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PATTERN CHEMISTRY OF THOUGHT AND SPEECH

AND THEIR HYPOTHETICAL ANCESTOR

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by Yuri Tarnopolsky

SUMMARY

 The parallel between linguistics and chemistry has been drawing attention since the discovery of the DNA's structure and its ability to carry a protein "meaning." Besides, chemistry uses a particular language (chemical nomenclature) to convert complex non-linear structures into a linear word which can potentially be communicated through speech.

 The present e-paper continues an investigation of thought, language, and conversion of one into the other within the framework of Pattern Theory of Ulf Grenander. This mathematical theory studies structural complexity regardless of interdisciplinary boundaries. It reduces structure to a set of atomic entities selectively connected by bonds, thereby representing observable objects of widest variety, including language and thought, quite like a generalized chemistry. The unusual aspect of Pattern Theory is its metrics which allows for distinguishing between more and less stable structures. Pattern Chemistry focuses not so much on stable structures as on the fleeting transition states between them, similarly to the way chemistry treats molecular transformations, making distinction between fast and slow transformations.

The central ideal of Pattern Chemistry is that complexity in nature and society evolves from simple states changing by simple steps.

Unlike speech, thought is not observable. The paper further explores a hypothetical protolanguage, called Nean, in which the simple elementary thought consisting of two connected entities directly translates into the simplest elementary phrase consisting of two words. Nean sounds like a repetitive random series of elementary doublets. Two doublets with common element can be combined into linear triplets. The paper explores the ability of this inherently both linear and primitive language to express more complex non-linear thoughts by means of the process of linearization. It appears that Nean, subjectively, is quite expressive.

 A computer simulation based on simple principles represents thinking and speech as a competition of alternative thought structures for a spot in consciousness and further generation of linear speech-ready expressions longer than elementary doublets. The story of Three Little Pigs serves as the substrate of the process. The potential of Nean for further complexification and grammaticalization is discussed. Nean is regarded as a point of divergence between thought and speech and origin of the variety of grammars.

CONTENTS

1. INTRODUCTION

This e-paper continues an exploration of Pattern Theory (Ulf Grenander) as generalized chemistry. My previous e-publications are listed in **complexity ,** see **APPENDIX 1.** They are duplicated on SCRIBD and could be found at some other sites on the constantly eroded by the flow of time Web. Referred authors can be also found through Web search.

As there was a common ancestor for humans and apes, there could have been one for thought and speech. How would it sound? What is the difference between thought and speech and, if there is any, how could they have diverged in evolution?

Unfortunately, the sounds of ancient speech cannot be heard. As for thoughts, although it is fortunate for all of us that we cannot "read" or "hear" them, it does not help us with understanding what thought is. By thought we typically mean the content of a verbal expression. Sometimes, however, we are stumbling at expressing our own thoughts.

Turning to origin of language, we must disregard written language and refined educated speech without which Chomskyan analysis would make but a few short steps. For most of history, even after invention of writing, the vast majority of people were illiterate.

I assume that thought and speech are essentially different. Until we decode thoughts, we may not know the truth, but I point to the fact that two people speaking very different languages seem to think in the same way because they can communicate their thoughts in a third language. Did thinking of an immigrant from Russia, like myself, change after abandoning the native language environment and switching to English? After a few years in America, I suddenly noticed that **in my spontaneous thoughts** people from my Russian past, who did not know a word of any foreign language, were speaking English. I am also certain that thinking of a chemist or a fan of music can be mostly non-verbal. I realize that I have no proof of either assumption because I cannot open my mind for the reader. But can I at least **speak** my mind?

I have been interested in those questions for a very long time. The central idea took shape around 1980, which coincided with my discovery of strikingly "chemical" Pattern Theory.

I was greatly influenced by (1) Ulf Grenander's work on GOLEM (*Patterns of Thought*), which I was lucky to watch closely, and (2) the development of the concept of transition state in organic chemistry, which coincided with my years as a graduate student. Some other major influences are:

(3) Manfred Eigen's concept of chemical evolution (since 1971);
(4) The Heraclitean world of novelty (further explored by Ilya Prigogine), as opposed to the logically closed world of Aristotle;
(5) Bourbaki's exotic concept of the scale of sets (rarely, if ever, remembered),
(6) Ross Ashby's ideas of stability and homeostasis (remembered, but not appreciated).
(7) René Thom's idea of most abstracts patterns of change (first abandoned, recently revived, especially by linguists).

My major factual sources are decades of life in both Soviet and American systems, linguistics of dissimilar languages, and the overall history of artificial intelligence and science of complexity, the infancy, promise, and missteps of which I observed live.

Although I am putting forward the **simple** idea that complexity is in fact an evolving **simplicity**, to elaborate this thesis would require a lot of words. I focus here only on some preliminary results, omitting most of the preamble, which can be found in **complexity** . Occasionally I will embed some digressions, as for example:

SOME PRINCIPLES OF PATTERN CHEMISTRY

1. Pattern chemistry is representation of the world in terms of elements and bonds. It is indifferent to the specificity of areas of knowledge, putting on equal basis molecules, thoughts, social and economic phenomena, and anything else having a structure. It lies **within** the much larger domain of Pattern Theory and uses it as a conceptual platform.

2. Pattern chemistry borrows general ideas of Pattern Theory and combines them with the chemical concept of transition state: stable configuration **A** changes into stable configuration **B** through an unstable transition state [**A , B**]. The transition state is irregular in the sense of Pattern Theory.

3. Pattern chemistry is a study of exystems—evolving complex systems. The chemical contribution to the problem of complexity is: **complexity evolves from simplicity in a sequence of simple steps**. If this statement evokes the idea of algorithm, there must be something to it, only without either the programmer or the computer.

4. Pattern chemistry is not supposed to have a closed set of axioms. It places on the foreground the little explored phenomenon of **novelty** (see *The New and the Different*). King Solomon was, apparently, the first neologist, of a negative type.

Exystems are unique, large, naturally (i.e., slowly and spontaneously) evolving systems **open** in both thermodynamic and logical sense. They change while we speak about them, thereby challenging Aristotle and hailing Heraclitus. Generalizing the paradoxical Greek idea discussed by Aristotle in *Ethics*

("Nobody can be called happy until he dies,") the history of the exystem is its only explanation, never complete until the exystem is out of existence, leaving only the shells of its patterns.

The inherent openness of exystems to novelty requires a decisively open mind from a natural scientist because it pulls the rug of theoretical solidity from under the feet and a possible grant together with it. You cannot promise knowledge, only understanding.

I distinguish between **artificial Artificial Intelligence** and **natural Artificial Intelligence.** The former is (1) designed, like a machine, for a specific function, (2) trained, tuned, and managed by human mind and therefore (3) "infected" with ready-made human knowledge. The natural AI is supposed to be launched by human mind as a primitive embryonic system with no specific function and then abandoned by its creator to feed, grow, and seek fortune on its own. The important idea behind this distinction, applicable also to Artificial Life, is that very simple systems can come to being by accident, while complex systems never can. Simple acts do not need a creator.

> NOTE: In the previous paragraph I did not intend an allusion to the Bible. I realize, however, that there is a **pattern**: the natural AI shakes off the blissful somnolence after the first bite of knowledge.

Characteristically, the origin of life used to be a very troubling question for physicists who considered life mathematically improbable (was Gödel's proof ever probable?) , but it is only a technical problem for the chemists whose daily bread is stepwise synthesis of new and never seen before complex molecules from simple ones.

If all this sounds rather grandiloquent, it may be justly disregarded. I am going to present here some synthesized thoughts, which, I believe, have some relation to natural ones.

I have to forewarn that I think and see the world as a chemist, which may be very different from the way other people do. My computer "experiments" are neither true experiments, nor computer models, nor simulations in the area of thought and speech. To be exact, they are just illustrations of my own thinking.

2. THE NEAN LANGUAGE

What happens when a two or three year old child listens to an illustrated book "*The Three Little Pigs*" read by a parent?

> There was an old sow with three little pigs and as she had not enough to keep them she sent them out to seek their fortune. The first that went off met a man with a bundle of straw and said to him, "Please, man, give me that straw to build a house." Which the man did and the little pig built a house. Presently came along a wolf and knocked at the door and said, "Little pig, let me come in." The pig answered, "No." The wolf then answered to that, "Then I'll puff and I'll blow your house in." So he puffed and he blew his house in and ate up the little pig.

The child might have never seen live sow, piglets, straw, and wolf. Some words, such as "poor" or "fortune" could be just sounds of parental babble. While animals and things are represented by pictures, some actions may be rendered only by words. One of them, like "blow" may be familiar from blowing soap bubbles, others, like "send away" may not.

Let us further modify the situation by placing the child inside a cave where ancient humans are right in the process of developing intelligence and mastering language. They are telling stories to children and each other. How could their language sound in *situ nascendi*? What trace does the story leave in the previously empty mind? What is the difference between thought and speech? How could this difference emerge?

While approaching those questions a few years ago, I called the hypothetic primitive language Nean. The name Nean honors the Neanderthals, but does not imply that they were speaking it or speaking at all. I believe, however, that early humans did, as does a two year old child, who "combines words into a short sentence-**largely noun-verb combinations**" and only by the third year strings together at least three words.

CONCEPT OF RECAPITULATION

> Although the universality of the concept of recapitulation—repetition of evolutionary stages in individual development ("ontogeny repeats phylogeny")—has been disputed, its general validity is widely recognized. In terms of pattern chemistry, recapitulation means that the pattern of complexification could be the

same in all exystems. In terms of embryology it may mean that the order of the evolutionary path is partially recorded in the individual genome. We can say this about a pattern, not configuration. Individual human life in modern society is an example of exystem, too.

Nean consists of single words (singlets), doublets, and, at most, triplets. Unlike modern developed languages, which convert the often branching, non-linear, fuzzy, and meandering thought into a linear speech along convoluted grammar rules, Nean is straightforwardly linear and, I suggest, allows us to literally hear the thoughts which do not depend on any modern or primitive language. Nean opens a window into thinking not obscured by the complexity of modern language, which overwhelms even some heads of states. It is not infected either with intelligence or with ignorance. Nean is the language of simplicity, not complexity. Its chemical flavor consists in a potential for unlimited complexity in further evolution.

The closest "adult" approximations to Nean are pidgin languages and early stages of mastering a foreign language by adults.

At the opposite end of the scale of complexity we find the language of philosophers and most writers, as well as scientists, which would be impossible without writing and ability to keep long strings of words on paper or computer screen for an indefinite time, all the more, edit them.

SIMPLICITY IN NATURE

Simplicity means building complexity from a simple beginning through a sequence of very simple steps fitting a limited number of patterns. Related mathematical objects are recursive functions, complete mathematical induction, and, especially, fractals. The entire enormity of chemical structures, from many monomeric natural components of plants and animals to the monotonous complexity of biopolymers, consists of simple elements and can be generated by simple operations of synthesis, predominantly, within the environment of a single atom or two, and essentially reduced to breaking or locking up a few bonds.

Organic chemists, as also, probably, architects, strongly prefer visual perception to verbal communication. As a chemist, I favor demonstration over explanation. **Figure 1** presents three substances found in plants. Chemists place them all in one class: terpenes (from *turpentine*). Terpenes and their derivatives terpenoids (e.g., camphor, menthol) form a wide, motley, and nice smelling variety, see **Gallery**. What can they have in common and how could plants be so chemically sophisticated as to produce them?

The carbon skeletons of terpenes (and natural rubber) are built of the same relatively **simple** isoprene unit : five carbon atoms with a fork at the end. They are all related by chemical origin and properties and can undergo dramatic, dizzying rearrangements of their skeletons which turn one terpene into another. Steroids,

produced by both plants and animals, have the same isoprenoid regularity of the skeleton. A single simple principle explains the diversity and its origin in nature. To borrow Richard Dawkins' metaphor of Blind Watchmaker, the nature, having once invented a single isoprene gear, found a way to all terpene and steroid "clockworks," some of which endow humans with the joy of sex.
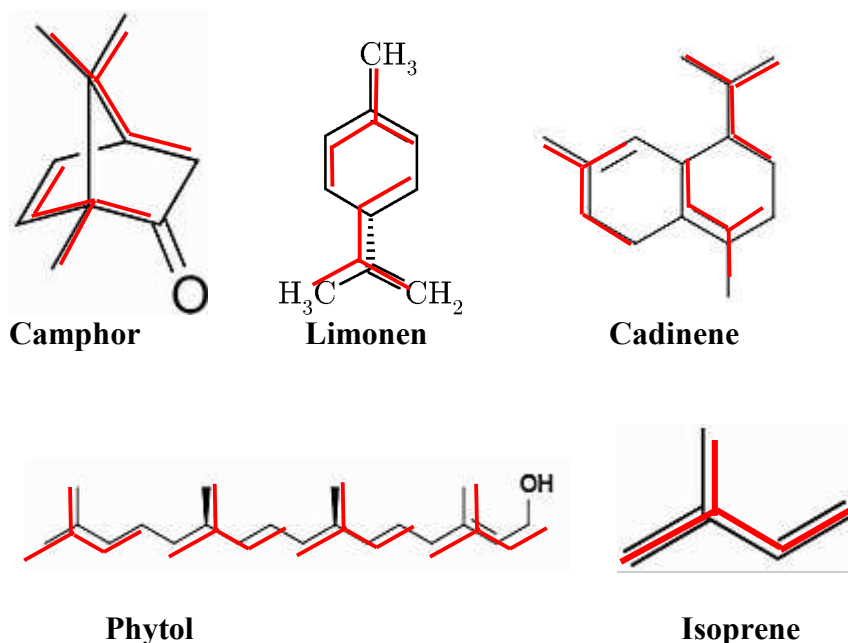

Camphor   **Limonen**   **Cadinene**

Phytol   **Isoprene**

Figure 1: **Simplicity behind complexity. Terpenes are a richly diverse class of natural components of plants, all built of the same isoprene unit**

From pattern-chemical view, both thought and language emerged from the once invented single connection in the nervous system: **A—B** .

I want to draw attention to the essence of pattern perception of the world: it transcends the borders between disciplines of knowledge and different domains of reality. The molecular chemistry of terpenes and steroids is of no significance whatsoever for linguistics and *vice versa*. When, amazed by the richness and diversity of the world, we try to understand how **it all** is related and how **it all** was "created," we need some vantage point from which **it all** can be seen. This point has always been in the realm of poetry as art and is what Pattern Theory offers as science.

3. LINEARIZATION: FROM THOUGHT TO SPEECH

Nean starts with the smallest nuclear particle of complexity: a bonded pair.

I translate the pig story into the "classic" doublet (two-word phrase) dialect of Nean:

> **Sow** is **old. Sow** has **pig**s. **Pig**s are **three.** Their names are: **First** is **pig.
> Second** is **pig. Third** is **pig. Sow** is **poor. Sow sent**s. **Sent**s **first. Sent**s
> **away. Sent**s **seek. Seek fortune. First meet**s. **Meet**s **man. Man** has
> **bundle. Bundle** of **straw. First say**s. **Say**s to **man. Man give. Give
> straw. Give** to **First. First build**s. **Build**s **house, Wolf come**s. **Come**s to
> **house. Wolf ask**s. **Ask**s **First. Ask**s to **enter. First say**s. **Say**s **no. Wolf
> blow**s. **Blow**s **house. Wolf eat**s. **Eat**s **First.**

I have added some words and endings in small print just to illustrate what Nean ignores, but I will further do without them, like the standard written Hebrew and Arabic do without vowels.

Nean is understandable not from a podium but in a context of a concrete situation. Its only rule of grammar is that the doublet can be ordered, so that first ask and ask first may have different meanings in a particular local dialect of Nean.

I advise considering words of Nean simply as symbols, and I would prefer pictograms like 　　▓ 🚶 🐺　　 to English words. Ideograms, like the Chinese 狼 , wolf, 猪, pig, 男 man (male, "the one who toils in the field"), and 福, fortune, are even better because they are mind-sterile for a non-speaker of Chinese. Numbers are the best, but only for computers talking to each other. I will use English words instead of numbers, although my computer program operates with numbers assigned in a particular order, which I will further describe.

The phrases of Nean are singlets, doublets ("classic, pure" Nean) to which the "Late" decadent Nean adds triplets. The triplets are formed by a transformation rule which is a kind of "pattern-chemical" reaction:

wolf—eat + eat—first → wolf—eat—eat— first → wolf—eat— first

Triplets and doublets can be further **polymerized** into longer phrases, but what for with no **time** on a hunt or too much of it in a cave? If you get used to Nean, it sounds remarkably expressive and quite capable of nurturing its cave Hemingway.

COMPLEXITY OF LANGUAGES

In post-Nean era, agglutinative languages (like Latin and Russian) acquired a freedom of word order, which they much later used for expressing fine, even redundant, nuances of speech. Probably, all languages at an early stage were synthetic, richly inflected and complicated, as opposed to analytic ones. The Old English was more complex and had a looser word order than the modern English, the Old Church Slavonic was even more complex than Russian, and Sanskrit was much more intricate than its posterity.

Why could complexity of language, supposedly, evolve through an explosive growth and then subside is an interesting question. I believe the answer might be found in the hypothetical area of linguistic thermodynamics, which would approach language evolution as any natural process (not a completely new idea after all principles of economy, least effort, etc.). General laws of nature are the only reliable guides into extinct past.

We access extinct languages through their **written** fossils. Writing is a natural jungle-like habitat for complexity. Tribal polysynthetic languages, like the Navajo, which beats all records of complexity, typically developed in relatively stable, insulated, or widely dispersed types of environment (large planes, mountains, islands) in tribal societies with little mixing. A writer is also a loner, as compared with the buyer-seller pair at the marketplace. We can only speculate about the evolution of linguistic complexity, however. Some new insights into this problem could come form studying the relative complexity of language, i.e., the ratio of complexity of language to socio-economic complexity, taking to account the socio-economic temperature. We might find then enough simplicity in Navajo and the Inuit dialects.

Of course, I express my opinion not as a linguist, but as a pattern chemist. The keystone principle of pattern chemistry, formulated only in 1970's (Ilya Prigogine) is: the processes in living nature, human history included, are radically different from the processes in inanimate nature. The exystems (organisms, societies) stay far from equilibrium, while natural inanimate systems are either as close to it as possible under circumstances or slowly moving toward it. Besides, ethnic mixing, the pattern counterpart of physical heat and chemical stirring, destroys stagnant communities and any melting can only simplify a system.

Probably, the principle of stringing words together, invented with Nean, turned out too successful: everything on hand was glued together. Here is an example that fascinates me, see **Table 1**.

Among blue objects, in Russian, flag is masculine, its English equivalent of personal pronoun is he. Sea and sky are neutral, it, and cup is a she.

Table 1: **Parallelism of personal pronouns and adjectives in the Russian language**.

English	Russian: declension of "he" and "blue flag"			
he	on (he)	siny flag (blue flag)	он	синий флаг
to him	ye**mu**	sine**mu** flagu	е**му**	сине**му** флагу
about him	o n**em**	o sin**em** flage	о н**ем**	о син**ем** флаге
with him	s n**im**	s sin**im** flagom	с н**им**	с син**им** флагом
without him	bez n**ego**	bez sin**ego** flaga	без н**его**	без син**его** флага

Why in the world should the endings of **adjectives** copy the endings of **personal** pronouns? I see it, half-seriously, but not half-jokingly, as a relic of Nean:

English: I go to blue sea
Classic Nean: I-go **go-to** to-it **it-to** to-it it-blue blue-sea **sea-to** it-blue **blue-to** to-it.

For some reason, the spoken language tends to eliminate the doubling of syllables in words. This phenomenon is called haplology ("saying a half of it"), which the term itself illustrates: hap**lol**ogy. Haplology of "haplology" would produce "hap**lo**gy," but writing preserves the longer form of an exotic word. If "haplology" were a common fruit, it would collapse into "haplogy." Probably, a longer word takes more time to say and this is why a compressed version wins the competition with the longer one: it is, in chemical parlance, more **stable**, or, in physical parlance, has lower energy, and, in pattern-theoretical parlance, is more probable.

Evolution of language, as any natural evolution, is a never-ending walk to resting places of stability through the rough and uncertain terrain of transition states. This, of course, is only a hypothesis and we have to wait for somebody to develop thermodynamics of spoken language to see if it makes sense. It certainly makes as much sense to say **wolf-eat-first** instead of **wolf-eat-eat-first** as to say **laundromat** instead of **laundry automat** even if you are not in a hurry.

REDUPLICATION

Accidental doubling of syllables in haplology does not carry any semantic or grammatical load. On the contrary, **reduplication**, which on the surface is the

same, carries a function. It can be an expression of plural, as in Indonesian (*orang-orang*: people), or of a some special degree of quality, as in emphatic colloquial Russian (*bely*, white, *bely-bely* , perfectly, amazingly white, *idet*, walks, *idet-idet,* walks for a long time, especially in folklore) or standard Thai (*uan*, fat, *uan uan*, very fat). So, regarding the pig story, **eat-eat** could be retained for expressing either speed of eating or its shocking cruelty.

Nean is the language of thought in the sense that it expresses the thought directly by an ordered linear string of words. More exactly, Nean preserves the **topology** of thoughts, so that the speaker literally speaks his mind. There is, however, an important and instructive chemical complication when we attempt to linearize doublets into triplets.

How can we combine, compress, and line up the thought represented by the following pairs of doublets or even all four of them?

<p align="center">sow poor , sow sent or sent away , sent seek</p>

Between the initial state of the thought consisting of two doublets and the final linear triplet of speech lies the nonlinear—because of the word order—transition state.
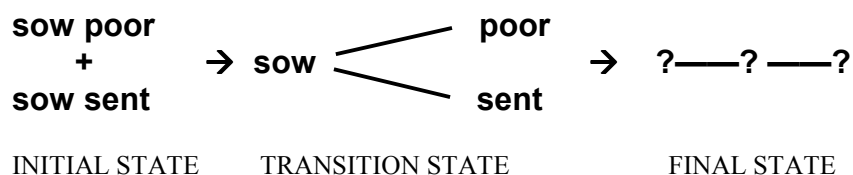
We cannot linearize it by the rules without either reversing the word order (**poor sow sent** or **sent sow poor**) or breaking up one of the doublets (**sow poor sent** or **sow sent poor**).

This is exactly the point at which the evolutionary ways of thought and speech must diverge.

Thought is a state of mind, a mixed bag (not the "bag" of set theory) of singlets and doublets (can of worms is a better metaphor). There are different ways of linearization and different languages deal with the problem differently: **sow poor sent** can be standard in French (*La **truie pauvre** a envoyé le cochon*), and **poor sent sow** is not good, but still possible in Russian, something like: "Disappointed, went she home." Isn't it possible to say in English, "School is almost done! Oh, so happy away we go to college?" We are so **excited** (abstract temperature of thinking is high) that we do not care about grammar anymore: the rules melt down. Neither a natural process nor an artificial one is possible without change in energy or entropy or sensitivity to temperature.

Regarding the mind, we deal there with configurations and patterns which cannot be pored from a bottle and put into a flask, like chemicals, in zillions of tiny copies. We cannot talk about symbolic transformations, which I call "thinking," in exactly the same manner as about molecular transformations. They are not dynamic systems in physical sense. Events in exystems are Heraclitean: singular and happening only once through the timeline. Ilya Prigogine formulated this property, controversially, but neatly, as indeterminism, not in quantum-mechanical sense, of course.

Our pattern-chemical explanations by necessity are rather metaphoric and not rigorous, but to what exactly degree is an important separate topic which I am not yet prepared to systematically approach.

ENTROPY AND INEQUALITY

To give some hints, we cannot chase probabilities in unique and singular acts, with no actual statistical observations. Entropy without probabilities is hot air, even though initially it was a macroscopic thermodynamic parameter of hot air. We ask what entropy is and hear "uncertainty." We ask what uncertainty is and hear "entropy." This is why I, under an approving look of Aristotle, attempted to purge entropy from pattern-chemical language in *Introduction to Pattern Chemistry*, substituting **inequality of distribution** for it. For our purpose, Jini coefficient is fine, even though it does not bring a dime. It does not take it away either.

In the language of "simple reasons," the non-linear transition state is a higher barrier to speech simply because it takes time to make a choice. While the hunter is thinking how to warn his partner about a saber-tooth tiger, the unthinking tiger will come to instinctive decision much faster. Politicians, expected to be tigers, usually pay small political cash for "dithering."

The direction of the post-Nean evolution of language splits: one route goes toward long-distance fixed word order or affixes (Velcro fasteners between words), the other leads to the fixed word order and shorter sentences to preserve it. In pattern-chemical terms, both offer **catalysts** for linearization of thought. Grammar is a typical catalysts: it can be used again and again without losing its properties, while slowly evolving further, most probably, toward simplification, until literacy brings its evolution to a halt (and texting pushes its further).

However simple it is, the Nean has an obvious potential for increase of complexity.

Simple thoughts: first meet. meet man. man bundle. bundle straw.

Composite thought: first meet man bundle straw.

Synthesis of modern speech as linear composition:

first meet-s a man with + man with a bundle of (something) + bundle of straw

→   **first meets a man with a bundle of straw.**

"First meet man bundle straw" is still Nean, but on the way to complexity. The original simple doublet Nean version looks understandable enough, but I am afraid to infect my model with human predilections. With all the precautions regarding sterility, objectively, I can see that the chain of four doublets "**first meet, meet man, man bundle, bundle straw"** is longer than the single quartet   "**first meet man bundle straw** " but the linearization is straightforward: the speaker of Nean has only to **speak his mind** to be understood in context.

It is different with the poor sow. The synthesis ("de-duplication") produces a non-linear thought, **Figure 2**.

After the **de-duplication**, the non-linear configuration still must be linearized some way. This is how diverse grammars emerge and those which ensure more stability at the marketplace win.

My intent, however, is to stick to Nean and try to extract as much linearity from it as possible. As a chemist, I want to fill up a beaker with words and see what kind of chemical reaction can happen between them and whether I can get any composite thought from the mixture without the germs and enzymes of my own language and intelligence. The computer illustrations, therefore, consist of three parts: **LISTENING** (filling up the beaker), **THINKING** (mixing and linearizing), and **SPEAKING** (generating linear output). The graphic output will even look like a beaker.

**sow poor + sow sent +
sow sent + sent first +
sent away + sent seek +
seek fortune**

poor

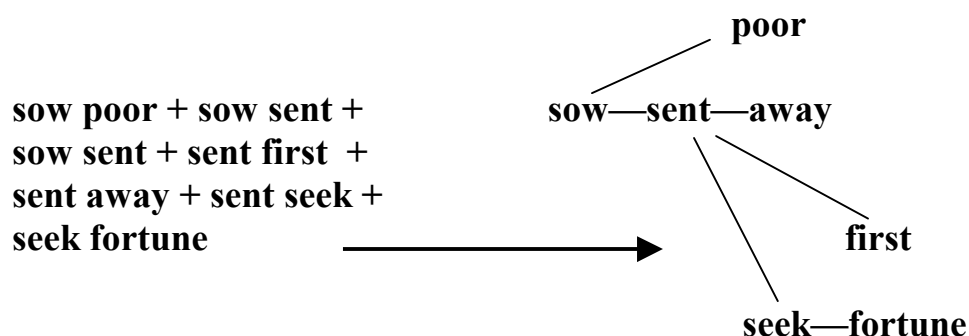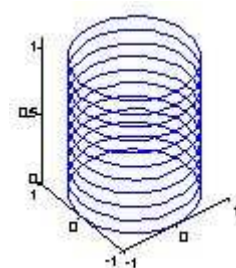**sow—sent—away**

first

seek—fortune

Figure 2: **Synthesis of non-linear thought**

I do not know for sure whether what I call listening, thinking, and speaking has anything to do with the human functions of the same name, but I believe that there is a way to find out.

I do not think that language is absolutely necessary for thought. I want to give a personal account regarding non-verbal thinking of a chemist and I start with a simple illustration.

Chemistry is a headache for most normal people. This is why I take aspirin as an example. When I think about it, I imagine its chemical structure. It is shown in the figure.
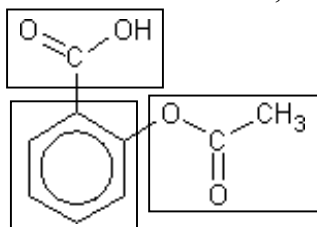
Aspirin

Nevertheless, I do not mentally see the whole picture, although I can draw it. I see the three major components of the molecule—benzene ring, carboxyl, acetylated phenolic hydroxyl, and the way they are arranged around the ring. I can **say** what is in the formula: 2-(acetyloxy)benzoic acid . It sounds "two-acetyloxy-benzoic-acid", which is, actually, a phrase composed with a standardized dictionary and grammar developed by chemists for communication between themselves. Any organic chemist will understand me, although probably surprised that I do not say simply "aspirin." **Frequently used** chemical words are all shortcuts and not chemically correct names.

I see the process of verbal "expressing" the structure of aspirin as a linearization of non-verbal thought. Moreover, when I write the structure, I perform a dimensionality reduction: I translate the actual 3D structure, not shown here, into 2D picture. I cannot give an exact account of what is happening in my head when I think about aspirin (if not I, then, for sure, nobody can), but I certainly feel it as an assembly of some fragments and features of structure, whether verbal or visual.

LINEARIZATION IN CHEMSPEAK

Figure 3 presents a more complicated example. Atorvastatin Calcium (Lipitor) has the chemical name (**3R**,5R)-**7**-[2-(4-fluorophenyl)-**3-phenyl**-4-(phenylcarbamoyl)-5-propan-2-yl**pyrrol-1-yl**]-3,5-dihydroxyheptanoic acid, calcium salt.
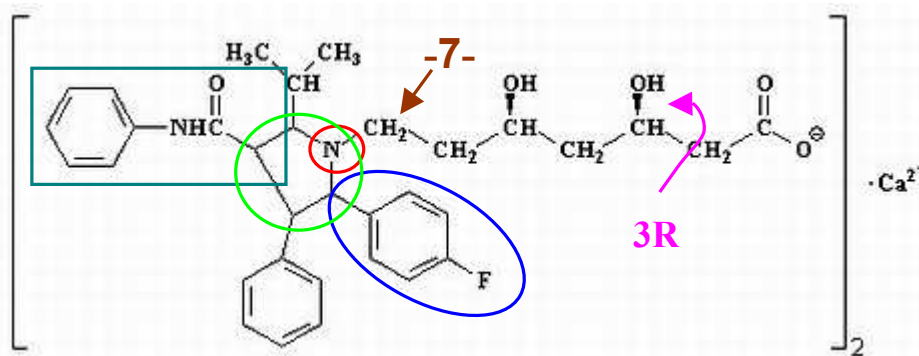
Figure 3: **Brain surgery of Atorvastatin Calcium**

The name is not even a word but a whole detective story. The tong-twisting language makes the name difficult to pronounce, but a chemist understands **the picture** faster than you can say "Jack Robinson." I am not sure, however, that more than a handful of chemists can **say** it if wakened up at 3AM.

When I **think** of the structure, not just stare at it, I have in my head a soup of fragmentary thoughts **in no particular order**: "fully substituted pyrrol in the center" "4-fluorophenyl," "phenyl," "isopropyl," "*ω-dyhydroxyheptanoic acid* (not a correct chemical expression) at pyrrol's N," and other finer details, mostly non-verbal, including the order of substituents. I show **by color** the correspondence between some fragments of the name (morphemes) and the elements of structure which they designate.

Anybody can now find   **5R** in the formula. Another test for a non-chemist: find **phenyl**. Most probably, you will find yourself thinking non-verbal, except for the word **phenyl** sounding in your head (perhaps not even sounding).

It is the **grammar** imposed by International Union of Pure and Applied Chemistry which orders my thoughts about the structure and guides me through packing them into the long chemical name, if I need to do that. I have to look at the structure for that because it is too big for my visual memory. As for the fluorine (**F**), I feel an instinctive aversion to fluorine in drugs, water, and toothpaste. I refuse to take Lipitor and prefer a totally different Simvastatin. This is how my thoughts, either visual or verbal or irrational, guide my behavior. The structure of Simvastatin, by the way, invokes memories of my very first postgraduate work on one of its fragments (lactone ring) and starts a new chain of thoughts far away in time and place from statins.

Spoken language is not the only way of expressing a thought. Gesture, dance, ceremony, and picture are non-linear ways of communication, too, although some only one-way. Sound is not as restricted by environment as vision and speech and, unlike gestures, it does not impede work and movement. Writing definitely followed pictures until the divergence between letters, pictograms, and ideograms, which survived in Chinese and flourish in public signs. As to art installations—I am speechless and so should be you.

I am repeating these trivialities to put forward the non-linear origin of thinking. Thought could be much older than language and not limited to humans at all. What has been much less discussed is that the linear language ensures communication between humans and things and brings it up to speeds far exceeding natural human possibilities.

1927

When thought lags behind speech, electronic economy collapses. Do we remember that the Great Depression happened in the era of telegraph, telephone, and ticker tape?

4. LISTENING

The following text is ready for entering as character strings:

'sow old' 'sow pig' 'pig three' 'first pig' 'second pig' 'third pig' 'sow poor' 'sow sent' 'sent first' 'sent away' 'sent seek' 'seek fortune' 'first meet' 'meet man' 'man bundle' 'bundle straw' **'first say'** 'say man' 'man give' 'give straw' 'give first' 'first build' 'build house' 'wolf come' 'come house' 'wolf ask' 'ask first' 'ask enter' **'first say'** 'say no' 'wolf blow' 'blow house' 'wolf eat' 'eat first'

There are 33 doublets in the text. I allow **'first say'** to occur twice, just to see what happens, but it is counted, inconsistently, only once in the array of words NAMES. What happens will be seen later, but I did not know it in advance.

There are 28 elementary words (singlets):

'!' 'sow' 'old' 'pig' 'three' 'first' 'second'   'third' 'poor' 'sent' 'away' 'seek' 'fortune' 'meet' 'man' 'bundle' 'straw' 'say' 'give' 'build' 'house' 'wolf' 'come' 'ask' 'enter' 'say' 'no' 'blow' 'eat' .

I call the simple algorithm of my "LISTENING" program "SCALE." The name SCALE honors Bourbaki's "scale of sets ". SCALE adds combinations of set elements as **new** elements, remembers their composition, but, more importantly, SCALE has a primitive recognition function: it distinguishes between **new** and **old**. Its workspace WORLD (square matrix WW) initially contains only the "tohu-ve-bohu" (formless and empty) element '!'.   The total number of elements (words) is, therefore, 62. Programs SCALE and, for "THINKING," PROTO were first described in *Molecules and Thoughts* (2003).

In the subsequent illustrations, my input is in square brackets after "TYPE". The rest is the output of the program. I initiate SCALE with typing sc . start initializes the workspace, but there is an option to continue filling up the previous one.

WORLD (WW) is a 62 x 62 connectivity matrix filled up in the order of the appearance of words in the text. The words are stored in NAMES.

>> [TYPE sc] sc

1 to start, 2 to continue [TYPE 1] 1

enter number of cycles (nn): [TYPE 2] 2
      ATTENTION: Interspaced components should be entered
      between apostrophes as single string of characters

            press any key to continue   [ENTER]

I start with the basic singlets and then load the doublets in the order of their appearance in the text. Command link processes a row of matrix WW and lists all words with the same element. Here is an example from the middle of the process:

enter components [TYPE 'sow old']   'sow old'   [ENTER]

This is new. Name it [TYPE 'sow old']   'sow old' [ENTER]

enter components [TYPE 'sow pig']   'sow pig'   [ENTER]

This is new. Name it [TYPE   'sow pig']   'sow pig' [ENTER]

If you want to check WORLD for a name, type: link
To see NAMES, type: NAMES
To display the 3D world, type plotw

>> link	>> link	>> link
NAME to check	NAME to check	NAME to check
[TYPE 'sow'] 'sow'	[TYPE 'pig'] 'pig'	[TYPE] 'sow pig'
sow old		sow old
sow pig	>> link	
	NAME to check	>> [TYPE] NAMES
>> link	[TYPE 'sow old'] 'sow	NAMES =
NAME to check	old'	!
[TYPE 'old'] 'old'	sow pig	sow old
		sow pig

Note that the structure of WORLD retains the order of its genesis. I hint here to the idea of recapitulation, but I am still far from exploiting it.

SCALE detects the components of doublets, accepts and assigns a name to a **new** combination or classifies it as **old**. If the order of components in a **possibly new** doublet is different from what is in WORLD, SCALE remarks Looks like W , gives the coordinate of word W in WORLD and asks: ‘Is it new? 1/0?’.   SCALE, therefore, may reflect or disregard the order of components, which increases its universality.

In short, words , from singlets, to doublets, are connected in WORLD if they share a component. Examples:

sow—sow_old
sow_sent—sent_away
sow_sent—sent_seek
first_build—first_ask

For the purpose of visualization, all 62 words are arranged in a circle. A sequence of stages in building WORLD can be portrayed in 3D.

CRITERION OF INTELLIGENCE

One may note that I (or another operator, **educator** , as I would say) take part in building WORLD and in this way infect it with human knowledge. For example, the operator decides whether the order of components is relevant. This is true, but note that it is done in the manner of a dialogue. Whether education was right or wrong, good or bad, can be ultimately decided only in a socio-economic and intimate setting, not by the educator. AI, I am sure, can create a good model for dialogue, which is the ultimate criterion in much disputed Turing test, but EVE—I decide for the first time to call "it" by name—is born in a dialogue. I see a test of intelligence as the ability to achieve prolonged stable states **inside an exystem**, not the ability to be taken for a human on the basis of email communication, all the more, texting. From this point of view, animals are intelligent, which is exactly my point. I do not measure intelligence, but simply look for its presence. Probably, it has already been suggested, but I have not found anything except Ross Ashby's homeostasis. Is humankind intelligent? We need more time to think about it. (Answer: there is no such thing as humankind).

Figure 4 shows how SCALE connects the bond between **sow old** and **sow pig** because of the common component **pig** .

After the entire text is acquired, its internal representation looks like in **Figures 5 , 6 ,** and **8 . Figure 7** shows a (25:35) fragment of WORLD on both sides of the borderline between the first 28 singlets and the following (29:62) doublets. The singlets do not have any bonds until their entries into doublets appear **from the later doublets**, not toward them. WORLD takes heed of the arrow of time. It can look back, but not ahead.

New singlets can be acquired at any time, of course, and I placed them all in the beginning to imply that the listener to the story is already familiar with all words. This is not a necessary condition, however.
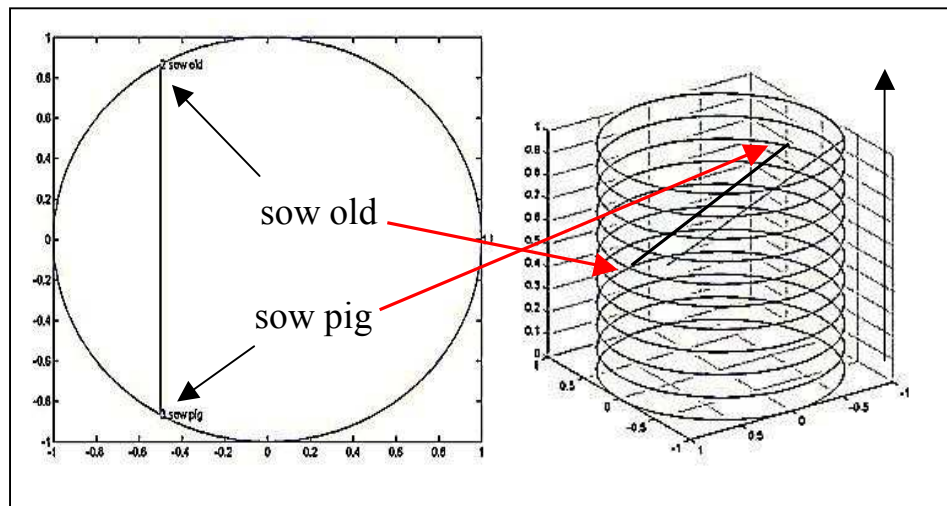
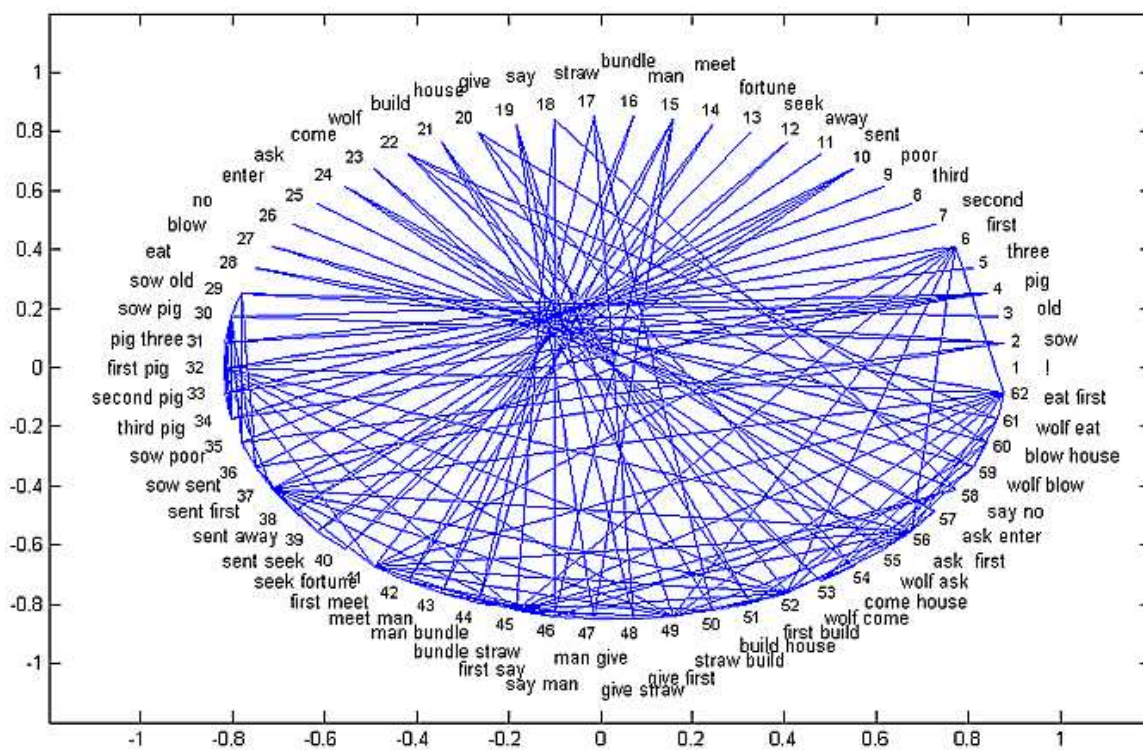Figure 4: **SCALE absorbs 'sow old' and 'sow pig'. Timeline goes up.**

Figure 5: 2D view of WORLD.
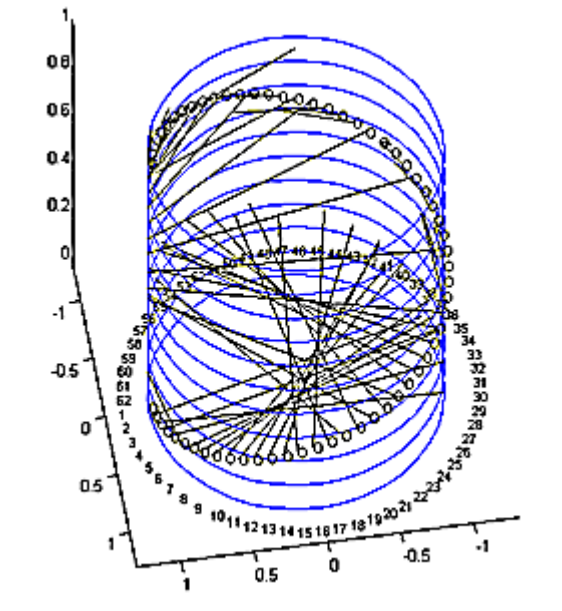
Figure 6: **3D view of WORLD ordered along the timeline of acquisition (axis Z)**
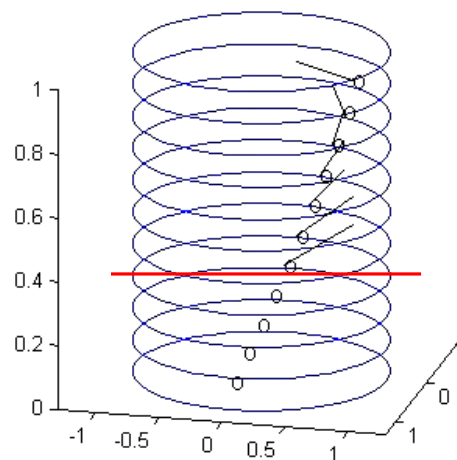
Figure 7. **Fragment WW(25:35) in process of buildup and the border (red) between singlets and doublets**
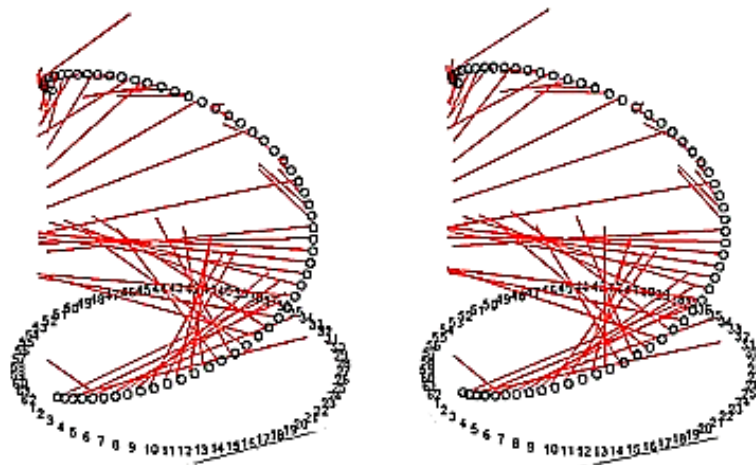
Figure 8: **Imitation of stereoscopic view of WORLD**

The READING stage can be extended indefinitely by adding new entries of WORLD on top of the old ones. Note, that during the READING, bonds go not from past to present, but from present to past. Therefore, the deeper and older areas of WORLD are being enriched by new bonds induced by new acquisitions.

Building of WORLD does not require operator's intelligence (it can be automated) and does not serve any utilitarian behavioral function typical for AI.   It is not difficult to imagine further steps toward realism, however. Thus, in principle, WORLD can—and should—react to any external stimulus by activating SCALE. We can also impose gradual fading of old areas, if desired. Next, we make WORLD fractal in an irregular manner.

I am trying to design not a mind, however, but a possible launching pad toward its emergence. All I expect from the intellectual newborn is to start feeding on new experience and digesting the foodstuff. It is not learning in the sense the dogs and traditional AI systems are learning to bring you a pair of slippers. The only function of the model is to grow and think.

The model (or, rather, the seed of a model) outlined here needs a name. I confirm the name EVE because Eve was the first to taste the apple and she liked the taste.

5. THINKING

The next stage is the pattern-chemical process of "thinking." It consists in generating a sequence of winners in a competition of singlets and doublets for, metaphorically speaking, ascent into "consciousness" in which, in our experiment, only one thought can be a star.

Consciousness is a serious business and I do not want any extra controversy. I call the selected or appointed thought **acton** and give it the star status marked by asterisk.

THINKING starts by designating the initial thought in consciousness, although it can be chosen at random. All next actons are selected along the probability distribution calculated before selection. The core of THINKING is a modified procedure PROTO , script p3d3. There are several versions of the unit select which calculates the probability distribution.

The selection of acton is based on a modified idea of the pioneering work of Manfred Eigen, initiated in the 1970's and still progressing. It would take a lot of space to explain my choice of computation for the stage of thinking. Darwinism and neural realism are two of them. I can afford only a short digression.

MANFRED EIGEN AND MOLECULAR EVOLUTION

To say the least, Manfred Eigen's ideas, inspired by Darwin, but essentially chemical, are so general that they have put roots in areas as different as origin of life and origin of language (Martin Novak). Moreover, the readers (and authors) of the avalanche of literature triggered by the Ising model of ferromagnetism belong under the same conceptual umbrella, probably, unaware of that, because the equations are, in principle, of the same type, better to say, **pattern**, as Manfred Eigen acknowledged.

REFERENCES:
Leuthusser, I. (1986), An exact correspondence between Eigen's evolution model and a two-dimensional Ising system, *Chem. Phys.,* 84, 1884-1885.
Eigen, Manfred, The physics of molecular evolution; In: Molecular evolution of life; Proceedings of the Conference, Lidingo, Sweden; 8-12 Sept. 1985. pp. 13-26. 1986

The core of the idea is that the state of the topological neighbors (in not necessarily Euclidean space) **influences, but not predetermines** the state of a node of a network.

The graph of the network is a subgraph of a full graph on all nodes (as any graph is). This is why I arrange the nodes of the network in a circle: each element can potentially connect with any other. A non-mathematician, I intuitively anticipate a specific kind of semi-regularity in the graphs which I draw here. They are not exactly point lattices, but the limits on the **valency** (degree) of vertices (**arity** of generators in Pattern Theory) prevent combinatorial explosions. This is the essence of thinking: stay focused. I would say, vaguely, that exystems are severely restricted subsets of the scale of sets.

Unlike the models of interactions on lattices, Eigen's original chemical model does not come to equilibrium. It is driven by non-stop replication, which in chemistry requires thermodynamic openness. At the same time it is cruelly conservative: the number of atoms is constant, although this can be modified.

Eigen's initial model of chemical evolution does not contain a single chemical symbol and remains, I believe, an excellent example of what I call pattern chemistry. The **concentrations**, used in chemical equations, are nothing but probabilities to find a species in a unit volume.

The only computational unit of PROTO—**selection**—calculates the probability distribution at time $t+1$ as:

$$ p_i^{t+1} = (p_i^t + \sum_{i,j} G_{i,j} p_j - F p_i^t) , $$

where F defines forgetting or dissipation and $\sum_{i,j} G_{i,j} p_j$ is a sum of influences on cell i over all neighbors j in the network. Parameter G can be different for different i, j.

There are additional rules interpretable as "the ping-pong player cannot send two balls in a row, but only in turn with the opponent."

1. The acton A_t selected at time t cannot be selected in time $t+1$.
2. The acton A_t selected at time t "remembers" its probability at time $t+2$ as **C ,** although it cannot be selected again until time $t+2$.
3. At time $t+1$, the neighbors perceive the probability of acton A_t as $H \cdot C$.

All constants, **F**, **C**, **G**, and **H**, $= < 1$, although it is not necessary. In principle, instead of p_i^t, I could (and even should, following Eigen) use $A p_i^t$, $A > 1$, to reflect

replication, but neural realism forbids it. I believe that parameter **C** sufficiently accounts for a quasi-replication because it increases the subsequent probability of selection. This aspect of thinking needs a separate discussion. See CONCLUSION for some specifics.

Further in the process of selection, the calculated distribution is normalized, probability of previous acton and empty word '!' nullified, and a random number cast for selection. The nullification of '!' is also optional because the empty word may represent a sudden loss of the train of thought for whatever reason.

The remarkably simple premises of SCALE and PROTO open a passage to an extraordinary complexity of choices and possibilities to make the model realistic.

A digression on neural realism follows.

NEURAL REALISM

The term itself has been used, obviously, in the area of simulated neural activity and cognitive models. Regarding PROTO, there are at least two considerations in the gray area of neural realism.

1. Neurons do not grow in numbers the same way organisms, molecules, and money do. Brain is a conservative system regarding matter. However intensely somebody is thinking, we cannot see any brain coming from his ears and we see, actually, nothing growing or even changing in any sense. The activity, of course, is detectable with proper equipment, but are we sure that we see thinking? We actually see metabolism, which is not growth, but dissipation.

The brain uses energy to maintain the neurophysiological activity, which is neither a two-way exchange, as in economy, nor a physical collision as in molecular chemistry, nor a physical multiplication, as in replication of organisms and nucleic acids. Neural events are impulses sent to neighbors in a network. Therefore, Eigen's equations could not be applied either in their initial form, or in their deep replicative meaning. What remains from the idea is **competition for a limited resource**, common for molecules, money, and organisms, as well as for all brain cells (I mean energy) and even their brain owners (I mean "fortune").

The event in PROTO is the one-time "contest" which results in a winner. As with humans, the participants can try their luck again and again. I do not mean that the competition in the mind is global and it elects a single winner. It happens, probably, all over the mind in a fractal manner.

2. Selected actons cannot retain their status at the next selection. The presence of refractory phase (inactivity after firing) in neuronal activity is the main source of realism in this regard. I can only guess, speculatively, that this cardinal, biologically unavoidable fact of natural neuronal behavior was a **condition for**

the development of the mind, and not in any sense a limitation. This condition makes neural dialogue possible. Marvin Minsky's "Society of Mind" is more than an apt metaphor.

AA= [46 52 10 39 41 56 39 37
41 45 41 48 38 19 37 52 41 56
32 6 38 52 38 41 38 42 62 36
52 6 32 52 37 62 32 62 37 18
37 56 49 62 49 10 19 62 19 62
41 46 41 46 16 6 57 45 62 6
41 62 42 49 32 49 41 33 41 52
6 52 61 30 6 33 32 33 58 62
49 58 37 52 41 46 62 46 32 47
62 33 49 34 58 19 58 31 46 62
50 56];

n=100
F=0.2
C=0.5
H=0.8
G=0.1
acton =meet man
a=42
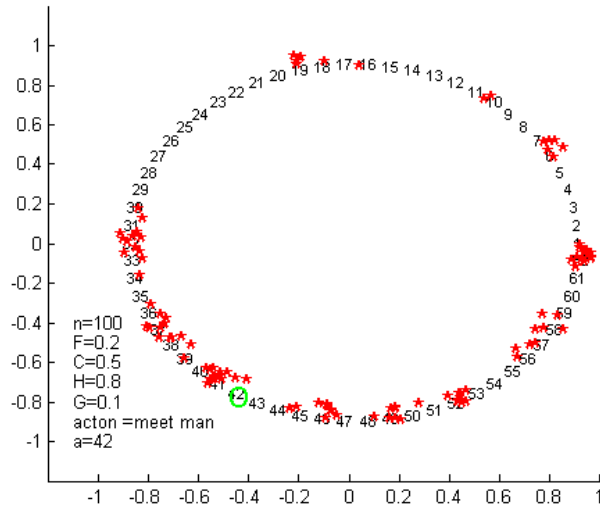
A.   Trajectory as a sequence of actons

B. Distribution of actons over NAMES
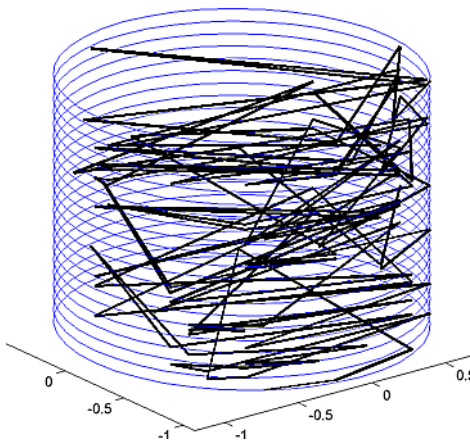
C. 3D trajectory. Z=1:100

D. Connector of thought. Z=1:62

Figure 9. Trajectory AA and its graphic outputs; n=100, F=0.2, C=0.5, H=0.8, G=0.1, initial acton a=42, 'meet man'

The output of "thinking" is the trajectory: a sequence of the actons which are elevated to star status. To say "consciousness" would be inappropriate here; let us say instead, "borderline area".

Figure 9 shows the graphic outputs of 100 cycles of "thinking" (i.e., selection of 100 actons) after the initial acton is enforced as do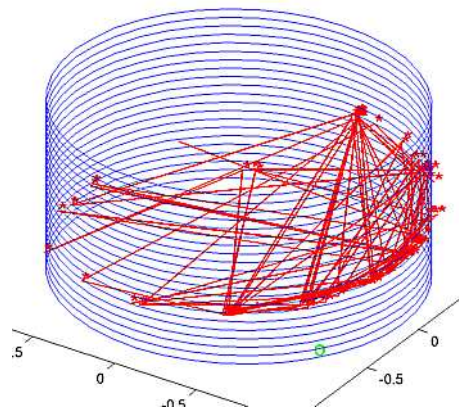ublet 42, '**meet man**'. In **Figure 9B** the position of the asterisk which represents an acton is slightly randomized.

Script nums (from "numbers") generates the activated thoughts along with their occurrences (column 2, bold font) and the Jini coefficient of the distribution of occurrences at the end:

>> nums			48 **1** give straw		33 **4** second pig		52 **8** first build	
			50 **1** straw build		38 **4** sent away		41 **11** first meet	
16 **1** bundle			57 **1** ask enter		56 **4** ask first		62 **12** eat first	
18 **1** say			61 **1** wolf eat		58 **4** say no			
30 **1** sow pig			10 **2** sent		6 **6** first		total 28	
31 **1** pig three			39 **2** sent seek		32 **6** first pig		JINI = 0.596	
34 **1** third pig			42 **2** meet man		37 **6** sent first			
36 **1** sow sent			45 **2** first say		46 **6** say man			
47 **1** man give			19 **4** give		49 **6** give first			

Thus, say (18) and sow pig (30) activate once each, while first meet (41) and eat first (62) appear 11 and 12 times within the 100 acton sequence. I am tempted to say that "consciousness" has depth and first meet and eat first are close to the surface, while bundle to first say sit at the bottom. Actually, I am quite serious. Earlier I proposed to consider consciousness as a cognitive mechanism necessary for linearization: one link of the chain of events at a time. To put it differently, consciousness is a window into the world, narrow enough to see the forest as a set of trees. Consciousness is a condition of cognitive analysis of the world and the synthesis in the form of thinking.

The output of script nums is similar to **content** in Ulf Grenander's GOLEM, while matrix WW corresponds to its **connector.** It is a small bowl of thought soup, in which we see pasta pieces of different length and quantity.

6. SPEAKING

At the stage of SPEAKING we already have the right to judge whether the output makes any human sense. We cannot hear the shrieks of thoughts being stretched on the Procrustean bed, but speech escapes the dark dungeons of the mind.

Script say_con ("say content"; later changed for saycon2) generates all possible triplets from doublets along the Velcro rule of haplology. The program compiles a **content condensate:** list of doublets and triplets of Late Nean, which is a transitional state to full language. The condensate is rather focused, which is expected, but still surprising. It has a potential to be even more condensed, as I will further illustrate, thereby producing longer thoughts and opening a way to full human language, breaking through a crucial transition state.

Here is an example of a trajectory, its content (third column shows number of occurrences), and its condensate:

Trajectory:

AA = [46 52 10 39 41 56 39 37 41 45 41 48 38 19 37 52 41 56 32 6 38 52 38 41 38 42 62 36 52 6 32 52 37 62 32 62 37 18 37 56 49 62 49 10 19 62 19 62 41 46 41 46 16 6 57 45 62 6 41 62 42 49 32 49 41 33 41 52 6 52 61 30 6 33 32 33 58 62 49 58 37 52 41 46 62 46 32 47 62 33 49 34 58 19 58 31 46 62 50 56];

Content:

		50	1	straw build	56	4	ask first
		57	1	ask enter	58	4	say no
16	1	bundle	61	1	wolf eat	6	6	first
18	1	say	10	2	sent	32	6	first pig
30	1	sow pig	39	2	sent seek	37	6	sent first
31	1	pig three	42	2	meet man	46	6	say man
34	1	third pig	45	2	first say	49	6	give first
36	1	sow sent	19	4	give	52	8	first build
47	1	man give	33	4	second pig	41	11	first meet
48	1	give straw	38	4	sent away	62	12	eat first

Content condensate:

give_first_meet ;
give_first_pig ;
give_first_say ;
give_straw_build ;
man_give_ ;
man_give_first ;
man_give_straw ;
meet_man_give ;
say_man_give ;
sent_first_build ;
sent_first_meet ;

sent_first_pig ;
sent_first_say ;
sow_pig_three ;
sow_sent_away ;
sow_sent_first ;
sow_sent_seek ;
third_pig_three ;
wolf_eat_first ;

eat_first_build ;
eat_first_meet ;
eat_first_pig ;
eat_first_say ;
first_meet_man ;
first_say_man ;
first_say_no ;
give_first_build ;

Longer regular strings can be velcroed together from the content:

first say man give first pig

Isn't it "First say[s] to man [:] give [something to] first [who is a] pig? "   (Just a question).

first meet man give first pig

Isn't it "First meet[s] man [who] give[s something to] first [who is a] pig?" (Just a question!)

A longer and bolder derivation:

first_**say_man ; say_*man*_give** *; man_give*_straw ; give_straw_build ; →

First say, "Man, give [me some] straw [to] build [a house]."

And don't you see that there were three pigs in a family: **first** [was one] **pig** [out of] **three ; second** [was one] **pig** [out of] **three ; third** [was one] **pig** [out of] **three** ? Still, the question needs an answer. In the context of the pig story told in Nean, the answer is:

Our interpretation is correct if it does not lead to instability with fellow cavemen.

This is crucial for understanding the emergence of language, but again, it is a separate topic. I believe, the book by Nikolaus Ritt, *Selfish sounds and linguistic evolution. A Darwinian approach to language change* (Cambridge University Press, 2004), should tackle this subject, but I have not yet read it.

Remember that the whole trajectory of THINKING in the last example was triggered by initial acton '**meet man**'. Our baby mind seems to stay focused on the topic. The tragic end of the hero is not forgotten, however: **wolf_eat_first** .

But what is the meaning of the common element in the non-linear clusters with the same beginning or end?

first_meet_man ;	**meet_man_give ;**	**eat_first_pig ;**
first_pig_three ;	**say_man_give ;**	**sent_first_pig ;**
first_say_ ;		**give_first_pig ;**

For the answer I have to refer to my e-publications on extraction of grammar by simplistic rules: **Salt** and **Salt2**.

The short answer is: common elements in the same position define a **category of grammar**: **first** for subject, **give** for verb, and **first pig** for object.

As soon as the words are categorized, the emerging grammar attributes either order or inflections, or both to them. Thus, **first** is a generalized symbol for all things which can **meet, be**, and **say**; **give** is something that at least **man** (and others, as will be seen with more experience) does; **first_pig** symbolizes everything that can be **eat**en, **sent**, and **give**n to.

The second interpretation opens a way to **vertical** linearization by common beginning:

man_give_first ;
…………   ➔   **man give first straw**   or   **man give straw** [to] **first**
man_give_straw ;

Indeed, haplology is just a particular case of **contraction**.

sow_sent_away ;
sow_sent_first ; ➔ **sow sent first** [pig] **away** [to] **seek [fortune]**
sow_sent_seek ;

There is also a third interpretation: the topic, as in Japanese and some atypical cases of English and other languages.

The modern language begins.

Leaving the cozy simplicity of Nean, humans face a great uncertainty of the choice of grammar. Would that be too hubristic to explain the overwhelming diversity of human languages by their common origin from the extreme simplicity of Nean? By starting from a point on a plane, you can move in any direction, but you have a tree of more narrow choices after the first step. Biological diversity illustrates the principle of "more complexity—less choice" best of all. A leopard can change its spots, but cannot get rid of its vertebrae. In the spirit of pattern chemistry, this applies to any evolution, from life (single cell) to politics (ambition) to Internet (fun of function) to terrorism (fun of killing).

Formally, human speech is just a particular kind of performance, whether improvised or memorized, but usually both. Regarding memory—not less mysterious problem than origin of the universe—here is a digression on the subject.

MEMORY AND LINEARIZATION

Professionals in any area are capable of keeping in memory sequences of words, numbers, movements, and other apparently non-linear configurations as large as a symphony, part in a long play, big chemical formula, epic poem, long mathematical proof, history of a nation, assembly of a device, etc. I suspect that this is possible because of a fast assembly of linear fragmentary thoughts with a hierarchy of Velcro fasteners to put them out as speech or action. It is also possible that long time memory is characterized by an especially conservative set of parameters in Eigen-type equations.

This is where Noam Chomsky's universal grammar comes to mind. If there is anything that could be qualified as universal grammar, it is the inborn ability of fast assembly of a linear behavioral configuration from short linear fragments of thought. The language instinct is to linearize the content of the mind.

There is no originality, especially, after the work of Eric Kandel, in saying that the elementary unit in pattern chemistry of memory is simply a **bond** between two physiological carriers, neurons or not. There is a subtler aspect of the problem, however.

A movie production is a good, albeit too literal, metaphor of assembly of a long sequence from short fragments shot along the linear script in often broken and non-linear order, so that death could be filmed before birth and divorce before marriage.

The performance of an actor on stage is unrolling in the natural time and strictly linear order, it cannot be cut into confetti, as a mortal combat in a violent movie. It appears non-linear, however: the actor (1) speaks and accompanies words with (2) emphatic intonation, (3) gestures, (4) body part movements, (5) facial expressions, (6) silent action, (7) manipulations of objects and partners. At a closer look, however, this complex multidimensional sequence of configurations is a **bundle** of **parallel linear actions**, which I have just enumerated. It is kept in order by the script.

A symphony is a similar, although more transparent, **fiber bundle**, visualized in the score. Each musician, in turn, performs a mini-symphony of smaller linear parts played by fingers, arms, and lungs. All individual strands of actions are organized by rhythm.

I use this digression to emphasize the contrast between the current paradigm of artificial Artificial Intelligence and its possible alternative, natural Artificial Intelligence. Natural thinking and behavior emerges neither from a likeness of a

computer code, nor from the equations of chaos theory, but from random but organized pattern-chemical interactions and transformations, each with its energy cost. Yet computer (non-parallel), like human mind, linearizes the non-linear ifs and loops of the code. In this sense, computer speaks without thinking. So, don't be fooled.

7. FROM SPEECH TO UNDERSTANDING

SPEAKING is not supposed to fall on deaf ears. Although SPEAKING of EVE sounds as a crude pidgin English, it is addressed to us, listeners who know the context of the story and probably even have seen a pig and a wolf live. Therefore, we are free to evaluate SPEAKING without the guilt of excessive anthropomorphism. This time we start a new turn of the spiral started by the cave stories as listeners.

We UNDERSTAND speech because it is ordered by the way it is generated by the speaker and is passing through the relatively wide and fading toward the periphery spotlight of consciousness **in the same order**.

The old paper tape telegraph is an appropriate ideogram of verbal communication. What it lacks is the "burn after reading" procedure performed by the ephemeral sound of speech on itself. This cardinal difference between reading and hearing was the point of divergence between spoken and written languages.

In this section I will present some observations of a listener on the behavior of EVE. I am trying to understand what EVE is saying and how it can help understand the origin of thought and language.

By no means I consider EVE a linguistic computer model, whatever I say—for lack of better terms or for excess of enthusiasm—about it here. EVE is just a means to generate **illustrations** of the principles of evolutionary simplicity, which might well apply to any other evolution toward a high complexity, for example, DNA, organism, society, or science. Therefore, the words "behavior of EVE," which I will use, mean literally the output of some software designed to produce illustrations.

The reason why I want some difficult to achieve clarity in this regard is my skepticism concerning computer models of exystems. I will return to this point in CONCLUSION.

By protolanguage we may mean at least two hypothetical things. One is the very first spoken language, *die Ursprache*, with its lexicon, and the other is the structure of the first language, regardless of the lexicon and phonology, which is what I mean. It is difficult to achieve consensus on something as hypothetical. Whether Nean is a protolanguage or not a language at all is a matter of definition, which I will put aside.

Thought is not as hypothetical as protolanguage, but it is even more evasive. There is something going on in the mind, which we call "thought" (inner thought, process) but never **see** anything but some brain imaging shadows. There is also thought as the meaning of speech or written sentence (outer thought, content, idea), which can be etched in stone, but from Shakespeare to Sartre to Sarah Palin, to achieve consensus on what
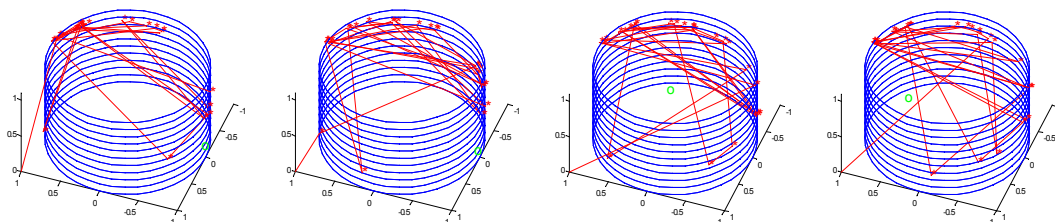
they were thinking before uttering a phrase is not always an easy task. Besides, as Chisholm's Second Corollary [to Murphy's law] says, "If you explain so clearly that nobody can misunderstand, somebody will.

As a pattern chemist, I see the **inner thought** as a "soup" of fragments and the **outer thought** as their spoken linearization **as it is understood** and can be translated and explained. Instead of "soup" a chemist would say: liquid mixture of short elementary thoughts and longer clusters in motion, i.e., physical suspension or solution (strangely cerebral opposites). "Soup," however, is a standard term in any discussion of chemical origin of life. It is a typical ideogram.

The linear topology, however, is not enough for understanding: thought has to carry a message (thought, message, idea, content—so confusing!). Moreover, thought can carry a message relevant only in a context of a particular situation (a saber-tooth behind partner's back or a philosophy class) or a timeless message retold through generations, like a myth, ancestral lineage, or a real story about the hunter and his partner still remembered by older members of the tribe only because it was **extra**ordinary. Message requires tags, like time and place, which asks for a larger and consistent thought, or, rather, a story. Language develops from signal to story.

The behavior of EVE shows some distinct patterns, depending on the parameters **C, G**, **H**, and **F** . Regarding selection, the calculation unit (script select3.m) takes to account the arity **Ar** of the NAME) by dividing the sum of influences from the neighbors by $\sqrt{Ar}$. Probably, ln Ar instead of $\sqrt{Ar}$ should also be tested. This kind of choice is intuitive and I cannot yet find any rationale for it. Random mutations of the algorithm would be the best.

Several types of graphic output are shown next. The runs begin with initiation (equalization of probability distribution), initial acton NAME 53 (**wolf come**), and 150 subsequent cycles in batches of 25, of which only the 25 last are shown here as trajectories in WORLD space, ordered along axis Z from 1 to 62. The actons can flock together either in the last section of the WORLD (upper part of the cylinder) where **wolf** appears (**Figures 10-1** and **10-9**, or, in addition, heavily refer to the 1:28 section of single NAMES (**Figures 10-8** and **10-10**), or are highly condensed, as in **Figures 10-7**, and **10-8**.

1: C = 0.5; G = 1;   **2:** C = 0.5; G = 1;   **3:** C = 0.5; G = 1;   **4:** C = 0.2; G = 1;
H = 0.8; F =0.8;   H = 0.8; F = 0.2;   H = 0.2; F =0.2;   H = 0.2; F =0.2;

5: C = 1; G = 1; H = 1; F = 1;

6: C = 0.1; G = 0.1; H = 0.1; F = 0.1;

7: C = 1; G = 0.1; H = 1; F = 0.1;

8: C = 1; G = 0.1; H = 1; F = 1;

9: C = 0.2; G = 1; H = 1; F = 0.5;

10: C = 0.2; G = 1; H = 1; F = 1;

```
disp(' 1 : C =  0.5; G = 1; H = 0.8;  F = 0.8; ')
C =  0.5; G = 1; H = 0.8;  F =    0.8; %1
init, n=25 , disp ('init '), a=53;
p3d3s, disp(' '); disp(['AA=[' , num2str(AA'),
']; ']), nums, saycon2, disp(['ain ',
num2str(ain), ',  a fin ' num2str(a)]),

n=25; p3d3s, disp(' '); disp(['AA=[' ,
num2str(AA'), ']; ']), nums,   saycon2,
disp(['ain ', num2str(ain), ',  a fin '
num2str(a)])
```
(etc… 4 more times)
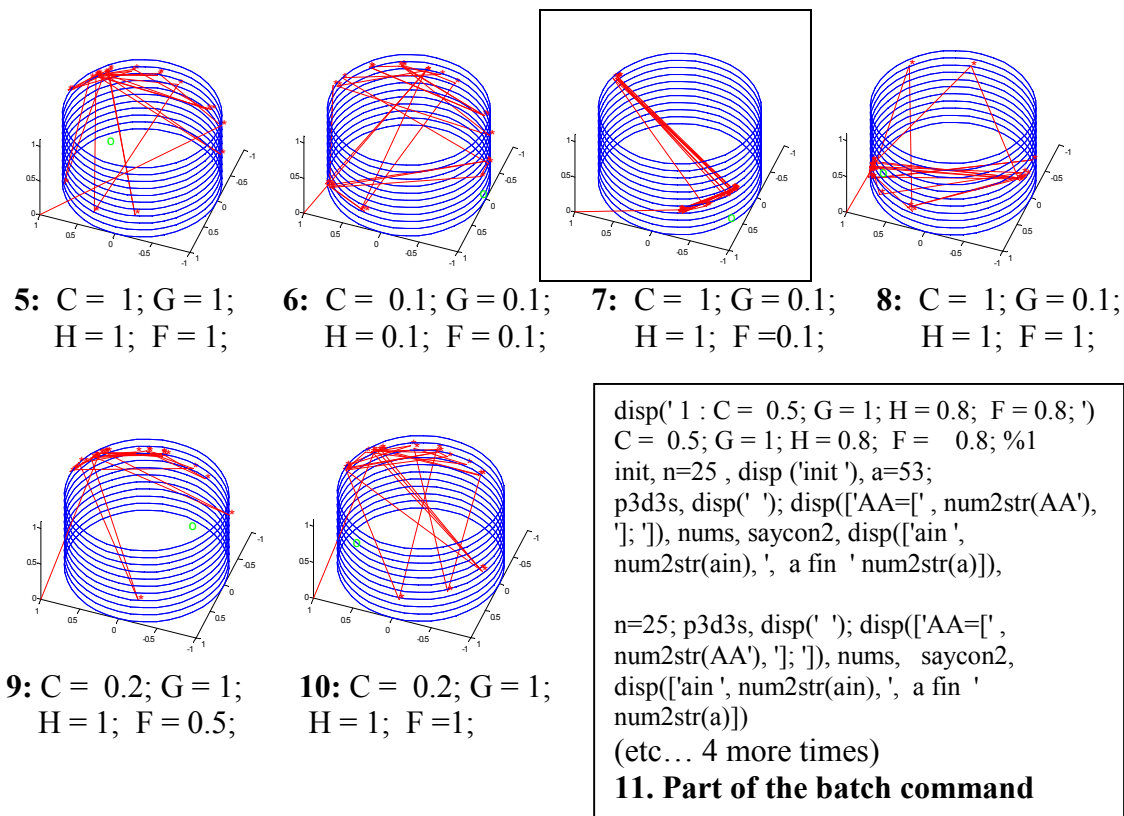**11. Part of the batch command**

Figure 10. **Graphic output of EVE, initial acton "wolf come," No. 53.**

The following is part of text output,   C = 0.5; G = 1; H = 0.8; F =   0.2; , cycles 75:100.

AA=[54 50 49 48 37 50	10 37 2 sent first	eat_first_say ;
21 32 56 49 56 45 62 49	11 50 2 straw build	first_say_man ; *
62 56 62 61 57 28 37 55	12 54 2 come house	give_straw_build ; *
46 54 62];	13 49 3 give first	wolf_ask_first ; *
	14 56 3 ask first	wolf_ask_enter ; *
content:	15 62 4 eat first	wolf_eat_first ; *
1 21 1 build	condensate:	total content 15
2 28 1 eat		condensate 13
3 32 1 first pig	sent_first_pig ; *	narr. cond.7
4 45 1 first say	give_first_pig ;	JINI = 0.79
5 46 1 say man	ask_first_pig ;	cond/cont = 0.87
6 48 1 give straw	eat_first_pig ;	nr.cnd/cnt = 0.47
7 55 1 wolf ask	sent_first_say ;	ain 48, a fin 62
8 57 1 ask enter	give_first_say ; *	
9 61 1 wolf eat	ask_first_say ;	

--.

The end comments in the output show the sizes of content, condensate, and narrow condensate, Jini inequality coefficient, and the size ratios of condensate and narrow condensate to content.

Asterisks mark triplets, the starting doublets of which, for example,   **sent_first +
first_pig → sent_first_pig ,** have the difference of coordinates in WORLD equal to not
more than **5.** This difference (**condensate range)** can be varied. I remind that WORLD
approximately preserves the order of LISTENING, i.e., **the order of events in the story**
(Leibniz: time is order of a sequence of events).

The consistency of the **narrow condensate**, as I call it, improves, as expected, although
without much room for further stitching. Thus, the confusing "eat_first_say" and
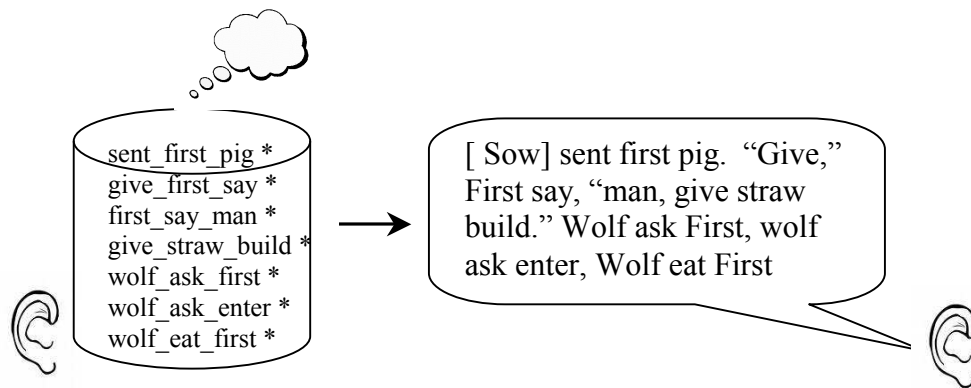"ask_first_say" do not get into the "thought soup" :

Figure 11. **Transmission of thought from condensed thought soup to
SPEAKING to LISTENING and toward UNDERSTANDING**

A fragment of the story is approximately retold, with gaps.

Let us take the case presented in **Figire 10-7**,   C = 1, G = 0.1, H = 1, F = 0.1, cycles
126:150. It is marked by a border. With influence of neighbors as low as G=0.1 we
would expect a very rambling THINKING. Yet with low forgetting F and high C it looks
well focused:

content:

	5 60 1	blow house		condensate:
	6 57 2	ask enter		eat_first_say ;
1 18 1 say	7 61 3	wolf eat		wolf_ask_enter ; *
2 24 1 ask	8 62 3	eat first		wolf_blow_house ; *
3 45 1 first say	9 22 5	wolf		wolf_eat_first ; *
4 55 1 wolf ask	10 59 7	wolf blow		

Wolf ask enter, wolf blow house, wolf eat first. This is the essence of what happens
after **wolf come**.

It might be of interest how content in this particular and strange (**Figure 10-7**) case
progresses with time (1:150) from empty condensate. It tells something about the
kinetics, as the chemists say, of the process: the relatively slow speed which is typical of

most transformations in organic chemistry. A slow chemical kinetics was considered an evidence of a bottleneck and a major stimulus for the theory of transition state.

1:25 **content:**
1 21 1 build
2 31 4 pig three
3 59 4 wolf blow
4 61 7 wolf eat
5 22 9 wolf
condensate:
[empty]

26:50 **content:**
1 27 1 blow
2 23 2 come
3 55 2 wolf ask
4 57 3 ask enter
5 59 3 wolf blow
6 53 5 wolf come
7 22 9 wolf
condensate:
 wolf_ask_enter ; *

51:75 content:
1 20 2 house
2 53 2 wolf come
3 55 2 wolf ask
4 60 2 blow house

5 22 3 wolf
6 27 4 blow
7 61 4 wolf eat
8 59 6 wolf blow
condensate:
wolf_blow_house ; *

76: 100 **content:**
1 22 1 wolf
2 51 1 build house
3 53 1 wolf come
4 60 2 blow house
5 27 8 blow
6 59 12 wolf blow
condensate:
wolf_blow_house ; *

101: 125 content:
1 27 1 blow
2 55 1 wolf ask
3 60 1 blow house
4 20 2 house
5 23 2 come
6 53 2 wolf come
7 61 2 wolf eat

8 22 3 wolf
9 54 4 come house
10 59 7 wolf blow
condensate:
wolf_come_house ; *
wolf_blow_house ; *

126:150 content:
1 18 1 say
2 24 1 ask
3 45 1 first say
4 55 1 wolf ask
5 60 1 blow house
6 57 2 ask enter
7 61 3 wolf eat
8 62 3 eat first
9 22 5 wolf
10 59 7 wolf blow
condensate:
eat_first_say ;
wolf_ask_enter ; *
wolf_blow_house ; *
wolf_eat_first ; *

Thinking could be a slow, truly chemical process, but the result can come any time, which is an evidence that human thinking is a random process in a system of a moderate size. The smaller the system, the sooner the result (i.e., **arrival to stability**) . This is why the standard way of solving a difficult problem is to simplify it and to think for a long time, I am not sure in which order. Henri Poincaré and Jacques Hadamard left classical descriptions of the process of mathematical creation, which illustrate the major kinetic properties of thinking .

> **MEYER'S LAW** : "It is a simple task to make things complex, but a complex task to make them simple." One of the reasons why democracy can be as dysfunctional as currently in the USA, is either impossibility of simplification or fast pace of uncontrollable events, or both (see APPENDIX 2). Problem solving could be one of future tasks for EVE and it may turn unsolvable.

The right choice of parameters C, G, H, and F or **just a longer thinking** can probably improve SPEAKING.

The left column in **Table 2** shows the combined **narrow condensate** from **150** cycles at C = 1, G = 1, H = 1, F = 1; the last 25 cycles are shown in **Figure 10-5**. Other columns are some of possible longer derivations. I assume that evolutionary contraction comprises elimination of repeating doublets, as well as singlets, and works vertically, as well as

horizontally, albeit with the inevitable uncertainty of linearization. Note that wrong thoughts are easily generated, too. Animals and humans make mistakes and what can be more natural than an error or an excessive enthusiasm which is often its precursor?

Wolf is not an object of any action and this is why there is no bond to it until the end of the full tripartite story, not yet told. **Meet_man_give** seems clever, but less straightforward: indeed, the distance between **meet_man** and **man_give** in WORLD is exactly 5, the maximum.

Table 2. **Derivation of longer thoughts from narrow condensate**

Narrow condensate	Horizontal derivations	Vertical derivations
ask_first_build; first_build_house; first_meet_man; first_say_man; give_first_build; give_first_say; man_give_first; man_give_straw; meet_man_give; say_man_bundle; say_man_give; sent_first_meet; sent_first_pig; sow_sent_first; sow_sent_seek; wolf_ask_enter; **wolf_ask_first;** wolf_blow_house; wolf_eat_first;	ask_ first_build_house first_meet_man_give_first, first_say_man_give_straw, first_meet_man_give_straw give_first_say_man_bundle first_meet_man_give_first_build_house first_meet_man_give_straw **sow_sent_first_meet_man** (dubious) **wolf_ask_first_build_house** (wrong!)	first: meet man, say man, build house man give: first, straw say man: give, bundle sow sent: first, seek wolf ask: first, enter wolf: blow house, eat first

The vertical contraction of
    first_meet_man_give_**first_build_house** and
    first_meet_man_give_**straw**
gives:
    first_meet_man_give_straw_first_build_house .

At this point, the most significant and remarkable result for me is not the possibility of generating long speech-ready thoughts from doublets, but the fact that **doublets alone are sufficient** for verbal communication. Nean seems like a real language of thought. Nevertheless, looking at **Table 2** I have a feeling of a glass wall separating me from the full-blown language.

EVE is just dying for a grammar which would smoothly, without a bottleneck, handle:

man_give_first + man_give_straw → man give first straw or **man give straw first**

EVE's behavior definitely gives (at least to myself) some food for thought and generates questions which are halfway to understanding.

Doublets **first_say** (45) and **say_no** (58) are adjacent in the last part of the story, but **first_say_no** is not in the **narrow** content because **first_say** occurs twice, but has only one, much earlier coordinate (45), when **first** talks to **man**. I let it be so out of curiosity, not knowing what to expect, and here is the answer.

The impossibility to have **first_say_no*** in the narrow condensate poses a paradoxical problem: how to resolve this shortcoming without using my own creativity.

A possible way is to somehow use the **natural** signals of the end of phrase, like pause, intonation, or a word in a fixed syntactic position at the end of phrase, as, for example, the Japanese verb. Russian colloquial "nu" and its English counterpart "well" in the beginning of a spoken phrase convey the start of a thought expression. I believe the sterility will be preserved if we simply consider them (and punctuation marks) NAMES, but this seems already far beyond Nean. An intriguing question: when I think about fixing a problem in EVE, do I follow the same pattern as the evolving natural language did? Yes, but not as a blind watchmaker. *Nu*, well, how can I be sure?

It has taken me some time to notice that **first_say** is the only doublet that has been classified by SCALE as old during LISTENING. Therefore, something must happen with it on the second occurrence which does not happen with the rest of NAMES. What "second occurrence" implies is the single continuous timeline (history) of the system, which is the intrinsic property of an exystem and part of its definition. At normal conditions no memory of an exystem can be externally manipulated, even if it is an Orwellian exystem.

While I am developing some ideas about improving EVE, I realize that they are not sterile. I do not have a clear vision how the natural EVE could arrive to any such step on its own. But am I really outside EVE if it is a creation of my mind? I know introspectively that my thinking is not algorithmic and, therefore (can we even say "therefore?"), as chaotic as the movements of a trapped animal. I assume that in a way it is a recapitulation of some stages of phylogenesis of the mind. EVE stimulates asking difficult and troubled questions. The deepest among them is how the phylogenesis of mind can be spontaneously recorded, i.e., what is the genome of the mind? In molecular chemistry and AI this question is easy to answer.

There is another—smaller—problem: what to do about erroneous outer thoughts like **wolf_ask_first + ask_first_build + first_build_house → wolf ask first build house**? Is it enough to say that to err is human? It could be, of course, an honest mistake of a child retelling the story or answering a question. Now we are talking about possible psychological, not digital, experiments, but I intend to stay with pattern chemistry which is trans-disciplinary.

Evolution **is a sequence of solved problems:** a steeplechase of successfully passed **transition barriers ,** speaking chemically, known as **punctuated equilibrium** in biology.

I suggest the sterility condition for evolutionary games as:

The solution must be so simple that it could occur at random,

like the variation of the parameters and the size of the spotlight at SPEAKING. I must confess, however, that I had invented the variable spotlight myself (it suddenly occurred to me after intense chaotic, soup-like thinking) and found the excuse later. I hope this illustrates what I mean by intellectual infection and how difficult it is to avoid it in Natural Artificial Intelligence.

The above results illustrate, in my opinion, the importance of the knowledge acquisition through stories, procedures, and, generally, sequences, which opens, thorough the evolutionary feedback, a way to complex knowledge. This is why children should be told consistent stories. Origin of language is inseparable from the actual living conditions, environment, and material culture. Its closest pattern-chemical parallel is the origin of the cell genome. To fantasize further, the consciousness, which is the cauldron for the momentary batch of the thought soup, should not be either too big, or too small. Moreover, there could be various levels of **wider** subconsciousness below the narrow working consciousness.

In big systems some combinatorial situations can never realize, while in small systems they constantly repeat but do not have much choice.

A speculative discussion of all these problems could be endless. This is a good time to stop SPEAKING and do more THINKING.

8. CONCLUSION

No firm conclusion can be made from the first preliminary computer games.

But what exactly does "firm conclusion" mean?

The value of computer simulations is a vast and controversial topic. Manfred Eigen's entire work in chemical evolution could be questioned in this regard, not to mention the whole boundless area of the hectic activity of modern descendants of mythical centaurs: humans fused with controlled computer and computers fused with controlled humans.

I tend to draw a sharp distinction between **realistic** models, like weather, bridge, and airplane, and **speculative** modeling, like ALIFE (Artificial Life) and econophysics. Ulf Grenander's GOLEM belongs to the second category. On the contrary, Pattern Theory of medical image processing belongs to the first type.

The significance of the first kind is that it generates knowledge, while the second kind generates understanding. The whole Pattern Theory is, first of all, a way to understand the complex world as a whole, regardless of what money we can make on that. Knowledge today is for sale, but understanding is still almost free. Have in mind, however, that understanding can be wrong, while knowledge is testable and certifiable.

I start Nean with extreme simplicity, but very soon the horizons of extreme complexity come near, within an arm distance. In order to draw even speculative, but somewhat firmer, conclusions, I have to explore so many combinations of so many factors, that with the means at my disposal it would take a second life. Besides, I believe that for the sake of knowledge the mind should be built, not just simulated. Chemists just go to the bench and do what has to be done, quite like the heroes of John Wayne.

Manfred Eigen was earlier in his life awarded Nobel Prize for fine experimental work on "immeasurably fast" chemical reactions, based on an ingenious theoretical idea. Much later he expressed (see long interview) the relation between theory and experiment in this way: "No theory without experiment and no experiment without theory." Obviously, he could not be satisfied with speculation alone and his work after 1980 became experimental. Note, however, that it is not yet about **origin** of life and beginning of evolution, but about replication of biopolymers.

I stop here with a hope to be able to continue. I see the significance of the first speculative "experiments" in making the first **simple** step from **simplicity** to complexity and discovering that it in fact complexity emerges if we repeat simple steps. Whether it

all is true, false, or irrelevant (Manfred Eigen's tree-fold classification), I cannot say. The experiment, ultimately, would consist in **educating** a young EVE until it satisfies the Turing test even at a level much below Commander Data from *Star Trek*. It should be a machine with personality, capable of honest errors and progress.

Why is it important to be natural? Here is an example. The choice of **G** is especially difficult because words differ in the number of connections (arity, **Ar**). I have not yet decided on the choice of **G** and use in **saycon2** a coefficient **B** in **B·G** : $\mathbf{B} = 1 / \sqrt{\mathrm{Ar}}$. To tinker with parameters, however, is a cumbersome and very AI-ish work. A much more daring step toward naturalization would be to let the model search for maximum stability in the interaction with the human environment, registering the frustration or satisfaction of the humans around the model, as well as the "mood" of EVE. The idea, on which I have a fixation, that homeostasis is in the core of intelligence comes from Ross Ashby.

I must acknowledge that I have been ignoring the growing and exciting area of research on embodied agents and embodied evolution, including evolution of language, to which Stefano Nolfi has kindly drawn my attention. The word **embodied** here has no esoteric connotation and means simply that the objects of study are material objects and not just manipulation of digits in computers. In my opinion it is the direction which both John Wayne (whose sharp shots were fake) and Ross Ashby (whose rambling homeostat was 100% real) would welcome. Robots consume and dissipate energy, without which no exystem is possible. They can compete for a limited resource of energy, matter, and space, which is all we want from an avatar (move aside, John Wayne!) of the real life. I am especially interested in the stability dynamics of robots and their societies and whether their behavior is of the Levi walk type. How would they interact with a human? A dog?

It is my uneducated impression that embodied evolution has one important thing in common with classical artificial AI: the "genome" of neural networks, i.e., the feature that can be varied at random and submitted for selection, is explicit, observable, and controllable, quite like the molecular genome. This is a very strong realistic side of it. A big general question is: could that be in principle different for natural AI and, for that matter, natural-natural intelligence? Obviously, the parameters in EVE can be varied at random, but EVE seems less deterministic because random process is the very essence of blind selection. Biological selection is probabilistic and has no goal. Artificial AI selection is done by evaluating the result, like in sports.

This problem has an eerie aura of logical paradoxes and I do not yet have an answer. It might be impossible to get it other than from neurophysiology, but if so, is pattern chemistry of any value? On value is certain: it stimulates questions.

If not a firm conclusion than at least a soft one:

How far can we progress in understanding the origin of thought and language? "How far back can we go ahead," should I say because the question addresses a very distant past. The answer is: as far as a general theory permits. In my **firm** opinion, this general theory cannot be a theory of origin of thought and language, but a theory of any origin of

complex systems, in particular, exystems. This theory, as any theory of natural process, should have its own kind of generalized physics and chemistry which could tell us what mental constructs are more realistic than others. For two major reasons Pattern Theory (Ulf Grenander) is the only paradigm of this caliber: (1) in its trans-disciplinary approach it considers human thoughts, material objects, and anything between them on an equal basis as combinatorial structures and (2) it distinguishes between more probable and less probable structures and their transformations.

Finally, I want to accentuate that this project comes from Ulf Grenander's *"Patterns of Thought"* and the foundation which he had laid down around 1970, the time of many new and fundamental ideas in science, some still neglected or overwhelmed by faster sellable trends. For more on the mystery of 1970 see <u>Introduction to Pattern Chemistry</u>.

Shouldn't I also mention other predecessors, from Kant and Plato to the first speakers of Nean, in reversed order?

> It was Hegel who tried to pull out the big and complex world (in a trans-disciplinary fashion!) from the hat filled **simply** with being (*das Sein*) and nothing (*das Nichts*). Thus, if King Solomon says that there is nothing new under the sun, obviously, the opposite idea must be so reasonable that it needs to be denied. Niels Bohr summarizes: "The opposite of a trivial truth is false; the opposite of a great truth is also true."

MATLAB scripts (amateurish) are published separately and referred to in **APPENDIX 3,** next pages.

email

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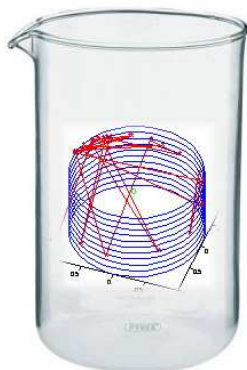
APPENDIX 1. PREVIOUS RELATED E-PUBLICATIONS

(also stored at SCRIBD)

[Molecules and Thoughts: Pattern Complexity and Evolution in Chemical Systems and the Mind](#) (2003) ; [SCRIBD](#)

[TIKKI TIKKI TEMBO and the Chemistry of Protolanguage](#)   (2004) ; [SCRIBD](#)

[Pattern Theory and "Poverty of Stimulus" Argument in Linguistics](#) (2004) ; [SCRIBD](#)

[The Three Little Pigs : Chemistry of language acquisition](#)   (2005) ; [SCRIBD](#)

[Salt: The Incremental Chemistry of Language Acquisition](#) (2005) ; [SCRIBD](#)

[Salt 2: Incremental Extraction of Grammar by Simplistic Rules](#)   (2005) ; [SCRIBD](#)

[The Chemistry of Semantics](#)   (2005) ; [SCRIBD](#)

[Do Pirahã speak Nean?](#) (2007) ; [SCRIBD](#)

APPENDIX 2 . SOME QUESTIONS AND ANSWERS

The following questions and answers may help clarify the approach of pattern chemistry.

1. Q: Why do I need to refer to the Great Depression or grumble about the dysfunctional American government in an opus on origin of language?

A: Pattern chemistry, as, more generally, Pattern Theory, is trans-disciplinary. It sees the world through the filter of patterns. Pattern is a space of configurations related through a similarity transformation. Transformation makes sense for not less than two configurations. The more configurations, the more distinct the pattern.

2. Q: In Bourbaki's scale of sets, a combination of elements of a set enters the set as a new element. If this is a general pattern of complexification, what prevents it in nature? It is said usually that brain contains billions of cells and even larger number of their

connections. If so, brain could be as lost in its own complexity as the American political system. Yet even some college dropouts can make swift and clever decisions in complex matters. What limits the connectivity?

A: The actual history of the system. Only one or a few out of many combinatorial possibilities in fact happens. History of an exystem squeezes out a thin spaghetti from the combinatorial space of connectivity.

3. Q: Marco Mirolli and Domenico Parisi ask: How can we explain the emergence of a language which benefits the hearer but not the speaker? (**Connection Science**, 17(3-4): 307-324). I take the question just as an example, but how would pattern chemistry answer this and similar questions about benefits and fitness?

A: The idea that **beneficial** changes are preserved and evolution is survival of the **fittest** is the key tenet of Darwinism. Yet it has always looked like a tautology. The statement that the world was created in six days does not look circular at all and, although **decently** false, is capable of winning some minds. The paradigm of embodied artificial evolution is more consistent: fitness is defined as performance of a certain function. If something extra happens, it is recorded, and so be it. The very essence of neural network requires somebody or something to approve or reject the state of the network and the distribution of connectivity and weights.

The answer of pattern chemistry is typically chemical: evolution is a search for stability. Since both hearer and speaker are subsystems of the same exystem, even if they do not cooperate or interact in any way, the property of verbal communication stabilizes the system by adding bonds. There is more finesse, however: if two trends compete, the fastest is more probable to win or dominate. This releases us from the duty to justify haplology, contraction, loss of grammatical gender and case endings, or any other simplification in the evolution of language. If I am not mistaken, Kolmogorov complexity (although I am not a fan of it) is, roughly, the minimal and, therefore, the **fastest** to transmit length of a certain string of symbols. **Faster** and **slower** are the prime terms of chemical kinetics.

APPENDIX 3 : SCRIPTS and WORKSPACE

Any trajectory AA (as a vertical array: AA =[….] ') can be replayed by script **repro** (in WORLD space) or script **tr3d** in time, quite like a video**.**

Codes are in <u>separate APPENDIX file</u> , periodically revised, last revision : February 19, 2010
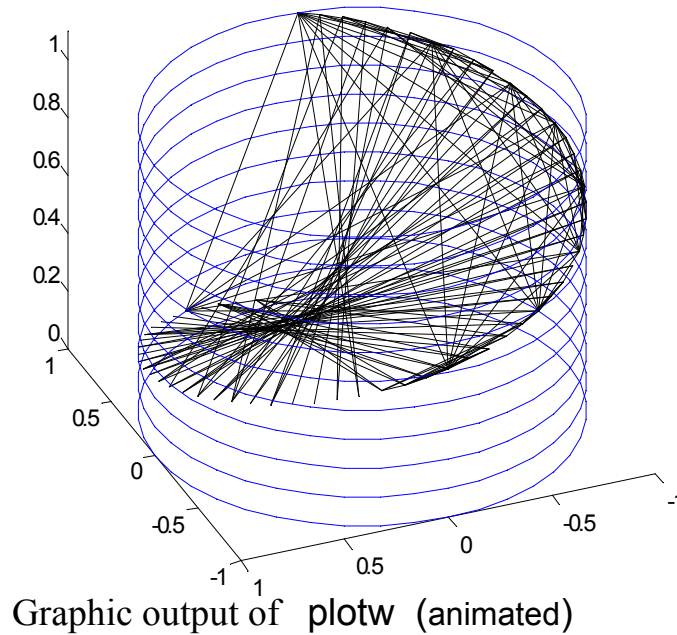
scripts and workspace as text file: http://spirospero.net/eve-scripts.txt

scripts and workspace as pdf   http://spirospero.net/eve-scripts.pdf

http://www.scribd.com/doc/26046555/APPENDIX-to-PATTERN-CHEMISTRY-OF-THOUGHT-AND-SPEECH

LIST OF SCRIPTS:

Part 1: SCALE

1. SCALE

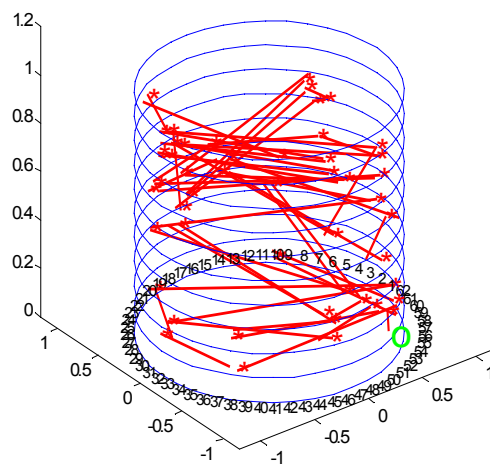2. LINK

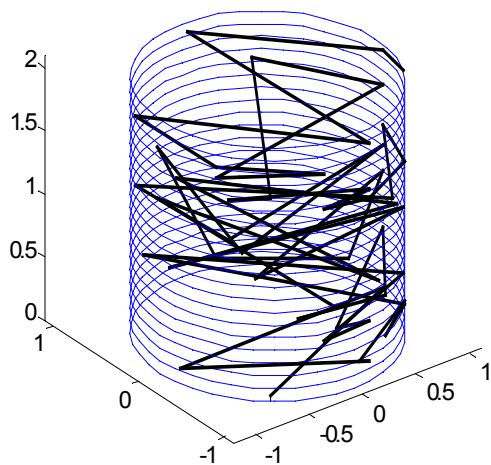3. PLOTW

Graphic output of plotw (animated)
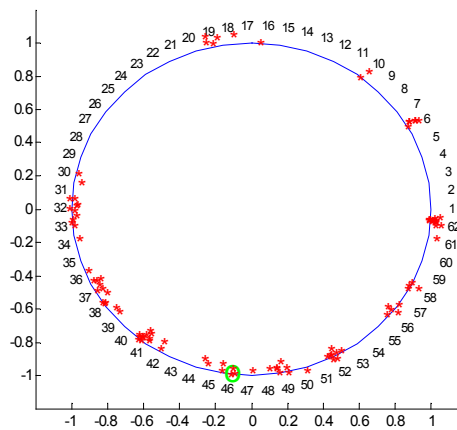
Part 2: EVE

1. INIT
2. P3D3
3. SELECT3
4. NUMS
5. SAYCON2
5A. SAY_CON
6. STACK
7. TR
8. TR3D
9. REPRO
   (replays   AA)
10. REPRO2d
(2D distribution of actons)

**Graphic output of repro. Axis Z is
space of WORLD   (1:62, animated)**

Graphic output of tr3d. Axis Z is time (animated)

Graphic output of repro2d

Last updated: November, 2010