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## Categories of the RK-Archive

# Morphogrammatics of "undifferentiated Encoding"

## *On a possible connection between neuronal encodings and morphograms*

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**Abstract**

An understanding of Heinz von Foerster's constructivist *"Principle of undifferentiated Encodings"* as differentiations of morphograms and computed by morphic differentiation machines is proposed.

(Work in progress 0.2.5, March 2013)

# 1. From perception to cognition

## 1.1. Perception, learning and memory as cognition

### 1.1.1. Neural studies and morphogrammatics at the BCL

One of the first astonishing results of bio-cybernetics and bionics at the Biological Computing Laboratory (BCL) at Urban, Illinois, in 1961 had been the device called "*NumaRete*" with the meaning: Numa-Rete ("RETina" that "saw" NUMbers)

Shortly after NumaRete and similar projects, Heinz von Foerster promoted Gotthard Gunther's theory of *"Cybernetic Ontology"* (1962) which was based on "morphograms" and compounds of morphograms involving concepts of distribution, mediation and reflection of classical logical systems. Von Foerster provided Gunther with the necessary number-theoretic material, calculated by A. Andrew, Table of Stirling Numbers of the Second Kind (1965), and combinatorial elaborations by Gunther's assistant H.S.H Na (1964).

Gunther's assistant Dieter Schadach established a very short link between morphogrammatic constructions, automata and information theory (1967).

The idea of difference-theoretic thinking of kenogrammatics had been strongly promoted by Von Foerster but a connection between his *Principle* *of undifferentiated Encoding,* and its forerunners, and Gunther's *keno- and morphogrammatics* as a foundation of cyber-ontology, had not been in the horizon.

> "Starting from the insight that nervous signals are merely electrochemical, Heinz von Foerster formulated the
> *Principle of Undifferentiated Encoding*:
>
> "The response of a nerve cell does not encode the physical nature of the agents that caused its response. Encoded is only 'how much' at this point on my body, but not 'what'" (Foerster 1973/2003, pp. 214–215).
>
> "The principle can be found in Maturana and Varela's claim that the cognitive apparatus is an organizationally closed system."
>
> http://www.univie.ac.at/constructivism/key.html
>
> "Heinz von Foerster dismisses reality, by referring to the *'principle of undifferentiated codification'*. This principle claims: "The state of agitation of a nerve cell only codifies the intensity, not the nature of its cause" (von Foerster 1993a, p 31). Thus he leaves every observer to *calculate* his own reality with exclusive reference to his own calculations.

So called *Radical Constructivism* and *Second-Order Cybernetics* had not been aware about the possibility of such conceptualizations of *"undifferentiated encoding"* by an application of *"kenogrammatic inscriptions"*.

Radical constructivism was mainly a German movement with its natural extensions to the neighbor countries. Its refusal to confront Gunther's work appears not just as a sign of ignorance and "Totschweigen" but also as an instinctive insight that both attempts are definitively two pair of shoes. One was focused on circular self-reference and autopoiesis in the framework of identive linearity, the other is still involved in labyrinthine tabularity beyond Western logocentrism.

From an *anecdotal* point of view I guess that Von Foerster and Gunther didn't have time enough to meet and discuss their approaches. Von Foerster was busy travelling to conferences and looking for funding for the BCL, and Gunther was obsessed to leave the Lab for skiing - (personal communication by Humberto Maturana) - and travels to Germany.

Because of the early dominance of Spencer-Brown's *Calculus of Indication* in the constructivist movement, heavely propagated by Heinz von Foerster and Francisco Varela, neither computer scientists nor biologically and sociologically oriented researcher of the constructivistic camp did confront the possibility of a connection.

Von Foerster's "*Principle of undifferentiated encoding*",(PuE), became a repeated standard alibi to not to do further foundational research, neither on topics of neuro-cybernetics nor on formalizations beyond GSB.

PuE wasn't the only crucial principle of Second-Order Cybernetics, the other was the emphasis on "*recursivity*", well supported by GSB re-entry construction but lacking any connection to the well established classical recursion theory.

The same lost chance to interact was the failure of the New Cyberneticists to see that their concept of recursivity was much more traditional than thought, and that Gunther's kenogrammatics was understandable only with a new concept of recursivity: a second-order recursivity as retro-grade recursivity.

Albeit there was an important research about recursively by Peterson at the BCL, Lars Løfgren's lessons about recursion theory didn't have a chance to be learned.

A PhD dissertation produced at the BCL:
Larry J. Peterson, The recursive nature of descriptions: A fixed point. April, 1975, BCL No. 252

XXX Gerhard Roth

**A missing link**

This paper tries to hint to a possible link between both approaches that dominated the BCL without trying to glue together that doesn't fit together.

Two simple questions that are not yet answered are to be considered:
*What is the meaning of "undifferentiated" and how is the statement to be understood that those 'undifferentiated' events just happens at a "point of the body".*

How are such 'points', where 'undifferentated' events happens, differentiated?
Is Von Foerster's *Poincaré* answer of the interplay of *Sensorium* and *Motorium* enough?

The rhetoric figure of "as such" ("als solche") gives a hint. Neuronal events, and in general, biological events, are not properly understood in isolation and 'as such'. Biological events are not given as such but are realized in complex contexts only.

In other words:

*What is the kind of "computation" that computes undifferentiated signals at different locations?*

*What kind of machines, trivial and non-trivial, could do the job?*

Because of the concept of the click-language, a first answer is obvious: a click is on or off, despite its fuzziness, it defines a binary language, codified, say as zero and one.

And the corresponding machines for physical events are ideally finite state machines (HvF). But what counts for a cognitive approach to neuronal activities are not the physical measures of the spikes but the differences between the spikes, independently of the intensity of the spikes.

> **HvF's types of machines**
> *"Foerster distinguishes between* trivial *and* non-trivial *machines. The former maps input to output according a mapping-function without memory (i.e., corresponds to finite state machines with regular grammar).*
> *Non-trivial machines consist of a memory holding an internal state and two mapping functions. The "effect" function that maps input to output depending on the internal state.*
> *The "state" function performs the state transition depending on the input.*
>
> *Of course, Foerster's classification is fully covered by the* Chomsky hierachy of formal grammars *but he uses his distinction to point out how difficult it is to deduce the structure of a non-trivial machine from its behavior."*
> http://www.univie.ac.at/constructivism/key.html

As proposed in recent papers, finite state machines, FSM, of whatever kind, are not difference machines, calculating information-independent differentiations of closed systems but identive symbol- and information-processing machines. Thus, Von Foerster' s machine concepts are members of the Chomsky-Hierarchy. What seems to be in strict contradiction to its subversive declarations.

In contrast, the newly introduced differentiation machines, morphFSM, are bet to be just the machines that are able to deal with 'undifferentiated' neural events in a highly specific and differentiated sense without being forced to reduce them to physical entities run by trivial or non-trivial machines.

Therefore, morphogrammatic machines are hardly to be unified under the umbrella of Chomsky’s grammars.

It should be clear that the morphogrammatic approach to computation, if successful, is not taking position for a computionalist or even digitalist position.

The *morphic* abstraction abstracts from the informational *“what”* of the neural events and uncovers its semantic-free structuration.

Morphogrammatic scriptures are not only semantic-free but also not organized in a syntactical tectonics (Curry) of formal languages.

**Brain activity as cognition or cognition as brain activity**

A crucial reason for the emphasis on the *Principle of Undifferentiated Encoding* by the constructivist movement is the desire or the insight that the *brain* is able to interpret, i.e. to compute, the “what” of the encodings delivered from different parts of the body, and is therefore cutting it from a too close involvement with a pre-given world.

This constructivist approach to a computed interpretation of the world is not yet taking position in the antagonism of a ‘*computational*’ or a ‘*dynamical*’ research program.

Brain activity as *awareness* or *vigilance* goes beyond that. In this case, the brain activity is not forced to accept the structure of a neuronal activity constellation. Depending on interest and focus, different configurations of neuronal constellations are constructively activated or deactivated. This is ruled by brain activities and not just by perception (dominated by an outside world). This activity corresponds morphogrammatically the activities of coalitions of cooperations of morphograms and morphic automata.

**Memristics of neuronal activities**

All that is just a very first beginning to characterize neuronal activities as undifferentiated encodings. As Francisco Varela discovered, neural activities are not just binary on/off-events, differentiated or undifferentiated, fuzzy or dichotomic, but are involved in intriguingly simultaneous complex *retro-grade* and *antidromic* actions.

Parts of these insights into a post-McCulloch neuro-cybernetics are developed in the context of the research of the behavior of *memristors* and *memristive systems*. The ambitious DAPRA program *SyNAPSE* is not just a new application of the old paradigm but the development of a new concept or even paradigm of brain activities based on memristive systems.The memristic specifific properties are not yet well understood.

Unfortunately there is not much conceptualization towards memristics to register. The main attempts are as usual a first modeling of old concepts and devices within the possibilities of the new framework and elements.

> **Varela: Design, reciprocity and contextuality**
> *"Basically the point is that in the wild an animal has to generate or define what is to be learned as these are not given as predefined lists. This is equivalent to putting the stress on the* autonomy *of the living system, and to realign cognition with voluntary action rather than information processing.*
>
> *"Thus, every synaptic action is* contextualized *by the pattern of activity of the constellation of inputs arrving at that point. The temptation to simplify this situation into just pre- and post-synaptic activity is great, but it surely distorts the actual neuronal dynamics far too much.*
>
> *"The substrate for these "voluntary" states is the universal* reciprocity *of connections between brain regions which makes it possible for central and periphal regions to cooperate in the generation of a global state, compatible both the animal's history and the current sensory coupling."*
> Varela, in: Cognitiva 85, p. 762/763

Recall again: *„On the other hand, a machine, capable of genuin decision-making, would be a system gifted with the power of* self-generation of choices*, and then acting in a decisional manner upon self-generated alternatives.“* (Gunther 1970, 6)
Gotthard Gunther, Proposal for the Continuation of a Mathematical System for Decision Making Machines,
Under Grant AF-AFOSR 68-1391 for One Year From 15 October 1970, July 31, 1971

More at:
http://memristors.memristics.com/MorphoProgramming/Morphogrammatic%20Programming.pdf

**Some literature**

Jamie Hutchinson, "Nerve center" of the cybernetic world
http://bcl.ece.illinois.edu/hutchinson/index.htm
Peter Asaro , Heinz von Foerster and the Bio-Computing Movements of the 1960s
http://www.stim.illinois.edu/unfinishedrev/11_asaro.pdf
http://www.univie.ac.at/constructivism/HvF/festschrift/weston.html
http://www.pangaro.com/HvF-Vienna2003-Pangaro-MS8c.pdf

### 1.1.2. Citations [1]

1

## 1.2. Types of codifications

### 1.2.1. Undifferentiated encoding

**Heinz's Klick-lanuage**

"Diese Sprache des Nervensystems ist *bedeutungsneutral* - oder wie Heinz von Foerster dies beschreiben würde: die Sprache des Nervensystems kennt nur das Wort "Klick".

"Die Erregungszustände einer Nervenzelle codieren nur die *Intensität*, aber nicht die Natur der Erregungsursache.

"Das "Original" geht in dieser "Klick"-Sprache verloren. Was wir wahrnehmen, ist also eine Interpretation, eine Bedeutungszuweisung unseres Gehirns aus sich heraus. Das Gehirn ist ein selbstreferentielles und selbstexplikatives System, d.h. "Alle Bewertungs- und Deutungskriterien muß das Gehirn aus sich selbst entwickeln." (Schmidt, 15)

**Morphogrammatics of the *"Principle of undifferentiated Encoding"***

Heinz von Foerster's *"Principle of undifferentiated Encoding"* corresponds exactly the differentiational characteristics of morphograms.
He says, its just a Klick. But the Klick is differentiated:
*firstly*, it is localized at a place or locus of a body,
*secondly*, it is differentiated into different intensities.
Both aspects are, obviously, not representing an original source and its semantics.
The meaning (semantics) of the Klick-structure has therefore to be interpreted, i.e. calculated by the "brain".
Nevertheless, the interpretation stands in some correlation to the Klick-structure, i.e. the quantity (intensity) and the locus to offer a meaningful calculation.

Morphogrammatically, the Klick-structure is represented by the EN-structure of a morphogram. That is, by the chain or grid of differentiations, - different E, non-differnet N -, and not the by the sequence of different or same Klicks 'as such'. In a differentiation model, a "Klick as such" as a singular event doesn't exist.

Kenograms are localized in the pattern of the morphogram. Localization and EN-structure are defining the morphogram at a position in a morphogrammatic compound-system (structuration).

Any logical meaning of the morphogram is an interpretation of the morphogram from a non-morphogrammatical point of view. Say, from polycontextural logic, semiotics or information theory.

Thus, morphograms are semantic-free, and therefore also negation-invariant.

Intensity means: equal or different events at different places. It has not to be a quantified entity.
Hence, the mechanism of perception is ruled by morphic FSMs. And not by information-processing FSMs.

## 1.3. Codification beyond information

### 1.3.1. How, what and where of neuronal activities

About some differences in the concept of undifferentiated encoding.

"But what is gained in variety, is lost in facility of *calculation*. Von Foerster insisted on the need for a computation but in 1973, date of a princeps communication, there were few data which could explain this computation.

"[...] neurons will be more sensitive to a sound stimulus, others to a tactile or odorous one. It is what Müller described as specific energy principle. Therefore, in the presence of a defined stimulus, all the neurons will not react in the same way; and the difference will be a source of a considerable information, in fact the most important one.

"- all neurons of the body do not have the same *site*. Since this site is encoded, it introduces a considerable additional variety."

http://cerveau.pensee.free.fr/livre/Neurons%20do%20not%20say%20what.pdf

### 1.3.2. Epistemology

**Kant's noumenon and phenomenon**

"In the line of the opposition *noumene/phenomene* postulated by Kant, two different meanings must be granted to the concept of reality:

- a reality in itself or *noumenal*. Such a reality can be logically postulated because we belong to this reality. To deny it, would result in denying ourselves, which does not mean anything.
On the other hand, such a reality escapes any description other than the existence.

- a perceptible or *phenomenal* reality. This reality is accessible to our knowledge but under a subjective form. It is one particular reality among a great number of possible constructions, deduced from the operation of our perceptive brain, indissolubly related to the characteristics of our means of knowing, and limited to our effective meetings with our environment.”

http://cerveau.pensee.free.fr/livre/Neurons%20do%20not%20say%20what.pdf

Following the distinction of semio- and morphosphere, Kant’s dichotomic distinction of noumena and phenomena is still restricted to the surface structure of the morphosphere.

Morphogrammatics attempt to uncover the limits set by Kant and tries to unmask the field of noumena and its deep-structure. Hence, the statement, that reality as noumenon *“can be logically postulated”* uncovers itself as much too weak because it denies its own morphic computability.

http://memristors.memristics.com/Morphospheres/Asymmetric%20Palindromes.pdf

### 1.3.3. Perception as information processing

Palindromicity of perception:
"As light passes through the lens of eye, the image is in-verted and focus on the retina."
http://bi.snu.ac.kr/Courses/g-ai06_2/ch5bw.pdf

### 1.3.4. Perception as morphic computing

The contrast of the ‘*how*’ of perception and the ‘*what*’ of perception is mirrored in the distinction of ‘differentiation’ and ‘information’ of the process of perception.

The “*how*” is measured by the Stirling numbers of the second kind.
The “*what*” is measured classically by the logarithm of information. Information measured by the binary logarithm is based on a hierarchical system of decisions.

Stirling numbers are codified by a retro-grade recursive heterachical system of ‘differentiations’ (in contrast to distinctions of decisions).

**Neural and neuronal coding**
The term “*neural*” is related to the activity of single neurons, while the term ‘’*neuronal*‘’ includes assemblies of neurons.
*intensity* of spikes: length of a monomorphy,
contextural *what* and *where*: distribution of different monomorphies over different loci and distribution of morphograms over different contextural positions in a positionality system (cf. ‘poly-cross bar systems')

**What, how, where (and other language dependencies)**
intensity, spikes (kenoms), monomorphy, locus

**Modeling of neural and neuronal activity**

model: (impuls, intensity, where, what) $\longrightarrow$ (kenom, monomorphy, locus, position).

Model: (neurol-activity, what) $\longrightarrow$ (morphogram, position)

*sign*: surface event of information processing.
*kenom*: differentiation structure of events.
*monomorphy*: multitude, quantity, intensity of a ‘undifferentiated’ impluse.
*locus*: the sites of a body, where synapses, neural events, are located.
*position*: Position is the mapping of a morphogram onto a positionality system of discontextural levels of a living system.

It is said that the neural activities of different perception systems are still undifferentiatedly the same as clicks, and nothing else, it has to be understood that the different positions on the body, sites, are as differences just defining the different kinds of “what”.

Again, *"The state of agitation of a nerve cell only codifies the* intensity, *not the* nature *of its cause.”* (HvF)

But the position of the action is not definied by the klick-actions at specific positions.

*"Inside the nervous system there are only “bips” passing from neuron to “*
Santiago Ramon y Cajal

Again, Heinz von Foerster *"On Constructing a Reality"*:

> *"Since the physical nature of the stimulus--its quality--is not encoded into nervous activity, the fundamental question arises as to how does our brain conjure up the tremendous variety of this colorful world as we experience it any moment while awake, and sometimes in dreams while asleep. This is the ``Problem of Cognition", the search for an understanding of the cognitive processes."*

http://ada.evergreen.edu/~arunc/texts/cybernetics/heinz/constructing/constructing.html

### 1.3.5. Elements of morphogrammatics

**Positionality** of morphograms: <Position, Locality, Place>.

***Position*** of the morphogram in *a* morphogrammatic
system defined by emanation and evolution.

***Locality*** of the monomorphies in *a* morphogram;

loci are offering place for different monomorphies.
**Monomorphies** might be reduced to homogeneous patterns or they might keep some structuration.
***Place*** of *a* kenom in *a* monomorphy depending on the length of the monomorphy.

$$MG^{(m,n)} = \left(\text{morphogrammatic grid}\left(\text{morphogram}\left(\text{monomorphy}\left(\text{locus}\left(\text{place}\right)\right)\right)\right)\right)$$

**Position** of *a* morphogram in the kenomic grid $MG^{(m,n)}$

| | |
|---|---|
| $MG^{(m)}$ morphogram | **loci** of *a* morphogram |
| $Dec\left(MG^{(m)}\right)$ decomposition | **monomorphy** at *a* locus |
| $Ken\left(MG^{(m)}\right)$ | **kenom** at place |

**Example**

| | |
|---|---|
| $MG^{(4)} = \begin{bmatrix} a & a \\ bb & c \end{bmatrix}$ | $loc_1$ $loc_2$ *a* place $loc_3$ $loc_4$ |
| Dec | $mg_1$ $mg_2$ $mg_1$ $mg_1$ |
| $MG^{1.0\ .1\ .0}$<br>$MG^{0.2\ .0\ .0}$<br>$MG^{0.0\ .0\ .3}$ | *a* – *a* –<br>– bb – –<br>– – – *c* |

| | |
|---|---|
| $\begin{bmatrix} a & a \\ bb & c \end{bmatrix}$ | **loci :** $loc_1$ $loc_2$ $loc_3$ $loc_4$ |
| Dec | **monomorphies :** $mg_1$ $mg_2$ $mg_1$ $mg_3$ |
| $MG^{1.3}$<br>$MG^{2}$<br>$MG^{4}$ | **kenom :** *a* – *a* –<br>– **place :** $pl1 = b$, $pl2 = b$ – –<br>– – – *c* |

### 1.3.6. Morphogrammatics of neuronal activities

**Combinatorics**

For the example of 5 sensors, the '*what*'-distinctions without redundancy are determined by the number $5^5 = 3125$. In contrast, the '*how*'-differentiations without redundancies are determined by the trito-number 52.

**Table of basic configurations (proto – structure) : sum 5**

| configurations | locus1 | locus2 | locus3 | locus4 | locus5 |
|---|---|---|---|---|---|
| [1, 1, 1, 1, 1] | 5 klick | – | – | – | – |
| [1, 1, 1, 1, 2] | 4 klick | 1 klick | – | – | – |
| [1, 1, 1, 2, 3] | 3 klick | 1 klick | 1 klick | – | – |
| [1, 1, 2, 3, 4] | 2 klick | 1 klick | 1 klick | 1 klick | – |
| [1, 2, 3, 4, 5] | 1 klick | 1 klick | 1 klick | 1 klick | 1 klick |

**Table of basic configurations (deutero – structure) : sum 7**

| configurations | locus1 | locus2 | locus3 | locus4 | locus5 |
|---|---|---|---|---|---|
| [1, 1, 1, 1, 1] | 5 klick | – | – | – | – |
| [1, 1, 1, 1, 2] | 4 klick | 1 klick | – | – | – |
| [1, 1, 1, 2, 2] | 3 klick | 2 klick | – | – | – |
| [1, 1, 1, 2, 3] | 3 klick | 1 klick | 1 klick | – | – |
| [1, 1, 2, 2, 3] | 2 klick | 2 klick | 1 klick | – | – |
| [1, 1, 2, 3, 4] | 2 klick | 1 klick | 1 klick | 1 klick | – |
| [1, 2, 3, 4, 5] | 1 klick | 1 klick | 1 klick | 1 klick | 1 klick |

**Constellations on the trito – level**

$$\sum_{k=1}^{m} Sn(5, k) = 1 + 15 + 25 + 10 + 1 = 52$$

For the example of 5 sensors, the 'how'-differentiations are determined by the 52 Stirling numbers of the second kind:

the distribution of 1 event results in 1 constellation,
the distribution of 2 events results in 15 constellations,
the distribution of 3 events results in 25 constellations,
the distribution of 4 events results in 10 constellations,
the distribution of 5 events results in 1 constellation.

Calculated by the function *Tcontexture 5*:

```
- Tcontexture 5;
val it =
[[1,1,1,1,1],
[1,1,1,2,2],[1,1,2,1,2],[1,1,2,2,1],[1,2,1,1,2],[1,2,1,2,1],
   [1,2,2,1,1],[1,2,2,2,1],[1,2,2,1,2],[1,2,1,2,2],[1,1,2,2,2],
```

```
[1,1,1,1,2],[1,1,1,2,1],[1,1,2,1,1],[1,2,1,1,1],[1,2,2,2,2],
[1,1,2,2,3],[1,1,2,3,2], [1,1,2,3,3],[1,2,1,2,3],[1,2,1,3,2],[1,2,2,1,3],
   [1,2,2,3,1],[1,2,3,1,2],[1,2,3,2,1],[1,2,1,3,3],[1,2,3,1,3],[1,2,3,3,1],
[1,2,2,3,3],[1,2,3,2,3], [1,2,3,3,2],   [1,1,1,2,3],[1,1,2,1,3],[1,1,2,3,1],
   [1,2,1,1,3],[1,2,1,3,1],
[1,2,3,1,1],[1,2,2,2,3],[1,2,2,3,2],[1,2,3,2,2],[1,2,3,3,3],
[1,1,2,3,4],[1,2,1,3,4],[1,2,3,1,4],[1,2,3,4,1],[1,2,2,3,4],[1,2,3,2,4],[1,2,3,4,2
],
   [1,2,3,3,4],[1,2,3,4,3],[1,2,3,4,4],
[1,2,3,4,5]] : int list list
```

```
–Tcard 5;
val it = 52 : int
```

Tcard 5 = 1 + 15 + 25 + 10 + 1 = 52

### Classification

The 52 trito-distributions of the events of complexity 5 gets resumed to 7 partitions on the deutero-level and to 5 on the proto-level of graphematic inscriptions.

- **Dcontexture** 5;

```
val it =
  [[1,1,1,1,1],[1,1,1,2,2],[1,1,1,1,2],[1,1,2,2,3],[1,1,1,2,3],[1,1,2,3,4],
   [1,2,3,4,5]] : int list list
```

- **Pcontexture** 5;

```
val it = [[1,1,1,1,1],[1,1,1,1,2],[1,1,1,2,3],[1,1,2,3,4],[1,2,3,4,5]]
  : int list list
```

**Totally homogeneous trito-distribution**

```
- ENstructure [1,1,1,1,1];
val it =
[[],
[(1,2,E)],
[(1,3,E),(2,3,E)],
[(1,4,E),(2,4,E),(3,4,E)],
[(1,5,E),(2,5,E),(3,5,E),(4,5,E)]] : (int * int * EN) list list
```

**Mixed trito-distribution**

```
- ENstructure[1,1,2,1,3];
val it =
[[],
[(1,2,E)],
[(1,3,N),(2,3,N)],
[(1,4,E),(2,4,E),(3,4,N)],
[(1,5,N),(2,5,N),(3,5,N),(4,5,N)]] : (int * int * EN) list list
```

**Totally heterogeneous trito-distribution**

```
- ENstructure [1,2,3,4,5];
```

```
val it =
[[],
[(1,2,N)],
[(1,3,N),(2,3,N)],
[(1,4,N),(2,4,N),(3,4,N)],
[(1,5,N),(2,5,N),(3,5,N),(4,5,N)]] : (int * int * EN) list list
```

### 1.3.7. Monomorphies

Decomposition of morphograms from *Tcontexture 5* into *monomorphies* and their distribution in the kenomic matrix.

**Examples from Tcontexture 5**

| [1, 1, 2, 3, 3] | $loc_1$ | $loc_2$ | $loc_3$ |
|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ |
| $MG^{1.0\ .0}$ | [11] | – | – |
| $MG^{0.2\ .0}$ | – | [2] | – |
| $MG^{0.0\ .3}$ | – | – | [33] |

| [1, 1, 2, 3, 1] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ |
|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_1$ |
| $MG^{1.4}$ | [11] | – | – | [1] |
| $MG^{2}$ | – | [2] | – | – |
| $MG^{3}$ | – | – | [3] | – |

| [1, 1, 2, 3, 1] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ |
|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_1$ |
| $MG^{1.4}$ | [11] | – | – | [1] |
| $MG^{2}$ | – | [2] | – | – |
| $MG^{3}$ | – | – | [3] | – |

| [1, 1, 2, 3, 2] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ |
|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_2$ |
| $MG^{1}$ | [11] | – | – | – |
| $MG^{2.4}$ | – | [2] | – | [2] |
| $MG^{3}$ | – | – | [3] | – |

| [1, 2, 2, 3, 4] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ |
|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_4$ |
| $MG^{1}$ | [1] | – | – | – |
| $MG^{2}$ | – | [22] | – | – |
| $MG^{3}$ | – | – | [3] | – |
| $MG^{4}$ | – | – | – | [4] |

| [1, 2, 3, 2, 3] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ |
|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_2$ | $mg_3$ |
| $MG^{1}$ | [1] | – | – | – | – |
| $MG^{2.4}$ | – | [2] | – | [2] | – |
| $MG^{3.5}$ | – | – | [3] | – | [3] |

| [1, 2, 3, 4, 5] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ |
|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_4$ | $mg_5$ |
| $MG^1$ | [1] | – | – | – | – |
| $MG^2$ | – | [2] | – | – | – |
| $MG^3$ | – | – | [3] | – | – |
| $MG^4$ | – | – | – | [4] | – |
| $MG^5$ | – | – | – | – | [5] |

| [1, 2, 3, 2, 4] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ |
|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_2$ | $mg_4$ |
| $MG^1$ | [1] | – | – | – | – |
| $MG^{2.4}$ | – | [2] | – | [2] | – |
| $MG^3$ | – | – | [3] | – | – |
| $MG^5$ | – | – | – | – | [4] |

**Table of basic configuration examples (trito – structure)**

| configurations | locus1 | locus2 | locus3 | locus4 | locus5 |
|---|---|---|---|---|---|
| [1, 1, 2, 2, 1] | 2 klick1 | 2 klick2 | 1 klick1 | – | – |
| [1, 1, 1, 1, 2] | 4 klick1 | 1 klick2 | – | – | – |
| [1, 1, 1, 2, 2] | 3 klick1 | 2 klick2 | – | – | – |
| [1, 2, 1, 2, 3] | 1 klick1 | 1 klick2 | 1 klick1 | 1 klick2 | 1 klick3 |
| [1, 1, 2, 2, 3] | 2 klick1 | 2 klick2 | 1 klick3 | – | – |
| [1, 2, 3, 1, 4] | 1 klick1 | 1 klick | 1 klick3 | 1 klick1 | 1 klick4 |
| [1, 2, 3, 4, 5] | 1 klick1 | 1 klick2 | 1 klick3 | 1 klick4 | 1 klick5 |

### 1.3.8. EN-structure of ‘undifferentiated’ encoding

A configuration of neural events of complexity 5 might be described by a tupel of events by (1,2,1,2,3).

The morphogram of this tupel is defined by its ENstructure[1,2,1,2,3]. But as the EN-structure of a configuration shows clearly, this special configuration has the same EN-structure as any realization by identitive events, say clicks.

Hence, for 3 different individual clicks A, B, C, the realizations are the permutations of the tupel:

(A,B,A,B,C)
(A,C,A,C,B)
...
(A,B,C,D).

But also redundant realizations, like: (C,D,C,D,E) or (A,D,A,D,E) are included.

Obviously, all those atomistic chains of individual Klicks have the same EN-structure.

```
- ENstructure[1,2,1,2,3];
val it =
  [[],
  [(1,2,N)],
  [(1,3,E),(2,3,N)],
  [(1,4,N),(2,4,E),(3,4,N)],
  [(1,5,N),(2,5,N),(3,5,N),(4,5,N)]] : (int * int * EN) list list
```

```
- ENstructure[3,4,3,4,5];
val it =
  [[],
  [(1,2,N)],
  [(1,3,E),(2,3,N)],
  [(1,4,N),(2,4,E),(3,4,N)],
  [(1,5,N),(2,5,N),(3,5,N),(4,5,N)]] : (int * int * EN) list list
```

**ENstructure and monomorphies**

The procedure of ENstructure applies to *monomorphies* as well. Monomorphies of a morphogram are providing some additional abstraction and classification that are characterized by EN-structures.

monomorphy([1,2,2,3,1]) = <[1], [2,2], [3],[1]>
ENstructure of monomorphy([1,2,2,3,1]) = ENstructure[1,2,3,1].

```
- ENstructure[1,2,3,1];
val it =
[[],
[(1,2,N)],
[(1,3,N),(2,3,N)],
[(1,4,E),(2,4,N),(3,4,N)]]
: (int * int * EN) list list
```

Therefore, the ‘undifferentiatedness’ of configurations of neural events is represented by its EN-structure.

As a morphogrammatic thesis for neural activities we get a first general statement:

**Undifferentiated encodings over a topology are modeled by the $\varepsilon/\nu$-distributions of the topology.**

**Morphic Encoding**

**Undifferentiated encodings over a topology are modeled by the $\varepsilon / \nu$ – distributions of the topology.**

## 1.4. Transformation of neuronal activity constellations

### 1.4.1. Closure thesis and maintenance

It is one of the most mind-bugling aspects of memristic machines as they are sketched in the research field of experimental and speculative memristics that such machines have neither input nor output.

Maturana's characterization of autopoietic machines offers some decisive descriptions which are supporting the idea and the formalisms of the proposed memristic machines.

> *"(iv) Autopoietic machines do not have inputs or outputs.*
> *They can be perturbated by independent events and undergo internal structural changes which compensate these perturbations."* (Maturana, Varela, p. 81)

Differentiation machines are the formal approach to model the mechanism of the *maintenance* of perturbated systems.

The *closure thesis* might have some negative or limitative aspects, set by negation.

The *mainenance thesis* is a complementary positive thesis that allows to describe the perturbance and the *compensations* of the perturbance by the autopoietic machine.

Perturbance in a formal sense might force a memristic machine to change its *complexity* or/and *complication*.
There are different formal types of perturbations.

A machine might be forced by an external additive perturbance to *prolongate* its internal structure by acting on its parts (monomorphies) in an additive way.

More complex perturbations might force to *coalition* building or to *cooperation*.

All those perturbances have to be responded with the aim of *maintaining* the structure/organization, i.e. the character of the machine as being a memristic machine and not another type of machines.

Closure thesis and maintenance, more at:
http://memristors.memristics.com/MorphoProgramming/Morphogrammatic%20Programming.pdf

# 2. Differentiation machines

## 2.1. Operations of morphoFSMs

Differentiation machines, morphFSM, are computing all kinds of morphogrammatic operations.
Similar to the classical Finite State Machines, FSM, they might be involved in different kinds of interactions. For morphFSM the main interactions between morphFSMs are *coalitions* and *cooperations*.
*Emanativ* and *evolutive* operations are defining the range of the complexity and complication of the machines.
A single machine is computing all kinds of *transformations* of morphograms.

If the brain has to interpret the "click-language" of its sensory inputs, it has at first to recognize or accept the configuration of those neuronal assemblies. Hence, the first job of morphoFSMs is to recognice morphic distributions of neural activities.

Classical FSMs are manipulating identitive data, morphFSMs are transforming kenomic configurations. Both approaches are conceptually discontextural (strictly disjunct). Nevertheless, the operativity of FSM is covered by morphFSM. In this sense, FSMs are frozen morphFSMs. On the other hand, FSMs are not qualified to simulate morphFSMs.

http://memristors.memristics.com/MorphoFSM/Finite%20State%20Machines%20and%20Morphogrammatics.html

## 2.2. Examples of morphoFSM

### 2.2.1. Recognicers

Example of a recognizer for the constellation [abbcddcdd].

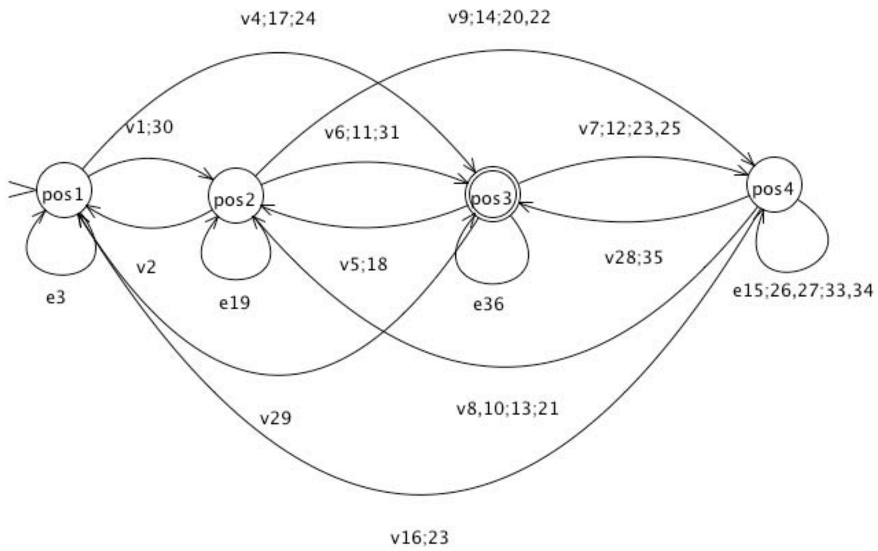
**Table of monomorphies**

| $MG^{(4)}$ = [abbcddcdd] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ | $loc_6$ |
|---|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_4$ | $mg_3$ | $mg_4$ |
| $MG^{1.0\ .0\ .0\ .0\ .0}$ | *a* | – | – | – | – | – |
| $MG^{0.2\ .0\ .0\ .0\ .0}$ | – | bb | – | – | – | |
| $MG^{0.0\ .3\ .0\ .3\ .0}$ | – | – | *c* | – | *c* | – |
| $MG^{0.0\ .0\ .4\ .0\ .4}$ | – | – | – | dd | – | dd |

**ENstructure table with enumeration**

| **EN[abbcbbcbb]** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | [] | v1 | v2 | v4 | v7 | v11 | v16 | v22 | v29 |
| 2 | □ | □ | **e3** | v5 | v8 | v12 | v17 | v23 | v30 |
| 3 | □ | □ | □ | v6 | v9 | v13 | v18 | v24 | v31 |
| 4 | □ | □ | □ | □ | v10 | v14 | **e19** | v25 | v32 |
| 5 | □ | □ | □ | □ | □ | **e15** | v20 | **e26** | **e33** |
| 6 | □ | □ | □ | □ | □ | □ | v21 | **e27** | **e34** |
| 7 | □ | □ | □ | □ | □ | □ | □ | v28 | v35 |
| 8 | □ | □ | □ | □ | □ | □ | □ | □ | **e36** |

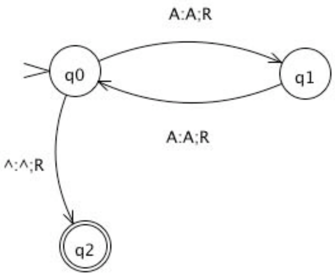
**DiagrMorphoFSM[abbcddcdd]**



| **Table –MorphoFSA[abbcddcdd]** | pos $_1$ | pos $_2$ | pos $_3$ | pos $_4$ |
|---|---|---|---|---|
| pos $_1$ | e3 | v1; 30 | v4; 17; 24 | – |
| pos $_2$ | v2 | e19 | v6; 11; 31 | v9; 14; 20, 22 |
| pos $_3$ | v29 | v5; 18 | e36 | v7; 12; 23, 25 |
| pos $_4$ | v16; 23 | v8, 10; 13; 21 | v28; 35 | e15; 26, 27; 33, 34 |

### 2.2.2. Generators

**morphoTM-A(even)**

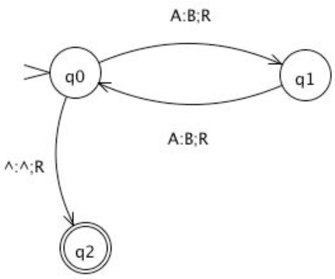



read “A”: write “A”; goto R
run= **A**AAA ⇒ **AA**AA ⇒ **AAA**A ⇒ **AAAA** ⇒ ^: accepted

*Transition rules*

| |
|---|
| q0; A : A; R, q1 |
| q1; A : A; R, q0 |
| q0; ∅ : ∅; R, q2 |

**morphoTM-AAAA2BBBB**




**Explanation**
read “A”: write “B”; goto R.
read “∧":write “∧"; goto R = acceptance state “q0”.

*Transition rules*

| |
|---|
| q0; A : B; R, q1 |
| q1; A : B; R, q0 |
| q0; ∅ : ∅; R, q2 |

Linearized notation, plus EN-structure.
run: [AAAA] to [BBBB]

run= [**AAAA**] ⇒ [**B**AAA] ⇒ [**B**A**B**A] ⇒ [**BBB**A] ⇒ [**BBBB**] ⇒ ^: accepted.

EN:

$$\begin{pmatrix} e1 & e2 & e4 \\ e3 & e5 & - \\ e6 & - & - \end{pmatrix} \begin{pmatrix} \mathbf{v1} & v2 & v4 \\ e3 & e5 & - \\ e6 & - & - \end{pmatrix} \begin{pmatrix} v1 & \mathbf{e2} & v4 \\ v3 & v5 & - \\ e6 & - & - \end{pmatrix} \begin{pmatrix} e1 & e2 & v4 \\ \mathbf{e3} & v5 & - \\ v6 & - & - \end{pmatrix}$$
$$\begin{pmatrix} e1 & e2 & e4 \\ e3 & e5 & - \\ \mathbf{e6} & - & - \end{pmatrix}$$

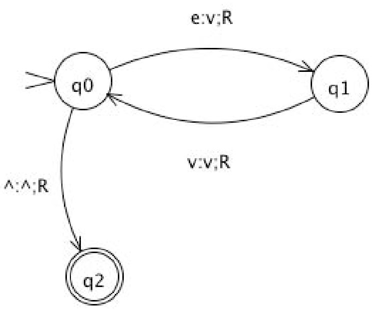
Hence, the morphoTM transforms [AAAA} into [BBBB] with EN[**AAAA]** = EN**[BBBB]**, therefore **[AAAA]** $=_{MG}$ **[BBBB].**

It might be said that the morphoTM is transforming the morphogram [AAAA] into itself by changing its semiotic appearance from [AAAA] to [BBBB].

The chain "[AAAA] ⇒ [BAAA] ⇒ [BBAA] ⇒ [BBBA] ⇒ [BBBB] $=_{MG}$ [AAAA]" is self-applicative:
morphoTM([AAAA]) $=_{MG}$ [AAAA].

On more turn:
run= [**AAAA]** ⇒ [**B**AAA] ⇒ [**B**A**B**A] ⇒ [**BBB**A] ⇒ **[BBBB]** ⇒
**[BBBB]** ⇒ [**A**BBB] ⇒ [**A**B**A**B] ⇒ [**AAA**B] ⇒ **[AAAA]** ⇒ ^: accepted.

**morphoTM-e-v**




EN-run: $\begin{pmatrix} \mathbf{e1} & e2 & e4 \\ e3 & e5 & - \\ e6 & - & - \end{pmatrix} \Rightarrow \begin{pmatrix} \mathbf{v}1 & v2 & v4 \\ e3 & e5 & - \\ e6 & - & - \end{pmatrix} \Rightarrow \begin{pmatrix} \mathbf{v1} & \mathbf{v2} & v4 \\ \mathbf{v3} & e5 & - \\ v6 & - & - \end{pmatrix} \Rightarrow$

$$\begin{pmatrix} \mathbf{v1} & \mathbf{v2} & \mathbf{v4} \\ \mathbf{v3} & \mathbf{v5} & - \\ v6 & - & - \end{pmatrix} \Rightarrow \begin{pmatrix} \mathbf{v1} & \mathbf{v2} & \mathbf{v4} \\ \mathbf{v3} & \mathbf{v5} & \mathbf{-} \\ \mathbf{v6} & \mathbf{-} & \mathbf{-} \end{pmatrix}$$

run= [**AAAA]** ⇒ [**B**AAA] ⇒ [**B**A**C**A] ⇒ [**BACD**] ⇒ **[ABCD]** ⇒ ^: accepted

**Explanation**

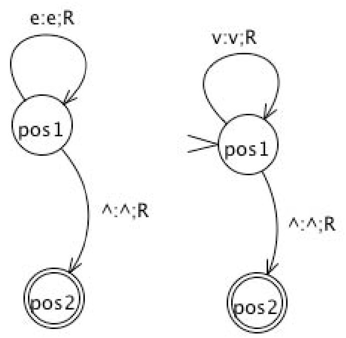
At q0, read "e": write "v"; goto R to q1.
At q1, read "v": write "v"; goto L to q0.
At q0, read "∅": write "∅"; goto R to q2.

*Transition rules*

| |
|---|
| q0; e : v; R, q1 |
| q1; v : v; L, q0 |
| q0; ∅ : ∅; R, q2 |

EN-notation, plus linearized morphogram in trito-normal form (tnf) with [AAAA] to [ABCD].
run: [AAAA] to [ABCD].

**Elementary morphoTMs for iteration and accretion**




**morphoTM-iteration**

$$EN-run:\left(e1\right)\Rightarrow\begin{pmatrix}e1 & e2\\ e3 & -\end{pmatrix}\Rightarrow\begin{pmatrix}e1 & e2 & e4\\ e3 & e5 & -\\ e6 & - & -\end{pmatrix}\Rightarrow\begin{pmatrix}e1 & e2 & e4 & e7\\ e3 & e5 & e8 & -\\ e6 & e9 & - & -\\ e10 & - & - & -\end{pmatrix}$$

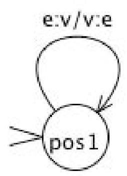
LIN-run: **[AA]** ⇒ **[AAA]** ⇒ **[AAAA]** ⇒ **[AAAAA]** ⇒ ^: accepted

**morphoTM-accretion**

$$EN-run:\left(v1\right)\Rightarrow\begin{pmatrix}v1 & v2\\ v3 & -\end{pmatrix}\Rightarrow\begin{pmatrix}v1 & v2 & v4\\ v3 & v5 & -\\ v6 & - & -\end{pmatrix}\Rightarrow\begin{pmatrix}v1 & v2 & v4 & v7\\ v3 & v5 & v8 & -\\ v6 & v9 & - & -\\ v10 & - & - & -\end{pmatrix}$$

run= **[AB]** ⇒ **[ABC]** ⇒ **[ABCD]** ⇒ **[ACDE]** ⇒ ^: accepted

**morphTM-(v,e)**




*Accretion*
[e,e,e] ⇒ [v,v,v]: [AAA]/[e,e,e] ⇒ [ABA]/[v,e,v] ⇒ [ABC]/[v,v,v].
Alternatively:
[e,e,e] ⇒ [v,v,v]: [AAA]/[e,e,e] ⇒ [BAA]/[v,v,e] ⇒ [BAC]/[v,v,v].
*Inversion*
[e,v,v] ⇒ [v,v,e]: [AAB]/[e,v,v] ⇒ [ABA]/[v,e,v] ⇒ [ABB]/[v,v,e].

```
- kref[1,1,2];
val it = [1,2,2] : int list
```

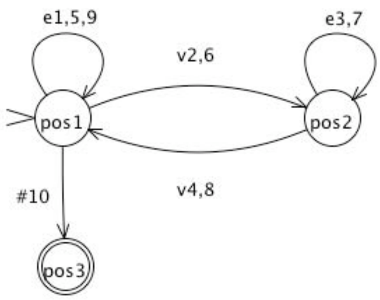
**Mixed iterative and accretive repetitions**
*Transition rules*

| |
|---|
| pos1; e : v; pos2 |
| pos2; v : e; pos1 |
| pos1; ∅ : ∅; pos3 |

run iteratively on {A, B}: AA AAB AABB AABBA AABBAA AABBAAB ...
run accretively on {A, B, C, ...}: AA AAB AABB AABBC AABBCC AABBCCD AABBCCDD ...

Even productions are, trivially, morphic palindromes.

```
- ispalindrome [1,1,2,2,3,3,4,4,5,5];
val it = true : bool
```




Cognitive computation of the intensity of perceptive sensations are ‘evaluating’ the relevancy of the intensity of perceptions.

This kind of computation is ‘*emanative*’, thus happens in the frame of the activated perceptions, i.e. ‘perceptrons'.

*Evolutive* computations are augmenting or reducing the activity range of perceptrons.

### 2.2.3. Coalitions and cooperations

For example, the *coalitions* between the two morphic machines, morphoFSM[1,2,2,3] and morphoFSM[1,2,1,1,3,4], are resulting in a field of 73 neuronal assemblies of complexity 7, calculated by *kconcat [1,2,2,3][1,2,1,1,3,4]* out of *Tcontexture* 7 with *Tcard* 7 = 877.

The same configurations set into the activity of *cooperation* is producing a field of 30240 cooperations of complexity 24, calculated by *kmul[1,2,2,3][1,2,1,1,3,4] out* of *Tcontexture* 24 with *Tcard* 24 = 445958869294805289.

**Coalitions**

**Examples for kconcat*[1,2,2,3][1,2,1,1,3,4]***

[1,2,2,3,2,1,2,2,4,5],[1,2,2,3,2,4,2,2,1,5],[1,2,2,3,2,4,2,2,5,1],
[1,2,2,3,4,1,4,4,2,5],[1,2,2,3,4,1,4,4,5,2],[1,2,2,3,4,2,4,4,1,5],
[1,2,2,3,4,2,4,4,5,1],[1,2,2,3,4,5,4,4,1,2],[1,2,2,3,4,5,4,4,2,1],
[1,2,2,3,1,3,1,1,4,5],[1,2,2,3,1,4,1,1,3,5],[1,2,2,3,1,4,1,1,5,3],
[1,2,2,3,3,1,3,3,4,5],[1,2,2,3,3,4,3,3,1,5],[1,2,2,3,3,4,3,3,5,1].

**Cooperations**

**Examples for *kmul[1,2,2,3][1,2,1,1,3,4]***

[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,2,4,4,6],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,6,4,4,2],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,2,5,5,6],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,6,5,5,2],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,2,6,6,7],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,6,7,7,2],
[1,2,2,3,4,3,3,5,1,2,2,3,1,2,2,3,5,1,1,4,3,4,4,6],

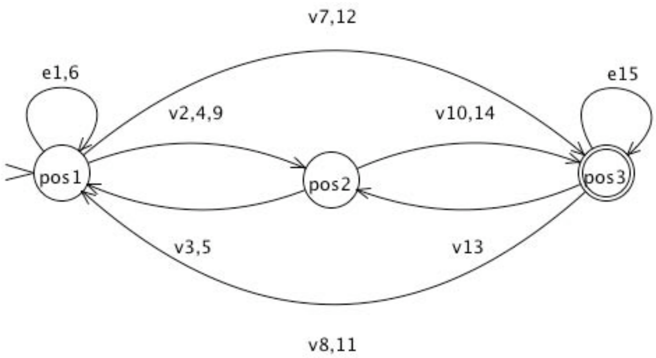
### 2.2.4. Morphic palindromicity

A very special kind of morphic distributions of neuronal activities is represented by *morphic palindromes*.
This property of *asymmetric* palindromicity is not accessible for identity-based considerations.

**Example for the constellation [1,1,2,2,3,3]**

- ispalindrome [1,1,2,2,3,3];
val it = true : bool

**DiagrMorphFMS [1,1,2,2,3,3]**




**- ENstructure [1,1,2,2,3,3];**
val it =
[[],
[(1,2,E)],
[(1,3,N),(2,3,N)],
[(1,4,N),(2,4,N),(3,4,E)],
[(1,5,N),(2,5,N),(3,5,N),(4,5,N)],
[(1,6,N),(2,6,N),(3,6,N),(4,6,N),(5,6,E)]] : (int * int * EN) list list

**ENstructure automaton table for MorphoFSM [1,1,2,2,3,3]**

| MorphoFSA[aabbcc] | $pos_1$ | $pos_2$ | $pos_3$ |
|---|---|---|---|
| $pos_1$ | $e_{1,6}$ | $v_{2,4,9}$ | $v_{7,12}$ |
| $pos_2$ | $v_{3,5}$ | – | $v_{10,14}$ |
| $pos_3$ | $v_{8,11}$ | $v_{13}$ | $e_{15}$ |

http://memristors.memristics.com/Morphospheres/Asymmetric%20Palindromes.html

### 2.2.5. From trito- to deutero-structures

Because of the enormous quantities of morphograms defined by contextures, a reasonable procedure of reduction has to be found.

A very strong abstraction that still preserves the kenogrammatic properties of non-identitive patterns is given by the *deutero*-abstraction. The deutero-structure is abstracting from the distribution of kenograms over different loci.

Numerically it is a transition from the Stirling numbers to partitions. Combinatorial analysis of systems is conceived as an alternative, maybe complementary account, to statistical analysis to deal with big numbers.

A reduction from *Tcontexture 24* to *Dcontexture 24,* is therefore given by the calculation of *Tcard 24* and *Dcard 24.*

Reduction from *Tcard* 24 = 445958869294805289 to *Dcard* = 1575

| **trito – structure** [1, 2, 3, 2, 4] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ |
|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_2$ | $mg_4$ |
| $MG^{1}$ | [1] | – | – | – | – |
| $MG^{2,4}$ | – | [2] | – | [2] | – |
| $MG^{3}$ | – | – | [3] | – | – |
| $MG^{5}$ | – | – | – | – | [4] |

| **deutero – structure** [1, 2, 2, 3, 4] | $loc_1$ | $loc_2$ | $loc_3$ | $loc_4$ | $loc_5$ |
|---|---|---|---|---|---|
| Dec | $mg_1$ | $mg_2$ | $mg_3$ | $mg_4$ | $mg_5$ |
| $MG^{1}$ | [1] | – | – | – | – |
| $MG^{2-4}$ | – | [$2\times 2$] | – | – | – |
| $MG^{3}$ | – | – | [3] | – | – |
| $MG^{5}$ | – | – | – | – | [4] |

# 3. Morphic information theory

## 3.1. Classic information theory

Classic information theory for neuronal events is well known.
It is based on the principles of the semiosphere with some speculative attempts to produce knowledge of noospheric events.

## 3.2. Morphic information theory

The advocation of *Principle of undifferentiated Encoding* has not opened up many advices how to compute the field of undifferentiatedness.

This fact has supported a kind of schism between the prestigious conceptual aspirations of Second-Order Cybernetics and the factual empirical research that stayed untouched in its traditional experimental setting.

On the other hand it motivated Varela's approach to neuro-phenomenology.

# Notes

## [1] Citations of results and developments

**Heinz von Foerster,**
**Molecular Ethology, An Immodest Proposal for Semantic Clarification**
**Cognition**
"In essence this paper is a proposal to restore the original meaning of concepts like memory, learning, behavior, etc. by seeing them as various manifestations of a more inclusive phenomenon, namely, *cognition*.An attempt is made to justify this proposition and to sketch a conceptual machinery of apparently sufficient richness to describe these phenomena in their proper extension. In its most concise form the proposal was presented as a search for mechanisms within living organisms that enable them to turn their environment into a *trivial* machine, rather than a search for mechanisms in the environment that turn the organisms into trivial machines.
**Finite state machines**
"Within the conceptual framework of *finite state machines*, the calculus of recursive functionals was suggested as a descriptive (phenomenological) formalism to account for memory as potential awareness of previous interpretations of experiences, hence for the origin of the concept of "change," and to account for transitions in domains that occur when going from "facts" to "description of facts "and—since these in turn are facts too—to "descriptions of descriptions of facts" and so on.
**Elementary finite function machines**
"*Elementary finite function machines* can be strung together to form linear or two-dimensional *tesselations* of considerable computational flexibility and complexity. Such tesselations are useful models for aggregates of interacting functional units at various levels in the hierarchical organization of organisms.
**Recursive functionals**
"While in the discussion of descriptive formalisms the concept of *recursive functionals* provides the bridge for passing through various descriptive domains,it is the concept of energy transfer connected with entropic change that links operationally the functional units on various organizational levels. It is these links, conceptual or operational, which are the prerequisites for interpreting structures and function of a living organism seen as an autonomous self-referring organism. When these links are ignored, the concept of "organism" is void, and its unrelated pieces becomes trivialities or remain mysteries."
http://www.polkfolk.com/docs/Ref-Library/Von%20Foerster/Heinz%20Von%20Foerster%20-%20Understanding%20Understanding,%20Essays%20On%20Cybernetics%20And%20Cognition.pdf
**Bernard Scott, April, 1996. Second Order Cybernetics as Cognitive Methodology.**
"In von Foerster (1980), he tersely states the *Principle of Undifferentiated Encoding:*
"*The response of a nerve cell encodes only the magnitude of its perturbation and not the physical nature of the perturbing agent.*"
"Put more specifically, there is no difference between the type of signal transmitted from eye to

brain or from ear to brain. This raises the question of how it is we come to experience a world that is differentiated, that has "qualia", sights, sounds, smells. The answer is that our experience is the product of a process of computation : encodings or "representations" are interpreted as being meaningful or conveying information in the context of the actions that give rise to them. What differentiates sight from hearing is the proprioceptive information that locates the source of the signal and places it in a particular action context.

"Von Foerster refers to this principle as *Poincare's Thesis*, in honour of the great French mathematician, who developed this argument in a paper about the processes of space and object perception (Poincaré, 1895). The thesis states:

"*The motorium (M) provides the interpretation for the sensorium (S) and the sensorium provides the interpretation for the motorium.*"

http://thehope.tripod.com/Bernard_Scott/Observer.html

**Bernd Lindemann, Neuronal identity and hybrid coding**

"Thus neural coding is *hybrid*: in first-stage neurons stimulus intensity is encoded by *spike* pattern and *contextual* what and where by molecular markers decisive for neuronal connectivity.

"Neural coding may be re-defined as *hybrid coding*, where intensity is encoded by spikes and contextual *what* and *where* by molecular markers (e.g. Lipscombs "glycocode") implying neuronal connectivity.

"Connectivity or network structure is not encoded itself. It enters into processing as the structure on which processing takes place. Thereby it is decisive for possibilities and limitations of the neuronal mechanism. It is context necessary to understand this mechanism and its results.

"Only if both parts of *hybrid coding* are recognized as necessary items in their own right is it justified to speak of a *complete* neural code.

"*Hybrid*" refers to the complementary use of (a) variable analog data and (b) fixed (discrete) molecular symbols or topological features addressing the context of the variable part."

http://www.bernd-lindemann.de/download_pdf/Neuronal_ID_and_Coding_01f.pdf

**Gerard Roth, Der Diskurs des radikalen Konstruktivismus**

"*Die neuronale Erregung [...], die aufgrund der sensorischen Reizung in den Sinnesorganen entsteht und zum Gehirn weitergeleitet wird, ist als solche* unspezifisch. *Man kann einer Nevenimpulssalve, die während einer elektrophysiologischen Registrierung auf dem Oszillographen dargestellt wird, nicht ansehen, ob sie z.B. durch visuelle, akustische, geruchliche Erregung hervorgebracht wurde.*" (1987)