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Review

Construction of a Data_Analyzer to Enrich H-M-I in a Complex Organization

Emeritus Prof. A.C. EHRESMANN[1] and Dr. Jean Paul VANBREMEERSCH[2]*

[1]LAMFA, Université de Picardie Jules Verne 33 rue St Leu 80039 Amiens, France

[2]Coordinating Physician, EHPAD St Joseph 80330 CAGNY, France

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***Corresponding author:** Dr. Jean Paul VANBREMEERSCH, Coordinating Physician, EHPAD St Joseph 80330 CAGNY, France

Introduction

In this paper, our aim is to design richer Human-Machine-Interactions for a complex organization S with a human sub-component Y able to deal with such interactions. This will be done by constructing a 4 parts cognitive artificial intelligence sub-system called **Data Analyzer** DA taking into account the different H-M-I; the 4 Parts of DA are: Receptors, Processing Unit, Memory, Effectors.

The method will use category theory methods (following Eilenberg and MacLane theory, (ref 1, 1945) and more precisely the more recent categorical notion of a Memory Evolutive System (or MES), introduced by A. Ehresmann and JP.

Vanbremeersch in earlier publications (1987 and 2007)[2,3].

Part 1: The Main Categorical Notions

We admit that **the "Complex" organizations** we are interested in have the following properties

i. They are evolutionary systems defined on the ii lifetime

ii. They have a tangled ***hierarchy*** of components varying in time.

iii. The ***change*** of state consists in Thom's 'standard structural changes'[4] as suppression of components or formation of new ones by 'combination' of a pattern of existing ones, e.g. to extend or modify the memory.

iv. They are **self-organized multi-agent systems**, each "agent" possessing its own temporality and logic.f

To model properties (i) to (iv), we have introduced the new categorical notions of **Memory Evolutive Systems** which are[3]

i. Evolutive Systems (ES) for modeling the dynamic; A system S is evolutive if there is an interval T of **R** - its life time, such that, for each t in T, there is given a category S(t) called its t-configuration and, for t' > t in T a partial functor transition from S(t) to S(t') which is a complexification of S(t) (cf(iii) later) for a specific t-procedure on S(t). All of them defining a functor from T to Par (Cat) of partial functors between categories

ii. Hierarchical categories[2]

iii. Complexification Process for a category[2-5]

iv. The Multiplicity Principal MP, its meaning for S and its role to enrich the situation[6]

These different categorical constructions are recalled in our pre-recorded pptx[10] to the AIML Congress - (November 2024)

A particular case of the construction has been initially proposed by JP Vanbremeersch, namely the case where the organization S is a **care-house for vulnerable persons** of which JP was the Coordinating Physician; then Y represents the helping and medical persons (cf.this case treated in PART 2 of this article).

Methods

First let us recall the categorical notions mentioned above

Complexification process[2-5]

The complexification of a category H for a procedure Pr given on H is an important process which will be iteratively used to construct the Data Analyzer DA in a complex organization.

Complexification theorem: We consider a category H and a 'procedure' Pr on H with the following objectives:

to suppress the cone E, to add colimits cP' and cQ' to the functors P' and Q' in H.The complexification H' for Pr 'optimally' adds the colimit cones of bases Q' and P', the simple links cG and cG' binding the clusters G and G',the complex link c: cQ'->cP' which is their composite; whence the functor F: H -> H' **(Figure 1)**.

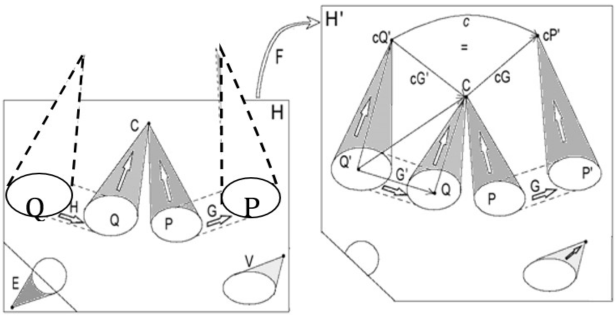

Figure 1: Complexification process[2-5].

Hierarchical categories[2]

Definition. A category is **hierarchica**l if its objects are distributed into different complexity levels (from 0 to m) so that an object C of level n+1 is the colimit of at least one pattern of connected objects of levels ≤ n.

It follows that each object C admits at least one ramification down to level 0 (whose base is a set of patterns of level 0) **(Figure 2)**.

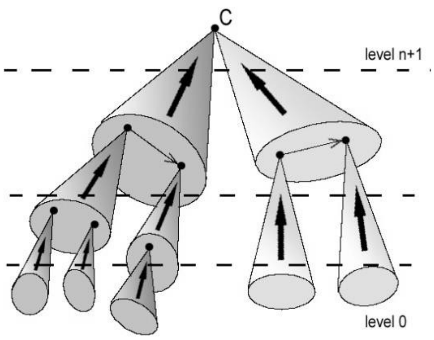

Figure 2: Hierarchical Categories[2].

The **complexity order** of C is the smallest length of such a ramification.

Pure reductionism would mean that all complexity orders are 0 or 1

The multiplicity principle (MP)[6]

Definition. If K is a hierarchical category, two diagrams P and Q to K **satisfy the MP** if they have the same colimit C and if there is no cluster between P and Q binding into the identity of C. Then C is called a ***multifaceted object*** of K.

The multiplicity principle corresponds to Edelman's Degeneracy principle[7] **(Figure 3)**.

MP implies the emergence of multipart links[6]

Let K be a (hierarchical or not) category. If P and Q are functors to K which satisfy MP the bindings g and g' of the clusters G and G' must have a composite g'g from B to C'. It is called a **multipart link**.

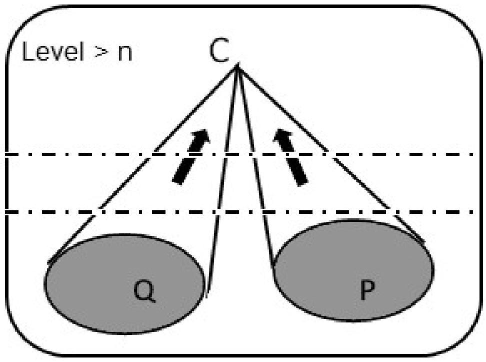

Figure 3: The Multiplicity Principle (MP)[6].

If K is hierarchical and if C is an n-multifaceted object of level > n the multipart link gg': B → C' is only 'emergent' at this level since it is not 'physically' observable' via morphisms connecting objects of Q' and P'. In fact, it depends on the 'global' structure of K which 'imposes' that Q and P have the same colimit C in K **(Figure 4)**.

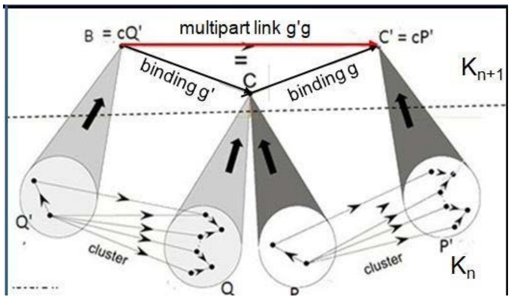

Figure 4: MP Implies the Emergence of Multipart Links[6].

MES Satisfying MP[9]

Let **S** be a MES. We say that it **satisfies MP** if it admits n-multifaceted components of each level n > 0. Such components give flexible redundancy to the system since they have a multiple identity and can operate under their different facets.

COMPLEXITY THEOREM. MP is a necessary condition for the existence in S of components of complexity order >1.

Otherwise, we have **Pure Reductionism**.

EMERGENCE THEOREM. If MP is satisfied and only in this case, a complexification process can lead to the formation of multifaceted components of increasing complexity orders and to the emergence of multipart links.

Emergentist Reductionism (in the sense of Mario Bunge,cf)[9].

COROLLARY. MP Is at the root of the development of a robust and flexible **memory**: it is a sub-system MEM ofS with components of increasing complexity orders, called records. If S has a DA, the memory unit of DA is included in MEM.

Improving decision-making in a MES S[9]

When Y and DA act together as coregulators of the MES S in meetings of S, DA acquires a better cooperation between elements in Y which allows the formation of a Y-archetypal pattern AY of their shared concepts. Therefore, it follows less misunderstandings in the meetings between the elements of Y **(Figure 5)**.

It leverages the MES' "Emergence Theorem"[8] which models how Y and DA acting as co-regulators of S, can form a 'macro-landscape' through two phases: first by constructing a shared understanding of the situation ("retrospection") and then by collaboratively searching strategies, evaluating them and selecting one ("prospection"). This co-regulatory dynamic enhances both individual and cooperative decision-making between Y and DA over time.

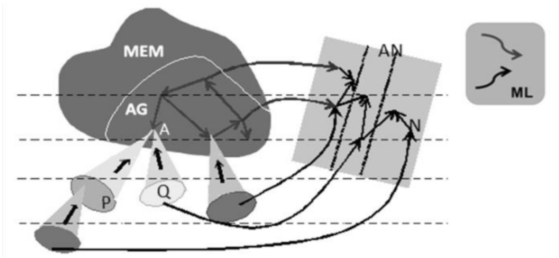

Figure 5: Improving Decision-Making in A MES S[9].

Part 2: A particular case

In the case of a care establishment for vulnerable people, one of the important challenges would be the development of alerts, for example to prevent the occurrence of epidemics within the institution. At this end,

a DATA-ANALYZER DA

is being built little by little by selecting specific arrows to develop learning and else via successive complexifications of the category generated by such arrows with its 4 Parts (Receptors, Processing Unit, Memory, Effectors). The Emergence Theorem shows that, over time, this process adds objects of increasing complexity order in DA **(Figure 6)**.

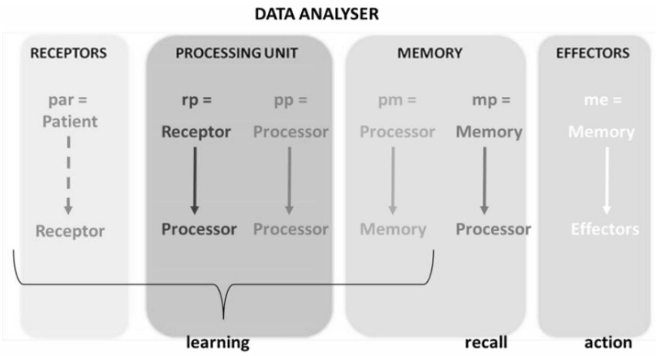

Figure 6: Data-Analyzer DA.

The Learning Process of the DA

a) At first a biological item is automatically measured through electronics skin sensors, and received (par) by Receptors **(Figure 7)**.

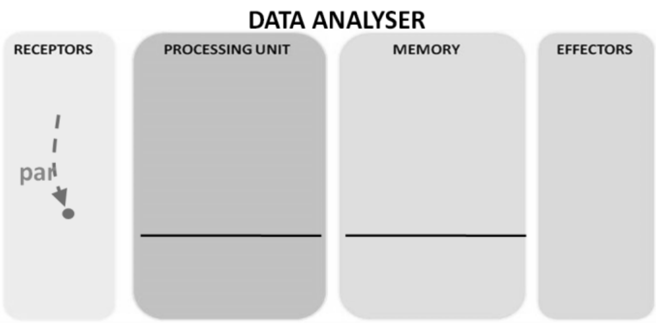

Figure 7:

Figure 8: for instance, sensor for continuous glucose monitoring.

b) Then the processing unit (CR) receives the information via rp, and transmit information to memory via pm **(Figure 9).**

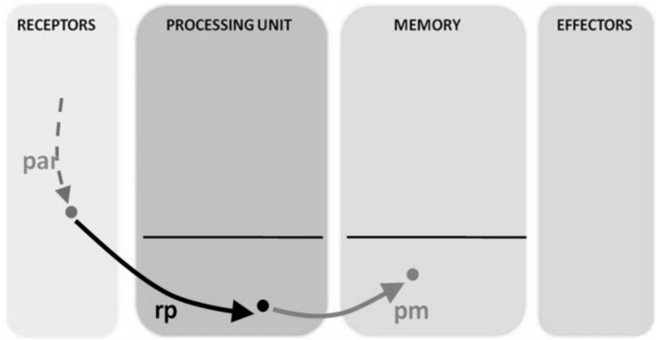

Figure 9:

c) Other information's are noticed by the processor through other sorts of physical or biological measures, such as renal function, arterial pressure, cardiac rhythm, temperature or even paraclinical data directly indicated to receptors of the DA by care people. Those items are integrated by complexification in a colimit within the processor **(Figure 10)**.

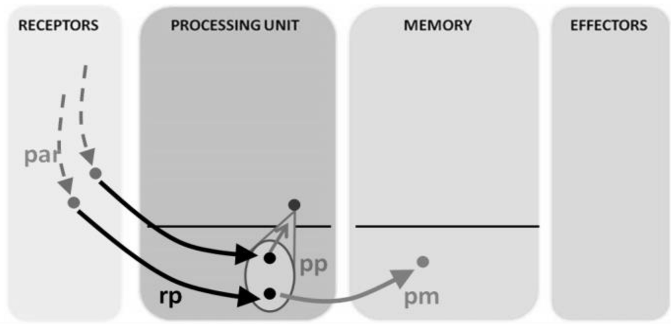

Figure 10:

d) It transmits, via pm, mm, mM, the data to the memory, increasing level at each measure to upper levels of the memory obtained by complexifications adding colimits the processor **(Figure 11).**

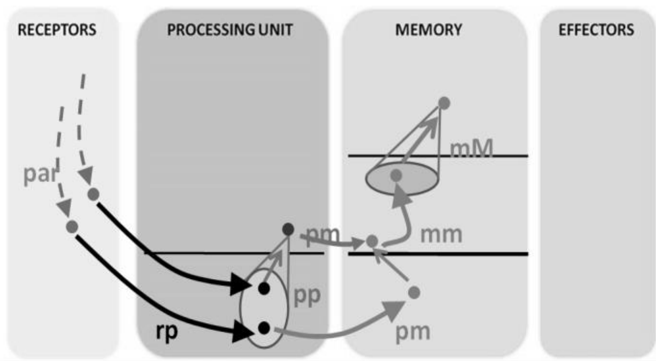

Figure 11:

e) When the memory of an item is hard built, then the recalling process introduces via complexification a hierarchical upper level in processing unit **(Figure 12)**.

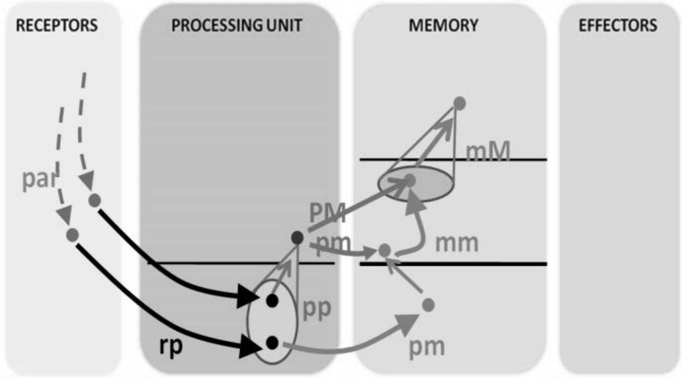

Figure 12:

f) Then through both the hierarchical complexification in Memory and Processor, the memorization has become stronger and allows a high-level recalling process PM and PM+ to mM **(Figure 13)**.

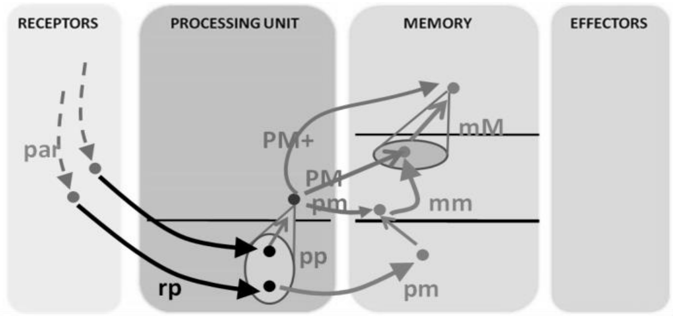

Figure 13:

g) From the higher level of complexification in the memory, there are links Me to the effectors, leading to actions by the DA on the patient **(Figure 14)**.

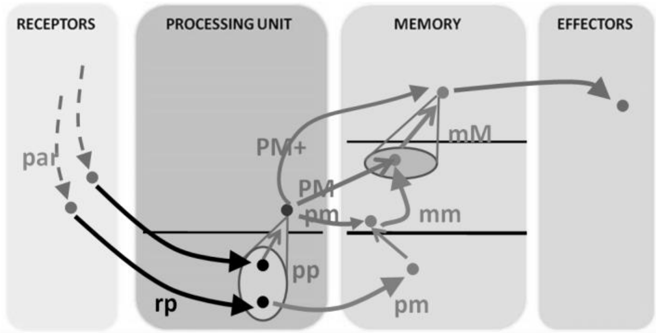

Figure 14:

h) The construction of higher and higher complexity orders of colimits allows a strong memorization ion of the whole process **(Figure 15)**.

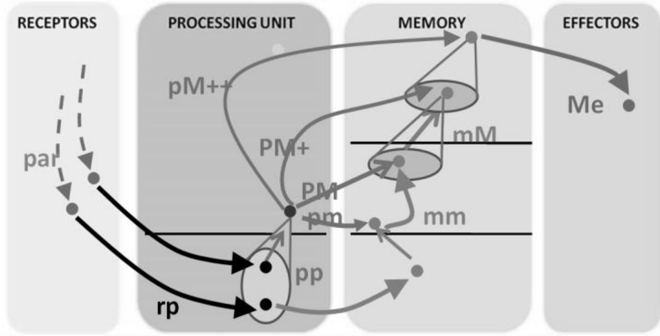

Figure 15:

The Recalling Process of DA

The purpose of the memorization by the Data Analyser, during a subsequent stimulation 'par-rp', will enable the system to react directly via pM++ to the effectors. **(Figure 16)**

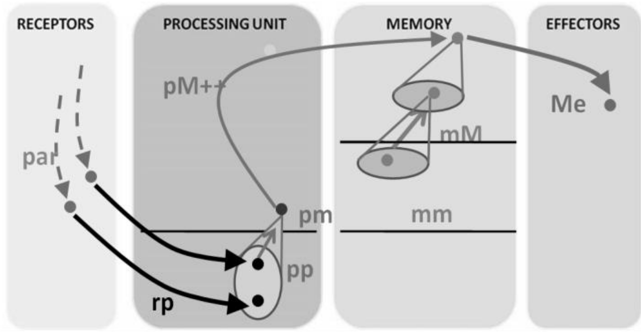

Figure 16:

Conclusion

Therefore, the Data Analyser, via the Emergence Theorem, develops the complexity order of its records in the processor and the memory, upgrading the use of the DA.

- It will optimize its reactivity,
- increase the quality of its observations,
- and the adaptation of its strategic responses.

In particular in the specific case of the care house, it could reduce the spread of an epidemy in the institution, and reduce the Morbi mortality.

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