, or *folding* of the proteins that is largely responsible for their properties. Because of its importance, this folding process has been studied extensively, mostly applying computational approaches. But no matter how heavy supercomputating is applied the long-range interactions cannot be revealed or exploited when these long-range effects are abstracted away to begin with in the standard molecular models.

This protein folding seems to be only one example of a wider class of phenomena: Intra-molecular affinities have to be understood to master many different kinds of processes. For example, study *RNA splicing*.

In eukaryotic cells, the gene sequences in DNA contain non-coding fractions, or *introns*, in addition to the coding ones, or *exons*. During the processing of pre-mRNA into the actual messenger-RNA, the non-coding portions are excluded in the process of *splicing* where the exons are connected to form a seamless sequence. The splicing process does not always produce identical messenger-RNA's, but there are alternative ways — sequences can be interpreted as introns or as exons in different environments. Nature has assumedly found this mechanism because it offers a flexible way to alter the gene expression results without having to go through the highly inefficient route of evolving the whole genome. However, today these mechanisms are still very poorly understood. Because there is no central control, it is evident that the locations that are to be reconnected need to attract each other. Again, it would be invaluable to master the attractions and repulsions among the atoms in the molecule.

The above questions are just the beginning. There are yet other mysteries in today's biochemistry, many of them related to the nature of catalysis in enzymatic reactions. How is it possible that the enzyme molecule, just by being there, is capable of reducing the activation energies so that a reaction can take place?

And what is the nature of the Van der Waals bonds among molecules?

It seems that the neocybernetic model can offer new insight into all these issues. Repulsion and attraction among atoms in molecules, as well as activation energies, are determined by the interplay among orbitals, and if the presented model applies, the properties of molecules can be studied on the emergent level. As presented below, when applying the "holistic" view of molecules as electron systems, orbitals extend over the whole molecule. All atoms count, and it becomes understandable how atom groups far apart can alter the chemical properties of the whole molecule.

2.2 Closer look at orbitals

According to the neocybernetic orbital model, the electron distribution along a molecule is determined by the covariation structure of the interaction among the atomic nuclei in the molecule; the "discrete orbitals" are the eigenvectors ψ_i of that interaction matrix, the elements of the vectors ψ_i revealing around which nuclei the orbital mostly resides (or where the "electron probability" is concentrated). Eigenvalues λ_i tell the number of electrons within the orbitals; simultaneously, the values λ_i reveal the energies E_i characteristic to each orbital, $E_i = \lambda_i^2$.

The time-independent Schrödinger equation that was discussed is not the whole story. As explained, for example, in (Brehm and Mullin, 1989), the complete wave equation consists of *two* parts, the other being time-dependent and the other being location-independent, these two parts being connected through the energy eigenvalues E. In traditional theory, the complete solution has the form

$$\begin{aligned} \psi(x,t) &= \psi(x)\,\mathrm{e}^{\sqrt{-1}\ 2\pi Et/h} \\ &= \psi(x)\,\sin(2\pi Et/h), \end{aligned} \tag{1}$$

where $\psi(x)$ is the time-independent solution, h is the Planck's constant, ant t is the time variable. Because of the imaginary exponent, the time-independent part oscillates at a frequency that is determined by the energy level of the orbital. Now in the case of discretized orbitals, one can analogously write for the orbital vectors characterizing the complete solution as

$$\psi_i(t) = \psi_i\,\sin\frac{2\pi E_i t}{h}, \tag{2}$$

where ψ_i is the orbital solution given by the neocybernetic model. Each energy level also oscillates with unique frequency. This means that the orbitals cannot interact: because the potentials are assumed to be related to integrals (averages) over the charge fields, there is zero interaction if the fields consist of sinusoids of different frequencies. On the other hand, if the frequencies are equal, the time-dependent part does not affect the results at all.

This way, it seems that each energy level defines an independent interaction mode, and these modes together characterize the molecule — and also each of the individual atoms within the molecule. Thus, define the matrix Ψ where each of the columns represents one of the atoms, from 1 to n, the column elements denoting the contribution of each of the orbitals, from 1 to n, to the total field in that atom:

$$\Psi(t) = \begin{pmatrix} \psi_1^T(t) \\ \vdots \\ \psi_n^T(t) \end{pmatrix} = \left(\begin{array}{c|c|c} \Psi_1(t) & \cdots & \Psi_n(t) \end{array} \right).$$

So, rather than characterizing an orbital, Ψ_j represents the properties of a single atom j within the molecule. The key point here is that the elements in these vectors reveal the mutual forces between the atoms: if the other of the atoms always has excess field when the other has deficit (orbitals containing “red” and “blue”, respectively), the atoms have opposite average occupation by electrons, and the positive attracts the negative. On the other hand, in the inverse case there is repulsion among similar charges. These forces determine whether the atoms can get enough near each other to react; indeed, this force is closely related to the concept of *activation energy* that is needed to overcome the repulsion among atoms. In the adopted framework, this activation energy between atoms i and j can be expressed as

$$\Psi_i \Lambda^2 \Psi_j, \tag{3}$$

where the total energy is received by weighting the attractive and repulsive components by the appropriate orbital energies (Λ being a diagonal matrix containing the electron counts on the orbitals).

There are only some 100 different atom types, but it seems that there are no bounds for molecule types and behaviors. The above discussion gives guidelines to understanding how this molecular diversity can be explained and how this understanding can be functionalized. A sequential molecule is like a “string” whose vibrations are modulated by the additional “masses” that are attached along it, and the vibrations determine its affinity properties.

Because of the universal quantization of the energy levels, the repulsions and attractions are, in principle, comparable among different molecules — assuming that the oscillating fields are synchronized appropriately.

2.3 Molecules as “antennas”

How is it possible that there seems to exist an infinite number of catalysts even thogh the number of alternative form for “keys” and “locks” seems to be so limited? The new view explains that there can exist an infinite number of energy levels, and thus there can exist an infinite number of attraction patterns, each molecule having a “fingerprint” of its own.

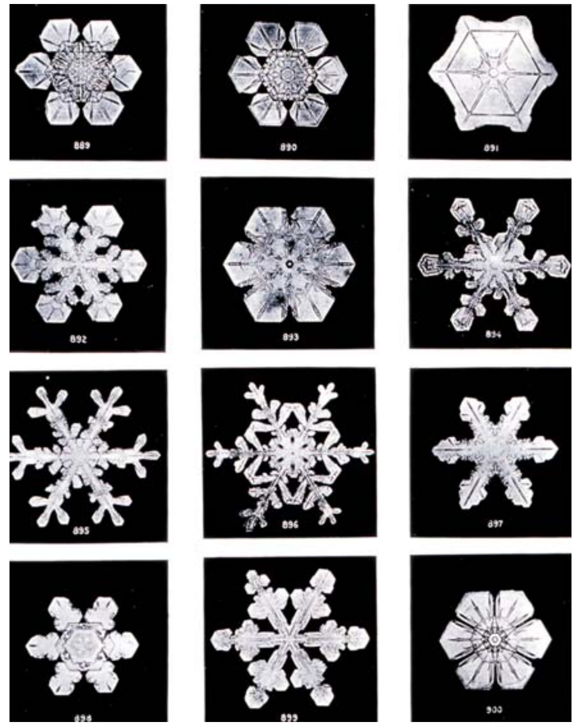

Figure 1: Looking at the marvels of nature is still the key towards enlightenment

Indeed, the attraction patterns determine a field around the molecule, where the structure of the field is very delicate, being based on vibrations. This field, and the energy levels contained in it, is perhaps best visualized in frequency domain, so that each molecule (and its affinity properties) can be described in terms of its “characteristic spectrum”. Actually, the situation is still more sophisticated, as there are different fields visible in different directions, depending of the outermost atoms. Because the molecules behave like *directional antennas,* there is possibility to reach *alignment of structures.*

As the energy levels of the molecule specify its oscillatory structure in the quantum level, neighboring molecules can find synchronization. There emerges resonance, and the molecule-level structure is repeated and magnified, being manifested as a special type of homogeneous chrystal lattice, or — why not — as a tissue in the organic case, where there can be a *functional lattice.* As compared to standard solid-state theories, one could speak of *structured phonons.* The resonances define a Pythagorean “harmony of the spheres”, cybernetic balance of vibrations.

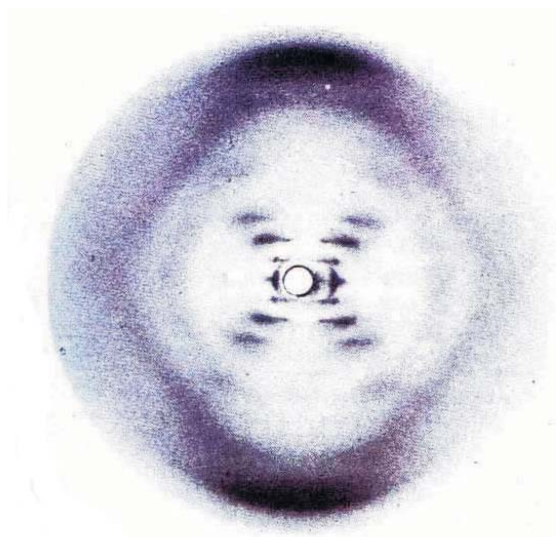

Figure 2: Rosalind Franklin's X-ray diffraction image of DNA. Perhaps the crystal structure can be applied for analysis of the underlying fields?

As an example, study a *snow crystal*. How to explain the many forms it can have, and how to explain its symmetry? Today's explanation is that as the crystal was formed, each part of it had experienced exactly the same environmental conditions, and that is why there are the same structures in each part. However, this explanation is clearly insufficient, as different parts of the snow crystals are in different phases of development (see Fig. 1). Still, each part struggles towards identicality and symmetry — this can only be explained if there is a very delicate phonon field extending over the whole macroscopic crystal. It seems that there are no theories today that could address such issues, except the neocybernetic framework.

What kind of tools there are available for analysis of such phonjon fields? The fields are reflected in the iterated structures in the crystal lattices, and perhaps for example 2-dimensional (or 3-dimensional) Fourier transform can be applied; in paractice, such iterated structures can be seen in X-ray diffraction spectra of solids (see Fig. 2).

3 Universality of fields

Is it just a coincidence that the *same* kind of analyses seem to be applicable to all kinds of cybernetic systems — or are such vibration fields characteristic to complex systems in general? This question is motivated in what follows.

3.1 Resonances in brains?

Why did the nature develop such a complicated system for transferring information within the brain? The neural activations applied in typical neural network models are just an abstraction, and on the physical level, signals in neurons are implemented in terms of pulse trains. This is a very inefficient way of representing simple numbers, is it not?

The more there is activity in a neuron, the more there are pulses — or the higher is the pulse frequency. The alternative way of characterizing the pulse train is not to use the pulse count, but the "density" of pulses. Indeed, in the same manner as in a cybernetic molecule model, high "energy" is manifested as high frequency. Activated neuron structures thus vibrate; if there are substructures, there can be various frequencies present simultaneously. If there are optimized neural structures for representing different kinds of cognitive phenomena having characteristic substructures, are the resulting vibration spectra not characteristic to them? Can the spectrum alone (or sequences of successive spectra) represent cognitive structures? Can the the spectrograms that are used to analyze brain waves reveal something about *thinking* really?

Of course, there cannot exist one-to-one correspondence between spectra and neurally implemented networks — but are cognitive structures that are manifested in terms of similar vibration patterns not *somehow* related? And what if structures with similar vibration patterns are capable of exciting each other? Could such resonances be the underlying mechanisms explaining associations, intuition, imagination, etc.? After all, cognition is not only data manipulation; one of the key points is how *relevant* connections are spanned among previously unrelated mental structures.

The field metaphor frees one from the physical realm into another domain. The original constraints of the substrate can be circumvented — for example, the *tree transformations* that are necessary when comparing logic structures are avoided as similar structures resonate wherever they are located in the trees.

Similarly, the spectral interpretation extends the limits of mind outside the brain: like olfactory signals are an extension of chemical cybernetics in lower animals, auditory signals with spectra are perhaps an extension of cybernetic cognition based on vibrating fields. If harmonies are the way to detect and connect to highest-level cognitive systems, perhaps music can be seen as a universal language.

> It has been said *music* has no universal relevance, it is *beautiful* only to the human ear. But maybe the deepest connection to alien intelligence *is* through music?

It is obvious that *music was there before speech.* And it can be claimed that the "truly natural languages" are still based on melodies. Perhaps the songs of birds are directly connected to their cognitive structures?

We know how individual signal sequences can be transformed into statistical structures, or into neocybernetic emergent models. One of the key problems in these models is that of how to "invert" the process, or how to create individual signal sequences when the model is there, and when there is some known activation inside it — how to explicate the system state? Rather than having to code the system state into one-dimensional utterances, into language, it might be easier for some artificial mind if the vibration structure could be directly communicated, perhaps in terms of nonverbal whining and humming?

3.2 Hierarchies of catastrophes

Spikes in neurons are caused by activity first cumulating and then abruptly going off; in a way, one could speak of *local collapses* or *catastrophes.* The role of catastrophes in cybernetic systems is discussed closer in (Hyötyniemi, 2006).

As models become more and more optimized, they typically become more and more sensitive to unmodeled disturbances. What is more, adaptive controls tend to eliminate from the environment the information that they forage on, thus eliminating their own "nourishment". As this happens, the systems sooner or later collapse back towards the chaos of non-models, to start their adaptation again from some less-developed state. Neocybernetic systems with self-controls are no exception of this general rule. During evolution such catastrophes take place with more or less constant time intervals.

As seen from outside, catastrophes are just noise peaks that deliver *information* for the *higher-level system;* without collapses, there would be no excitation for the next-level systems to exploit. Indeed, in a multi-level cybernetic complex, the variability is caused by a *fractal hierarchy of catastrophes.* As the cycles of catastrophes at a certain level are more or less regular, the observation data, as seen from a high enough standpoint, seems to have a more or less regular frequency structure. This means that the system has a characteristic spectrum.

Only during catastrophes the well-controlled information bursts out from a lower-level system. When creating a compact representation of a complex environment, the essence (?) of the system hierarchy is assumedly captured in the observed spectral structure. This proposes that "the next level" of cybernetic models could be based on signals after temporal (and spatial) Fourier transforms. At least, such spectral analysis is carried out in the ear for incoming auditory signals.

The relevance of frequencies also suggests that in natural systems there is evolutionary pressure towards modeling (periodic) time-dependent signals, not only static ones. This means that various samples of the same variables need to be available; this evolutionary pressure leads to longer-living and more sophisticated systems.

3.3 Analogies again

As has been observed, analogies are a very useful tool when trying to understand behaviors in neocybernetic systems. Indeed, again, when trying to illustrate the frequencies and vibration fields, analogies turn out to be practical. First, take the mechanical *steel plate analogy.* It is evident that when the steel plate is deformed and there is more tension, mechanical vibrations have higher frequency; or when the plate is boomed, the sound is higher. Depending of the other tensions affecting the steel plate, there is a complicated interplay among vibration modes.

Second, study the *electrical analogy.* Those who are familiar with electrical circuits know that oscillations are very characteristic to such systems, and there exist powerful tools for tackling with them. For example, applying *Laplace transform* time-domain signals are transformed into frequency-domain, so that the whole s-parameterized spectrum is operated on simultaneously. In practice, this means that the originally real-valued models become complex-valued, as the parameter s is connected to frequency f through the formula $s = \mathrm{j}\,2\pi f$, where j is the imaginary unit. The *impedances* of systems, or their "stiffnesses" in different frequency bands, can thus be studied formally all at the same time.

And speaking of electrical counterparts, one cannot forget perhaps the best part of the analogy: in the same manner as in a *transmission line*, a system of distributed parameters can be represented in terms of a lumped parameter model, and its power transmission properties can be understood. The theory states that *if neighboring systems are to interchange energy losslessly, their impedances have to be equal.*

3.4 Further cycles

There are also resonances of vibrations in ecosystems. In addition to the "phase-locked loop" of predators and prey, it is very clear that all plants and animals have to adapt to the environmental cycles: summer and winter alternate, as do day and night. One's lifestyle has to adapt to the cosmic frequencies. Indeed, the celestial systems also implement the "neocybernetic field" in the same way as do the molecules and neurons do: the more there is energy, the nearer the orbiting planet is, and the stronger is the force, meaning shorter orbiting time and higher frequency. Lunar motions, etc., only cause higher frequency variation in the energy spectrum of the overall solar system.

On the level of individual cells, additionally, there is the cell cycle, and on the level of individual animals, there is the cycle of birth and death. A local catastrophe is a robust built-in way of regeneration for a population, or deaths give room to fresh individuals. A population wastes individuals to map the "spectrum of the possible" in the environment. At the population level, when there are plenty of individuals, the unsynchronized deaths, or local "ends of the world", are seen only as permanent noise.

Just as in the case of neuronal pulses, at first glance the non-continuous nature of the individual signal carriers looks like a non-ideality. However, it turns out that optimization in general results in some kinds vibrations or *limit cycles*. For example, in artificial dynamic systems where there is no physical need for complex dynamics, cycles still emerge at some point:

1. **Industrial automation systems.** Even though one would like to maintain constant production, external conditions and raw materials, etc., keep changing. To map the area of optimal production, the reference values are tuned up until the process quality starts somehow deteriorating; after that, knobs are turned in the opposite direction. This results in the system more or less cyclically wandering within the operating regime.

2. **Optimized economical systems.** Even though the developments in technologies are more or less monotonous and consistent, overall economy becomes turbulent as there is economical speculation on top of the technical advances. For some reason, all economic booms end in depressions; sooner or later the economy recovers[2]. Indeed, such long-term cycles in economy are called *Kondratieff waves.*

As seen from outside, there are vibration fields with characteristic oscillation patterns also in man-made systems.

[2] Stock market is in balance by definition – still, paradoxically, there is a fractal sequence of collapses taking place all the time

4 Conclusions: *Harmony of Phenospheres*

Pythagoras first spoke of the "harmony of the spheres". He was a mystic, but was he also a visionary? Later, Rupert Sheldrake spoke of *morphogenetic fields*, meaning that "something is in the air": innovations, for example, are easier made if somebody has done that before, no matter if these persons have no contact whatsoever (Sheldrake, 1988). How about telepathy!? One can hypothesize that the cognitive fields extend over one brain; truly, it seems that in *ganzfeld experiments* some support to "brain reading" has been found (Alcock et al., 2003).

In the beginning, the fixed ways of thinking were ridiculed. It is easy to laugh at the medieval beliefs with divine and magical explanations, now when the scientific method has matured and it has shown us the "truth". However, today there still are dogmatic views that cannot be questioned — and what is amusing is that these dogmas are the views of the scientific establishment (see *Adaptive Tension Systems: Framework for a New Science?* in this Proceedings).

Pythagoras and Heraclitus — some of the deepest thinkers lived already 2500 years ago. They believed that there can exist something mystical, some fundamental principles. Were these guys less informed, or were they just less prejudiced?

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