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REPRESENTATION OF PSYCHIC EVENTS IN NEURAL NETWORKS *

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* This work was partially supported by a grant from BIAL Foundation, Porto, Portugal and by JNICT PBCIC/TIT/2527/95.

I- Introduction

McCulloch and Pitts demonstrated that it was possible to attribute logical functions to neurons of Central Nervous System (CNS) within the context of a calculus of temporal propositional expressions (McCulloch, Pitts,1943). Their proposal was based on a threshold logics approach related to Sherrington's model (Sherrington 1947) later confirmed by Hodgkin, Huxley, 1952a,b,c,d and Eccles, 1952.

Beyond its biological and philosophical meaning their work proved to have relevant consequences concerning the problem of computation in general initiating a new branch of mathematics namely the algebraic theory of automata (Kleene, 1956). The model of formal neurons did not contradict basic aspects of Bernstein theory of membrane (Bernstein 1902) later on developed by Cole and Curtis, 1939, Hodgkin and Katz,1949.

This model did not take into account the computational possibilities of dendritic structures. It was believed that dendritic potentials might play a minor role in neuronal processing due to the reduction of their amplitude which would occur when they progressed from more distal sites of the dendritic tree to attain the cell body where they might interact with postsynaptic excitatory and inhibitory potentials and ultimately trigger an action potential at the axonal hillock. Nevertheless the analysis of cable properties of dendrites did show that attenuation of dendritic potentials would be small when the sense of displacement was from more proximal to more distal sites relatively to the soma of neurons. Graubard and Calvin obtained direct records of dendritic potentials as well as of excitation transmission at dendro-dendritic synapses (Graubard, Calvin,1979). They demonstrated that those potentials might attain an amplitude of dozens of milivolts and therefore might be considered as putative candidates for a relevant computational role in dendritic compartments and local information processing. Dendritic potentials were graduate and might have waveforms of variable shape. On the other hand synaptic computation in dendritic networks required a model distinct from the integrative mode of operation proposed by Hodgkin and Huxley. Dendritic computation implies a spacio-temporal distribution of synaptic interactions which occurred along dendro-dendritic trees assuming characteristics of a coincidence filter very different from the integrative model of the neuronal cell body.

In previous works our group did study the possible computational properties of dendro-dendritic networks and it was demonstrated that the more relevant functions used in communication engineering might be implemented by those dendro-dendritic processes. The same happened concerning logical computation which might be conceived as implying a dynamic implementation without fixed values of excitation and inhibition that was attributed to synapses in the classical theory of artificial neural nets as it was formulated initially by McCulloch and Pitts (I. Barahona da Fonseca et al, 1995a,b, J. Barahona da Fonseca et al, 1995a,b, J. Simões da Fonseca, 1995).

The same authors proposed an hypothesis concerning the interaction between local computation processes performed in dendro-dendritic networks and on the other hand axonal mechanisms of communication at a distance through the consideration of the role that dendro-somatic synapses might play in the generation of action potentials in the membrane of the neuronal cell body (Figure 1.1).

Both the Hodgkin and Huxley model and the Graubard and Calvin proposal deal with excitation and inhibition processes in synapses exclusively in terms of ionic concentration and potential gradients across the membrane.

Their approach does not take into account the second and third systems of intracellular signaling which imply active biochemical mechanisms and not simply passive changes across the membrane.

In the model of the second and third messenger's transmission systems structure and function are almost indistinguishable in terms of molecular biology. Changes of structure of phospho-kinases and macro proteins are simultaneously structural changes and elements of the signaling chain. The second and third signaling systems modulate the activity of synapses belonging to the first system through what may be compared to an intracellular network for synaptic information processing.

It is well known that communication structures of the first, second and third systems either homologous or heterologous interact between them (Kacmareck,1986; Freissmuth, Casey, Gilman, 1989; Simon, Strathman, Gautan, 1991). Therefore the neuronal cell body itself is a complex communication system with characteristic roots for information transmission mirroring in some aspects the structure of a communication network, here at the level of synaptic processes within a single neuron which in this respect behaves like a network.

In the context of this model the neuronal operator may be adequately specified in terms of a characteristic matrix or set of matrices which define the relationships between input, output and state of the components of this subcellular network.

In this view, a subset of synaptic inputs produces local excitation but those synapses may elicit a change of excitability of another subset of synapses modifying the characteristics of responses to excitation and inhibition conveyed to them by their respective afferent lines belonging to the first system of neurotransmission. Here appears as adequate the distinction between a part of the afferent messages considered as operands and another component due to the interaction between the three signaling systems as carrying what may be interpreted as a programming set of instructions for local microcomputational processes within each single neuron.

In a similar proposal (J. Simões da Fonseca, 1967) the neuron was conceived as receiving information concerning data which play the role of operands as well as message contents which specify programs which interact with those already present in a neuron.

A matrix M_{ij} specifies the changes that inputs i impose on synapses j as well as on other subcellular structures of the neuron.

On the other hand temporal sequences of inputs may produce successive changes of a characteristic matrix $M^k{}_{ij}$,

$$M^{k+1}{}_{ij}=T_k\ M^k{}_{ij}$$

and in a computational chain with successive transformations T_k, $k=1,\ldots,n$, the characteristic matrix will be modified into $M^1{}_{ij},\ldots,M^n{}_{ij}$ which may be interpreted as successive subroutines of a computational program. This way these changes express modifications of the neuronal operator altering the characteristic matrix which specifies the operations to be performed on data or the successive program stages that the neuronal operator can perform.

This approach has interesting consequences in the representation of data from the viewpoint of the symbolization process. Namely the meaning of a signal might be conveyed either within a successive alternant data content and program specifications or else in parallel channels which would carry information about relational processes involved in previous operational stages.

Those messages sent along parallel channels would modify M^{k}_{ij} into M^{k+1}_{ij} and would create a specific computational context to process data contained in the operand part of a message.

The interaction between synaptic and symbolic computation would occur at this level-the signification and intention of a message would be specified by the information about computational relationships involved in the previous computational stage, in a recursive manner. The computational changes of each subroutine would be sent to the next neuron in a chain within a neural network. That neuron would interpretate the dimensional content of the message taking into account the relationships defined by the information about predecessor programming subroutines.

This elementary constituent of signification and intention would be present since the more elementary processing stages- the dimensional messages would be qualified by relational programming messages.

As an additional marker, as it was proposed in another context by Kandel,1976, some information might be carried by the modulation of genetic expressivity, for example in the case of specific modality characteristics of sensory messages.

These remarks lead to another relevant issue concerning neuronal computation, namely, synaptic computing operations have their own identity and autonomy in themselves largely independent of the generation of action potentials which involves pre and postsynaptic processes which belong to a computational chain that may occur below the threshold for the triggering of action potentials. A neuron at rest in what concerns action potentials would be continuously active processing synaptic information at the cell body and dendrites. Messages generated by this activity would be sent to the dendritic networks and progress along their compartments participating in dendritic computation to finally reenter the cell body through dendrosomatic synapses.

Synaptic processes with their two components, one dimensional, the other computational, would be the relevant correlates in the emergence of a conscious experience insofar as they carry the information for it possibly expressed through characteristic types of oscillation in dendritic trees or inside the signaling system of the cell body.

Significant to significate relationships would rest on a signaling code concerning both the dimensional and relational components of messages. The criterion for the putative attribution of such a role of the interface between biological signaling and conscious emergence of symbolic processes would be the presence of the required variety of signals correlated with the variety of conscious experience- the ontological nature of conscious phenomena is in itself a non-scientific question. Those local computational components would then be conveyed through axonal channels.

Here we can also admit that the axonal communication operations are distributed in two modes of signaling, one of dimensional contents and another of computational relationships either encoded functionally or else structurally due to a topic anatomic system of signaling specified during ontogenesis and modified by learning processes. In conventional neural network models, neurons receive only dimensional messages. Relational components which determine these messages are only accessible to an external observer which knows the operational structure of the net. Our proposal is that networks have to be redesigned in such a way that each neuron processes dimensional data together with messages which specify predecessor relationships which generated dimensional signals.

These complex processes may be conceived as implying a central interface, a kind of central periphery in which information carrying and computational behavior produce internal acts that are expressed at the level of some process of molecular biology. The conscious quality of the experience would be correlated with the intrinsic structure of the components of synapses, internal routes of the neuron, dendritic trees and molecular biology processes for which we may use the metaphor of the effectors inside the CNS on which depend the characteristic eigen behavior as much as it depends on the synaptic operations of the CNS.

Hypotheses concerning the signaling processes can be tested through the use of Electroencephalogram (EEG), Electrocorticogram ECoG and Magnetoencephalogram (MEG) applying techniques of signal extraction and distinguishing the characteristic range of frequencies for each type of phenomenon.

We think that this proposal of another type of formal model for neural computation does not conflict with the approach used by McCulloch and Pitts for an embodiment of logical operations in the brain.

Our intention is to find a working hypothesis to identify the way psychic events are represented in terms of neural operations, namely besides logical operations we aim to find a neural embodiment for perception, cognition, motivation, memory and other relevant psychological data and operations.

This is a foundation required for achieving a new understanding of psychophisiological relationships which is urgently needed in

Psychiatry and Psychopathology as well as in Psychology and Psychopharmacology.

II - Psychophysiological experiments

To study the relevance of the Graubard and Calvin model of dendrodendritic processes, concerning information and psychic representation in the brain the EEG may be used as a tool because it expresses a mass activity of dendrites and synapses and not of action potentials of cell bodies and axons. We can try to find characteristic patterns of EEG activity, by extracting periodic waveforms which can be correlated with specific psychological events in a way similar to what was established during the last 37 years concerning action potentials (Lettvin, Maturana, Pitts and McCulloch, 1959; Hubel and Wiesel, 1965a,b; Jung, 1959; Jasper, Ricci and Doane, 1960).

A significant ensemble of experimental results obtained through single cell recording led to the identification of very relevant consistent correlations between stimuli and trains of action potentials as they can be simultaneously identified by an external observer.

Our approach is based on the investigation of similar correlates but now concerning periodic waveforms extracted from EEG recordings using cross correlation methods.

The most convincing proof of the significance of such correlations would be the experimental finding of patterns of such periodic waveforms with sufficiently specific characteristics to allow the identification without the help of an external observer of the circumstances either environmental or intrapsychic which would be linked to these patterns of waveforms embedded in EEG records.

In case such correlations were verified as statistically significant we might then attribute representational and computational relevance to these signals recorded in associative areas of the brain.

In the experiments we are describing we did not use external sensory stimuli but rather we asked subjects to produce fantasies. In the first experiment we did choose four distinct types of psychic states - (a) agreeable fantasies; (b) disagreeable fantasies; (c) counting numbers; (d) remembering alphabet letters in a natural sequence. It was already mentioned that it was not used any immediately linked sensory stimulus.

The subjects remained with closed eyes in a situation of relative isolation. Electrodes were placed according to the international 10-20 system. During the experiment the subjects were asked to press a button using their left hand signaling that they were experiencing the desired fantasy. This was the external trigger signal to record the last second and the two subsequent seconds of EEG activity obtained through differential amplification between pairs of electrodes. These records were first submitted to cross correlation with periodically repeated delta waves of Dirac with the same frequency as the signal we were trying to detect and characterize.

Then the records concerning each frequency were placed in phase using the zero-crossing as a reference and an average was calculated on all the point values of the sample for each frequency, respectively (Figure 2.1).

Finally FFT was calculated over these results and it was determined the power spectrum concerning the fundamental frequency and its harmonic components.

The amplitude of these power spectrum components were then compared concerning eight areas of bipolar recording - Frontal

Anterior - Temporal Anterior; Temporal Anterior - Temporal Posterior; Temporal Posterior - Occipital; Parietal Anterior - Parietal Posterior in the left and right Hemispheres, respectively concerning the four distinct types of fantasies.

The results were clear cut and consistent- the four different types of fantasy were distinguished using Multivariate Stepwise Discriminant Analysis in the left hemisphere Temporal Anterior - Temporal Posterior areas (Figure 2.2) as well as in left Fronto - Temporal recordings. On the other hand, on the right Hemisphere records concerning agreeable and disagreeable fantasies were adequately classified. That was not the case concerning numbers and alphabet letters.

These results were obtained by I. Barahona da Fonseca in 1991(I. Barahona da Fonseca, 1991). The system was developed by J. Barahona da Fonseca, 1985a,b.

This experiment has been performed in a sample of 45 healthy subjects.

Later on the same kind of experiment was replicated in a sample of 20 subjects, using as fantasies joy, sadness, anxiety, anger and fear as the theme for fantasies (I. Barahona da Fonseca, 1996).

Again Discriminant Multivariate Analysis, using the same methods yelled a significant separation between groups in the left temporal Anterior- Temporal Posterior records (Tables 2.1 to 2.4).

This way it was proved that patterns of periodic waveforms were strongly related to the semantic meaning. These patterns of brain activity involved dendritic and synaptic potentials in the cerebral cortex.

It seems necessary to implement models of purely synaptic and dendritic computation which may help us to investigate dendritic computation in the brain. Some simple paradigms of such computation will be examined in the next section.

III-Formal models of dendro-dendritic computation

In the following examples we will exclusively use synaptic and dendritic processes which besides summation and subtraction allow the representation of multiplication and division, the four arithmetic operations. Multiplication and division are performed in a spatio-temporal form exclusively by synaptic and dendritic operations, using pre-synaptic facilitation and inhibition as well as feedforward inhibition.

Dendro-dendritic networks provide a powerful computational model for signal processing. The following dendro-dendritic diagram can compute convolution between two functions $f_1(t)$ and $h(t)$

$$f_2(\tau) = \int_{-\infty}^{+\infty} f_1(t)\, h(\tau - t)\, dt$$

In this network a finite difference representation of each of the two functions is carried respectively by two independent closed loops (Figure 3.1). Excitatory synapses corresponding to the loop on which circulate the discrete terms which define $f_1(t)$ are iteratively added the number of times specified by corresponding term of $h(t)$. Namely, this addition is performed the number of times specified by the corresponding term $h(\tau-t)$ through pre-synaptic facilitation. The inhibitory synapses present in the second closed loop on which circulate the terms of $h(\tau-t)$ represent a counter which specify the number of iterative additions. As for each addition any term of $h(\tau-t)$ suffers a diminution, when the value becomes close to 0, no pre-synaptic facilitation will take place and iterative addition ceases for that term. The introduction of a delay τ in the upper closed loop allows the computation of

$$\int_{-\frac{T}{2}}^{\frac{T}{2}} f_1(t)\, h(\tau - t)$$

Cross correlation between two functions $f_1(t)$ and $f_2(t)$ is represented by

$$\varphi_{12}(\tau) = \frac{1}{T}\int_{-\frac{T}{2}}^{\frac{T}{2}} f_1(t)\ f_2(t+\tau)\, dt$$

The division by T can be represented by a circuit which performs iterative subtraction (Figure 3.2). After a cycle of iterative subtraction by T, τ is incremented, the value T is regenerated the value of

$$\int_{-\frac{T}{2}}^{\frac{T}{2}} f_1(t)\ f_2(t+\tau)\, dt$$

is calculated for the new value of

$$\tau_{i+1} = \tau_i + \Delta\tau$$

and a new cycle of iteration starts again until the range of allowed variation is attained.

Presynaptic facilitation occurs only when

$$\int_{-\frac{T}{2}}^{\frac{T}{2}} f_1(t) f_2(t+\tau)\, dt\ -\ N\,T\ \geq T.$$

As dendro-dendritic networks produce results which may be conveyed only to relatively small distances dendro-somatic interactions are necessary to allow the transmission of information to much longer distances (Figure 3.3).

III.1 Intersection and union operations

Given an array A characterized as a sequence $[a_1\ a_2\ \ldots\ a_n]$ and a second array B characterized by a sequence $[b_1\ b_2\ \ldots\ b_n]$

$$A \wedge B \equiv [a_1 \wedge b_1\ \ a_2 \wedge b_2\ \ldots\ a_n \wedge b_n]$$

Union $A \vee B$ will have as a possible interpretation

$$A \vee B \equiv [a_1 \vee b_1\ \ a_2 \vee b_2\ \ldots\ a_n \vee b_n]$$

The operation of performing the union of all intersections in $A \wedge$

B

$$A \Delta B \equiv \vee (a_i \wedge b_i)$$

Simple dendro-dendritic networks can implement these operations (Figure 3.4). A threshold vector can perform the decision of attributing the value 1 or else 0 to any operation between elements. This would amount to

$$a_i \wedge b_i \geq \theta_i$$

The inference about a complex relationship defining a conceptual pattern p_i would be implemented by a network performing the operations of union, intersection, unions of intersections and filtering through reference thresholds introduced by θ_i arrays which imposing an inhibition would require a certain the effective inclusion of a new set of responses in a previous scheme. In our proposal scripts and their transformation account for symbolic guidelines which correspond to a predictive concept about some relevant aspects of a purposeful strategy, and which are mainly relevant for the specification of the intentional dimensions of that concept.

On the other hand complex logical relationships can be handled at the syntactic and semantic level as it was proposed by J. Simões da Fonseca and Jose Mira y Mira, 1970, which included concepts which were later developed extensively by M. Minsky, 1975, as a logic of frames. In the context in which the concepts of signification and intention were created, they were introduced within the frame of reference of a calculus of operators specified over modular operations in Galois fields with operations modulo 2.

The transposition of these results for dendro-dendritic networks can immediately be performed from the domain of formal neurons into formal dendro-dendritic networks specified by pseudo-Boolean equations and inequalities, characterized by discrete coefficients belonging to the field of real numbers and Boolean variables, both present in every term of such equations and inequalities, J. Simões da Fonseca,1967. Our proposal is that scripts specify behavior and criteria of satisfaction of the prescriptions for a stage. An enlarged concept may be conceived as an extension to the representation within a calculus of relationships for the inferences which can be made using a logical inferential method. These relationships can be used to render ostensive attributes or predicates which are only latent in the predicative framework which characterizes the environment in which scripts are defined, as well as the predicates which specify the characteristics of the actions which are prescribed by the script. In this view cognitive operations would depend on two sequential procedures- one along a script procedure with its characteristic direction in the sequence of stage derivation and the other along a logical inferential sequence without any characteristic backward or forward restriction of the processing of data on which relationships are defined. Results and data on one of these lines of sequential or parallel procedures should constantly be translated into the system of symbolic representation on which operates the other line of processing.

IV.2 - The internal space of representation

Using the dendro-dendritic computational paradigm we may define IM (internal model) as a subset of dendro-dendritic networks in the CNS. The Associative Brain Cortex is the anatomic and functional operative structure we will consider in the context of a motivational and cognitive problem solving.

$$IM \equiv \{Dd_i\}_i$$

where Dd_i stands for the members of a set of dendro-dendritic networks. $\{Dd_i\}_i$ corresponds to a computational space with inputs X_i and outputs Y_i. Long duration memory LM and short duration memory SM will load a subset of $\{Dd_i\}$ through X_i with the information which is needed for motivational and computational tasks. This information will be carried by characteristic sequences of symbols defining the objects on which cognitive operations will be performed according to a given motivation expressed by a script prescription.

The rules of operation to be performed on the logical variables u_j and v_k of IM will be specified in a dual and complementary way. Rules D_j will specify the derivation from one stage of planned action p_m into the next stage of planned action p_n, p_1 being the rules for the initial stage and p_f the rules for the final stage of the performance of the script in the IM, together with the satisfaction criteria for each stage of operation m, f_m.

We envisage the interaction which occur within each stage as a result of two processes. One of them generates function p_i over the variables u_j and v_k. The other produces function q_j over the variables u_m and v_n. It is supposed that during a stage of the development of a script both the agent and the environment produce successive states S_{p_i} and S_{q_j}. The criteria for each stage define a final state p_f which corresponds to the fulfillment of the development of the script and prescribes the transition to the next stage. Other intervenients in the script are defined as possessing a dynamics of its own. In a simplified approach process

$$A\ p_i = p_{i+1}$$

and process

$$B\ q_i = q_j.$$

Each p_i and q_j are state functions which operating on variables u_m, v_n define states $p(u_m, v_n)$ and $q(u_m, v_n)$. This process corresponds to a double control interaction in which criterion state functions $p'(u_m, v_n)$ are intended to be attained and some other functions $q(u_m, v_n)$ should not be allowed. Over two sets of varibles $\{u_i\}$ and $\{v_j\}$ an n-tuple of variables u_i and v_j would be selected and the state function $p_k(u_i, v_j)$ would satisfy the condition that an iteration procedure

$$O_p\ p_k = p_{k+1}$$

repeated n times

$$o_p^n\ p_k = p_f.$$

That is the selection of variables would aim to the attainment of the final criterion $f_n(u_m, v_n)$. Considering the environmental state function generating procedure

$$o_p'\ q_m = q_{m+1}$$

this operation should not lead to any $q_n(u_m, v_n)$ incompatible with the final attainment of $f_n(u_m, v_n)$. In case the iterative application of o_p' over $q_n(u_m, v_n)$ should lead to a state incompatible with $f_n(u_m, v_n)$, then a corrective operator A would transform o_p',

$$A\ o_p' = \beta.$$

β would then satisfy the condition that $\beta^n\ q_i(u_m, v_n)$ would not produce any state function incompatible with the attainment of $f_n(u_m, v_n)$.

Transition from p_m to p_n

$$T: p_m \dashrightarrow p_n$$

implies that operations o_p performed on u_m have yielded results which satisfy criteria f_m

$$o_p \circ p_m \Rightarrow f_m$$

$$o_p \circ p_n \equiv (o_p \circ p_n \Rightarrow f_m)$$

On the other hand objects v_k are included in another subset of action which interact with the subset u_j which we have been considering. Similar structures are considered to be present in both the operations over u_j and v_k at each stage of computation p_m. If the interaction between operations o_p . p_m . u_m and operations o_p . z_m . v_m are related in a cooperative manner, then f_m criterion will be fulfilled

$$C_{u,v}(m) \equiv (p_m \cdot u_m \cap z_m \cdot v_m \equiv f_m)$$

Conflict

$$R_{d,r}(m) \equiv (p_m \cdot u_m \cap z_m \cdot v_m \not\equiv f_m)$$

implies the interruption of the sequence of operations which is suspended at stage m. The suspension of the performance of operations at any given stage m due to criteria f_m having not been satisfied implies that the final interruption of the script at stage m and an output Y_i carrying the information that there are not adequate conditions to the performance of all the sequences which were prescribed in the script.

The complementary, dual system of inference, IF, will operate in each modular stage of operation under two main circumstances- either after interruption circumstances due to conflict or else to render explicit relationships and attributes or predicates of the u_j and v_k. In case some $f_n(u_m, v_n)$ is not attainable then an hypothesizing procedure produces a new q_{init} and a set of rules such that operators O_p' acting on the new $q'(u_m, v_n)$ state function would not conflict with the attainment of the desired final state function $f_n(u_m, v_n)$. This procedure would be equivalent to the derivation of inferences using the rule O_p, the state function q'_{init}, and a set of principles $h_1, h_2, \ldots, h_n$.

The logical inferential system will operate within a frame structure or on the elements of a vectorial space of representation of attributes or predicates considered together with the matricial operators which specify all the possible transformations of any such vectors. The exploration of the vectors and transformations at any given stage m, may allow the specification of the attributes which u_j or v_k must possess in order to allow the fulfillment of criteria f_m.

V- Personality and its situation- a script approach

The concept of personality plays a central role in contemporary psychiatry (Freud 1948; Barahona Fernandes, 1966; Ey, 1954). Clinical methods use a historical, biographic approach. Collected phenomenological data (Jaspers, 1948) are interpreted in the context of knowledge about normal psychological functions and their psychopathological transformations (Ey, 1954; Barahona Fernandes, 1966) which are considered as included in a global ensemble of the particular operationalities of an individual. This method provides data with characterization and predictive value to distinguish between human types and functional dimensions.

From a systemic viewpoint human psychological functions with relevance for the study of personality are specified here by matricial operators which relate inputs, internal state and outputs.

In our approach (Simões da Fonseca et al, 1970) denotation of variables is associated to a connotative specification in terms of attribute vectors, criterion vectors and distances together with decision rules to evaluate if the attributes and relationships defined over them are valid to specify a given category.

In those terms characteristic matricial operators specify the meaning of couples of inputs and internal states of the system as this meaning is carried by the next internal state. A couple of matricial operators together with criterion vectors and decision rules establish a relationship between inputs and internal states defining the intention of the system as it is carried by the output vector which is generated. The intentionality of the system is therefore obtained from the matricial operators which act on the input and state vectors to generate outputs together with criterion vectors and vectorial distances. The identification of attributes as belonging to a field proper of an ensemble of entities, beings and categories is relevant concerning both signification and intention.

This approach can be used to define meaning and intentionality of psychological states and functions that depend on psychophisiological systems in which the role of symbolic representation can be attributed to its biological components. A meaning and intentionality can also be attributed by the subject to environmental data on the basis of his own subjective characterization of environmental data together with his attribution of generative rules that characterized a system which produces those environmental states. Environmental data are then conceived as outputs of the environmental system to the interface of interaction with the subject in any given situation (J. Simões da Fonseca F. Pego Mira y Mira 1976).

To cope with any situation the subject uses not only the information about the state of the environment but also his knowledge about the generative rules which produce that state.

This systemic view concerning psychological functions might be used to define psychopathological counterparts and the biological correlates of the construct of personality (J. Simões da Fonseca T Gil J. Barata 1972) - an integrative network would receive information about the output of particular psychological operators, each one corresponding to a specific function and would send outputs to them.

The paradigm of the coupling of dimensional and relational contents in symbolic representations for neural messages, we presented in section 1, may be used concerning the generation of meaning and intentionality at the level of neural operators which stand as biological correlates for the psychological functions of the self.

That operator would suffer integrative and disintegrative transformations which would allow the shift of selective filtering from motivational functions in one circumstance of interaction with environment to another of preferential filtering of emotional functions in other cases, or else perceptive and cognitive functions in other environmental circumstances.

This concept corresponds in many aspects to the proposal of Ey ,1954, which considered consciousness as the whole of psychic experience in a single synchronic instant and personality as the experience of diachronic invariances of conscious experience in time.

Concurrent computations either cooperative or else conflictive would integrate psychological functions under the partial control of the operator characteristic for the self.

Concerning social interactions, operations of integration would include the appropriation of the psychological operations of other subjects and delegation mechanisms would serve to attribute functions to other subjects in a mutual interaction context. The operations characteristic of mutuality might assume a prosthetic mode as it happens for instance in therapy and in social or institutional support.

Two social experiments conducted by the group of Medical Psychology in the Faculty of Medicine of Lisbon give some support to these hypotheses (J. Simões da Fonseca et al 1982).

In a first experiment of social interaction, 10 groups of 15 subjects for a type of psychopathological disturbance, respectively - Schizophrenia, Major Depression, Reactive Depression, Disthymic Disorder, Obsessive Compulsive Disorder, Conversion Disorder

Centrencephalic Epilepsy and Temporal Lobe Epilepsy, a group of adolescents with adaptation problems which required treatment and Normal Volunteers were required to establish a relationship with a group of experimenters.

Subjects were asked to intervene in a strictly ritualized play performed by a group of four experimenters which simulated situations such as a) asking for collaboration in an experiment; b) family interaction; c) a court of justice interaction; and d) an admission in a Hospital ward.

Verbal communication between the members of the group of experimenters did not contain immediate denotative referents but rather connotative and functional characterizations in terms of attributes and relationships concerning the roles played by each one of the members of the group of experimenters.

Subjects were asked to characterize what was happening in the group after each eight individual interventions. Attributes present in the verbal content of utterances of the experimenters were constructed to convey attributes with equal probability.

When results were examined, contents like the use of reference, the use of logical inference with a two level structure, multilevel complex logical relational structures, use of summary or holophrastic statements, characterization of the self of the individual, characterization of the self of the others, statements of positive or else negative affective evaluations, hiperinclusive thinking, underinclusive thinking, normative statements, use of hypotheses not supported by data, use of cognitive distortions, explanations were in terms of personal historical descriptions, explanations based on private experience, justifications based on state of desease, etc, were counted in each record for every subject.

The numerical load of the use of these categories proved to allow an adequate classification of subjects, recovering the initial diagnostic groups in multivariate discriminant analysis (figure 5.1).

In another experiment members of distinct political parties and a group of subjects which characterized themselves as politically independent of any party were asked to classify the content of twelve speeches in the parliament produced by party leaders.

Subjects were asked to express their comments chosing attributes belonging to ten scales which expressed categories like (a)attribution of objectivity in political judgments, (b) combative standpoint, (c)defensive standpoint, (d)use of normative and valorative evaluations, (e)expression of positive qualification of the individual and his party, (f) proposals aiming to solve problems, (g)distortion of facts or of their meaning, (h)ostensibly ideological viewpoint, (i)attribution of incompetence, (j)communication ability.

The numerical data for the use of categories proved to allow a well ordered retrieval of the inclusion of subjects in their respective political groups. On other hand attributions to political parties and leaders preserved a consistent relational structure consistent with the a priori characterization of the groups (Figures 5.2a and 5.2b).

Differences of standpoint between president of a party and other leaders of the same party could also be identified defining a "tower of Pisa" strategy.

It is admitted that inferences about operational components in both cases do not involve personality traits directly as referents. They represented, nevertheless how individuals organized their psychological processes in a global operational structure to cope with the tasks proposed to them and they did so in a stable and consistent way.

This global organization of diachronic psychic processes in each subject may serve as a paradigm for the structural organizations of individuals as it was proved in the second study in which normal subjects were examined concerning their political evaluations, delegating or appropriating qualities from or over political leaders and parties.

The structural concept of personality does not take into account the time dimension in the unfolding of interactions with the environment.

The representation of cognitive processes, in terms of script logics allows the introduction of sequence characteristic of a trajectory which describes the successive stages of transactions with a structured environment specifying typical situations essentially in the perspective of the meaning the environment possesses for the self of the agent.

Nevertheless, introducing the script characterization centered on the environment structure does not provide any personal characteristic structure. It rather allows a classification of the repertoire of strategies the individual will use predominantly in the context of his commitment to solving problems posed by the external environment when he is producing behaviors aiming to satisfy his motivations making use of perceptive, emotional and cognitive information.

The problem of clarifying a proper script for the self or personality of a given subject, simultaneously distinguishing the subject from other individuals, can be solved by the concept of the double script- one script characterizes the stages of the interactions from the viewpoint of the responses the environment may provide for the intention of the subject and his motivations; a counter script may be defined in terms of the stages of the operations as well as integrative and disintegrative transformations which occur in the self of the individual when the environment solicitation elicit responses of the operational structures of the individual.Successive stages of the interaction represented within the subject generate distinctive configurations of the global organizations of perception, emotion, motivation, cognition, linguistic and non-linguistic communication, emotional states, memory, learning operations, decision making and performance of ostensive behavior, etc.

The successive configurations of representations, operations and transformations provide the identification of the characteristic scripts of a personality. The environmental operational structure and its stages expression crosses the individual structure generating a sequence of operational configurations and responses which defines the script of personality in situation.

In this approach the characteristic script of the self which is dependent on the stage structure of the environment script will be specified as a double script implying a concurrent computational structure either cooperative or else conflictive which takes the following form

Environment script	Script of the subject
Decision functions	Decision functions
$q_i(u,v)\ \ C_i(q_i,u,v)=\alpha_i$	$p_i(u,v)\ \ C_i(p_i,u,v)=\beta_i$

in which p_i represents decision functions which express the functional organization of the personality to cope with solicitations of the environment with a truth criterion for a field of variables (u,v) which assumes value β_i at a distance from β less than $\Delta\beta_i$. $p_i(u,v)$ holds true if

$$dist(p_i(u,v,\beta_i) \leq \Delta\beta_i$$

Matricial transformations $T_1, T_2, \ldots, T_n$ operating p_i will produce a succession of organizations of personality characterized from its decision making function as

$$p_{i+1} = T_i \quad p_i$$

A stage of the personality script will be characterized by an ensemble of u, v, p_i and T_i. With its meaning specified by the p_i as well as the semantic field of variables for which β_i criteria holds true.

Let us take the example of delusional disturbances in psychosis. A normal condition $\{q_i, u, v, \alpha_i\}$ would elicit a subject's ensemble of ordered structures $\{p_i, u, v, \beta_i\}$. In the case of delusion, some relevant components of $p_k(u,v), p_l(u,v)$, etc, will produce components $a_m, a_n, \ldots, a_z$, of $\beta_i, \beta_k, \ldots, \beta_z$. $A=\{a_1, a_2, \ldots, a_n\}$ generated by $A=p_k(u,v)$ which assume particular values $a_i > \beta_i$, β_i components of β which make the subject reject criteria

$$dist(p_i(u,v,\beta_i,C_i) \leq \Delta\beta_i$$

with

$$dist(p_i(u,v,\beta_i,C_i) = \sum |a_i - \beta_i|$$

When some components a_0, a_p, a_k, are significantly greater than β_0, β_p, β_k the subject will reject his characterization of himself in interaction with environment by a set $S=\{p_i, q_i\}$. In this case the subject rejects the script according to which he was behaving and introduces additional state functions $\{p'_i\}$ and $\{q'_i\}$. He uses abductive processes (Peirce 1966), he hipothetizes that elements of $\{p'_i\}$ and $\{q'_i\}$ produce distances $dist(p'_i(u,v,\beta_i)$ and $dist(q'_i(u,v,\alpha$

$_i$), truth values and decision functions and transformations which belong to another script- for example characteristic of a script of jealousy, persecution, political menace, etc, such that they satisfy the criteria $\Delta\beta_i$ and $\Delta\alpha_i$ better than $\{p_i\}$ and $\{q_i\}$. Then he makes the union $\{p_i\} \cup \{p'_i\}$ and $\{q_i\} \cup \{q'_i\}$. Conceptual hyperinclusion is produced this way and a new script is superimposed on the initial one producing a double interpretation for the same reality.

The new decision functions and variables will render dominant the second script and variables and truth criteria of the initial script are progressively deleted in such a way that the second script originates the labeling of the environmental script as well as of the personal script according with the rule

$$\mathrm{Del}(p_k(u,v),\beta_k) \text{ iff } \mathrm{dist}(p_k(u,v),\beta_k) > \Delta\beta_k.$$

As we remarked concerning experimental data in this section, the state characterization of psychopathological disturbances are transient and not stable traits of personality. They provide nevertheless a clear cut paradigm for less transient characteristic disturbances of personality as well as of normal personality types.

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List of Figures Captions:

Figure 1.1- A dendro-somatic interaction of dendrodendritic circuits and the cell body of a neuron.

Figure 2.1 Two examples of periodic waveforms (from 1Hz to 10 Hz) detected in EEG samples by Lee Method. The first and third column correspond to "agreeable fantasies" the second and fourth columns to thinking in numbers.

Figure 2.2 Results of Multivariate Discriminant Analysis of power spectrum components of periodic waveforms detected in Left Temporal Anterior/Temporal Posterior Leads. 1 represents agreeable fantasies, 2 disagreeable fantasies, 4 thinking in numbers, 4 thinking in alphabet letters. * Represents Group Centroids.

Tables 2.1 to 2.4 Classification results of Multivariate Discriminant Analysis of Periodic Waveforms detected in EEG samples registered in ive experimental conditions: joy, sadness, anxiety, mistrust, anger fantasies

Fig. 3.1- Convolution is represented using an iterative addition a number of times specified by a counter which determines the occurrence of pre-synaptic facilitation.

Figure 3.2. This figure represents divisive operations through iterative subtraction a number of times specified by a counter obtained through presynaptic facilitation (bottom line).

Fig. 3.3. This figure shows an oversimplified representation of a form of dendro-somatic interaction with parallel axonal channels of interneuronal communication at a distance.

Figure 3.4- This dendro-dendritic network implements intersection or else union between elements of two arrays A, B according to threshold θ_1. The threshold vector carries the conditions which define the logical operations which are performed by these dendro-dendritic networks.

Figure 5.1 Code used: 1) Schizophrenic (Sc); 2) Centrencephalic Epiletic (Ce); 3) Obsessive Neurotic (Ob); 4) Adolescent (Ad); 5) Conversion Disorder (Hy); 6) Temporal Lobe Epileptic (Te); 7) Major Depression (Ed); 8) Disthimic Disorder (Dd).Letters near the circles signal group centroids.

Figure 5.2a. Represents differences between parties from the viewpoint of independent subjects. In this figure and in figure 5.2b: PS-socialist party, PCP- communist party;PSD-social democratic party; CDS-conservative party

Figure 5.2b- Represents the characterization of the other parties from the viewpoint of members of the social democratic party.

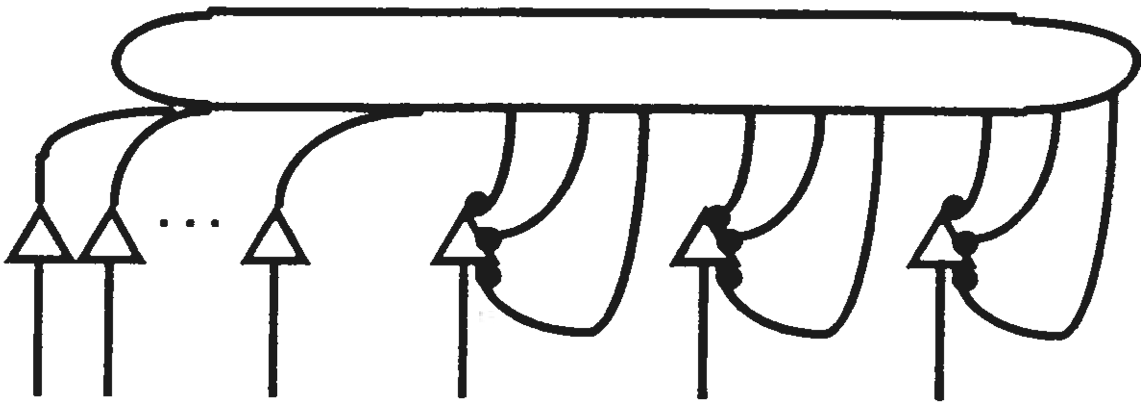

Fig.3. This figure shows an oversimplified representation of a form of dendro-somatic interaction with parallel axonal channels of interneuronal communication at a distance.

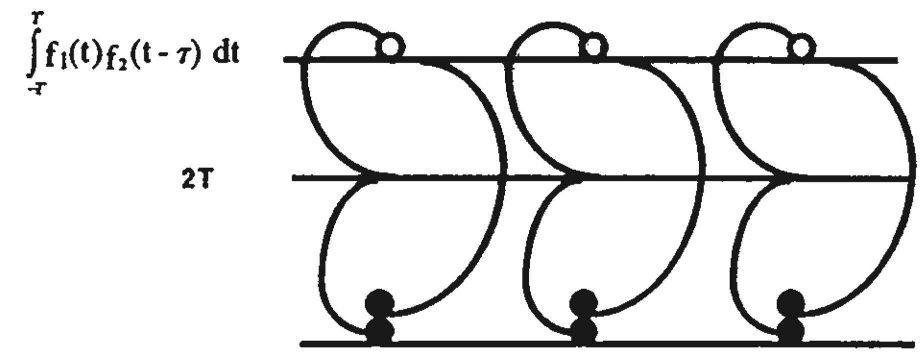

Fig.2. This figure represents divisive operations through iterative subtraction a number of times specified by a counter obtained through presynaptic facilitation (bottom line). Presynaptic facilitation occurs only when $\int_{-T}^{T} f_1(t) f_2(t-\tau)\,dt \; - \; N\,2T \;\geq 2T'$

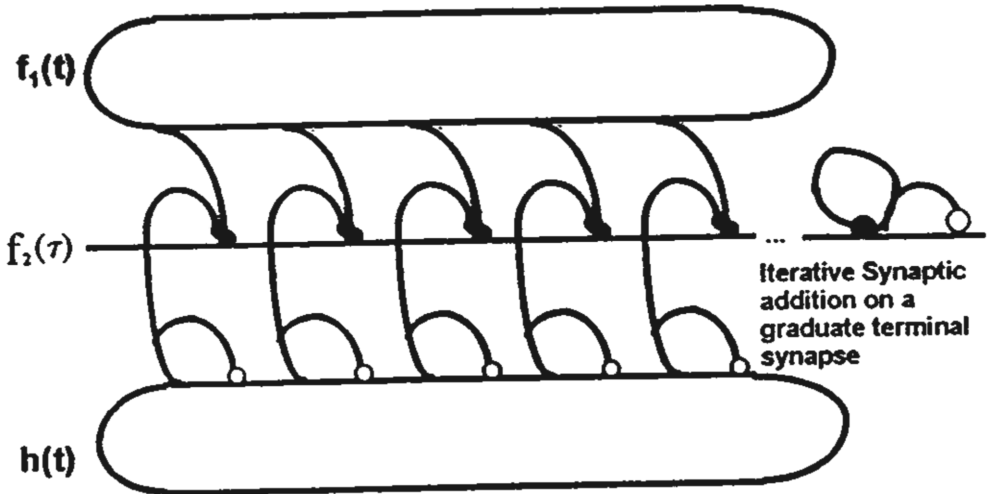

Fig. 1- Convolution is represented using an iterative addition a number of times specified by a counter which determines the occurrence of pre-synaptic facilitation.

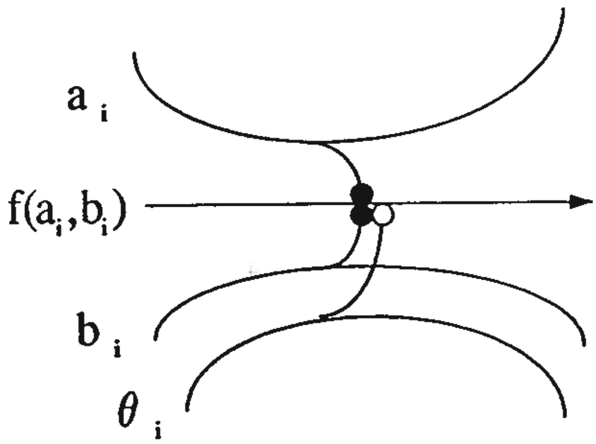

Figure 1- This dendro-dendritic network implements intersection or else union between elements of two arrays **A**, **B** according with threshold θ_i. The threshold vector carries the conditions which define the logical operations which are performed by these dendro-dendritic networks.

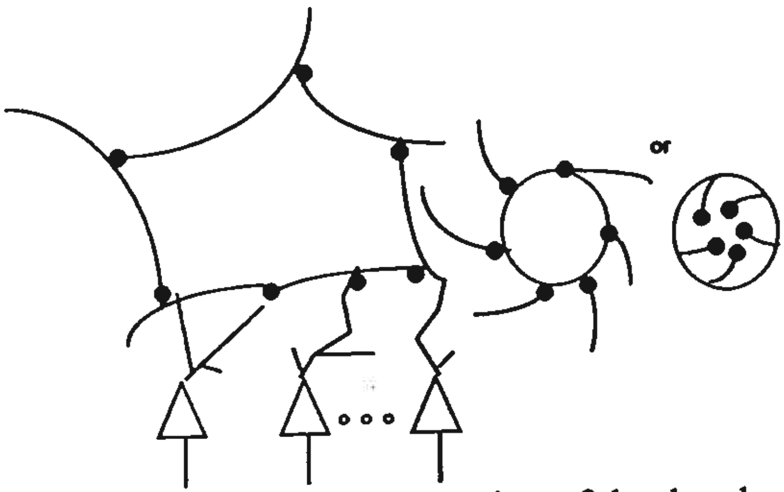

Figure 2- Further simplifications of the representation of dendro-dendritic circuits.