THE "ATTENTIONAL QUANTUM" MODEL OF HUMAN COGNITION[1]

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Abstract

A model of human cognition is proposed, that attempts to explain human intelligence in a way which addresses its most basic properties, i.e. its *autonomy* and its *creative power*. In the system of mental functions that make up this model the central role is played by ***attentional quanta*** (building bricks of cognitive processes) and *by* a postulated ***attentional organ***, which operates as a bridge at the *threshold between continuity and discreteness* and provides means for making possible *passages from discreteness to unity* and *from unity to systems*. This speculative model is supported by recent neurophysiological experiments in Berkeley and Zürich.

1. Introduction

Wassily Kandinsky, in his book "The Art of spiritual Harmony" first published 1912 in Munich under the title "Über das Geistige in der Kunst"[i] discusses in the conclusion what he terms "rhythmical compositions" (rhythmische Kompositionen). In this context he describes his conception of rhythm as follows (p. 140, my translation):

> *Like in music, where each construction holds an own rhythm, and like in the fully "accidental" distribution of things in nature where a rhythm is also each time at hand, similarly also in painting. Of course in nature this rhythm is sometimes not evident ...*

Kandinsky's considerations about rhythm express indirectly that the feature "rhythm" is *embodied* in music, in a painting or in a natural distribution of things. His description implies that what counts as far as perception is concerned, in this case the percption of rhythm, is a *given* meaning embodied in a *given* object as a feature of its own. Today, 90 years later, this way of thinking is still widespread, not only in common sense, but even in brain/mind science and in Artificial Intelligence.

What can be said about Kandinsky's description from the point of view of the "*Attentional Quantum*" model of human cognition ?

The Attentional Quantum Model (AQM) of human cognition is an attempt to model human intelligence (perception, cognition, knowledge, etc.) in a way which addresses its most basic properties, i.e. its *autonomy* and its *creative power*. The most original ideas of this model are based on of Silvio Ceccato's and Immanuel Kant's approaches to mind dynamics[ii,iii,iv].

In the following I begin by comparing further implications of Kandinsky's text with the ***goals*** of my AQ model, then I continue by applying the *premises* of this hypothesis to the case of the perception of rhythm and finally I conclude by suggesting a *system of mental functions* designed on the basis of these premises with the intention of reaching those goals.

2. AQM goals

A first goal has to do with what I call a *World Model*, which regards the (kind of) relation between thought (intelligence) and things. To state, like Kandinsky does it, that a piece of music, a painting or natural things have an own rhythm implies a world model (object model) which considers that, like physical existence also logical existence is a given attribute of a given object. The AQM approach on the contrary aims at distinguishing between physical and logical existence and tries to realize this by modelling the thought-to-things relation as an n-to-m *meaning-to-carrier* relation where each of m carriers can be *viably* connected with n meanings.

Another goal is addressed by what I call an *Intelligence Model*, which refers to the general attitude towards mind. Kandinsky's world model requires an intelligence model which emphasizes dependency and coerced responses. Such a model is implicitly based on the reflex model of behavior, which presumes that all behaviors can be expressed as

[1] Paper accepted for the Fourth Intern. Conference on COMPUTATIONAL INTELLIGENCE AND NEUROSCIENCE, Atlantic City, NJ, USA - February 27 - March 3, 2000. Submission supported by prof. Subhash Kak (kak@ee.lsu.edu) and prof. George M. Georgiou (georgiou@csci.csusb.edu).

a sum of responses to stimuli. The same model can be found in most of the Artificial Intelligence conceptual frameworks because they approach intelligence within the boundaries given by what computers can do. The AQM approach on the contrary aims at reaching a model of biological intelligence in which autonomy and creativity are its most necessary, fundamental characteristics.

A third goal is addressed by what I call a *Knowledge Model*, which refers to the most general task of thinking. From Kandinsky's world model follows that this task consists first in extracting (given) features from the outside world, secondly in making exact copies of them (called "data"), thirdly in incorporating them as representations of data and finally in analysing these data and extracting from them the meaning they embody (rhythm in paintings, etc. in the example). The AQM approach on the contrary aims at producing a model of mind in which meaning (information) and the operations of meaning processing are generated by the mind itself. This is why within this approach thinking is viewed as a self-organizing activity.

3. AQM premises

The premises of AQM specify in more details the ideas expressed by the goals. They are based on the premises which Ceccato has obtained for his theory as a result of his critique of the methodologies of conventional mind science. The crucial point here is, that recent neurophysiological experiments by W.J. Freeman[v,vi] and his group in Berkeley now give an experimental basis to these premises.

[1] The most general premise asserts, that the key to solving the mind-body problem is to view mind and brain in terms of the relation "*function-organ*": mind is here a system of behavioral functions and brain is the physico-biochemical system which implements those functions by means of part of its biochemistry.

[2] The most important premise asserts that the main effect of a mental (perceptual, etc.) process is to *generate* the patterns of activity that constitute a meaningful event. This means that in order to *perceive rhythm* in a painting or in a piece of music the mind/brain must *generate rhythm* as a mental/neural pattern of activity.

[3] Another premise asserts, that a perceptual performance cannot be expressed as a sum of responses to stimuli like in the reflex model of behavior. This means that the mental/neural pattern of "rhythm" is neither caused nor determined by the impact of stimuli on the mind/brain system.

[4] Closely connected to this is the premise according to which, first, "rhythm" (information) is not delivered into the system, second, the brain's job is not to incorporate "rhythm" as a given feature of the outside world and third the mental/neural activity pattern of "rhythm" is not an *internal representation of (given) data* like a binary pattern in a computer device.

[5] Finally, an extension of premise [2] asserts that the mental patterns of activity which constitute "rhythm" as a meaningful event are generated by a *self-organized* process which controls the current interaction with the environment on the basis of all the viable, meaningful events generated in antecedent controls.

In summary, the perception of rhythm in a painting or in a piece of music is not a stimulus induced, passive process in which the feature "rhythm" perturbates the receptors and is then copied and matched. It is instead an autonomous, self-organized process that creates meaning by generating activity patterns.

4. AQM system of mental functions

The model of cognition suggested by my AQ approach consists of a system of mental functions designed (under the constraints given by the above goals and premises) for answering the question: *how* does the mind-system generate activity patterns? Some of the main ideas proposed in this theoretical model are supported by the recent work of D.Lehmann and his group in Zürich whose results 'suggest that the seemingly continuous stream of consciousness consists of separable building blocks.'[vii].

Perceiving (and conceiving) "rhythm" in a piece of music or in a painting requires an autonomous, self-organizing environment which operates *as a bridge at the threshold between continuity and discreteness (C/D environment).* In the system of functions which make up this environment the crucial threshold function is performed by an *attentional organ*. Note that the function of attention as we know it from daily life *is only one from a set* of component functions provided by the attentional organ: we are not aware of the other attentional functions for the same reasons for which, at the muscular level, we are not aware of the elementary acts that are integrated into what we perceive as a voluntary movement. Because of the central role played by this *postulated* attentional organ in mental processing we can designate the whole C/D environment also as "Attentional Processing Environment" (APE)

5. APE overview

The component functions of the APE can be divided into 3 groups:

1.- functions for generating (and controlling) discrete operands out of continuity

2.- functions for coordinating discreete operands into units

3.- functions for integrating units into systems of units.

5.1 From Continuity to Discreteness

In this group the most important functions are the functions which provide "attentional quanta" (q) and "front-end fragments" (f). ***Attentional quanta*** are the key for passing the C/D threshold. They are discrete units generated by the cognitive system; functionally they are all identical to each other and can be combined to produce an infinite variety of cognitive constructions. A possible implementation of an attentional quantum in the brain may be provided by a set of spatially distributed neurons collectively activated in the sub-second range (cooperative neural mass) through attentional processes. *Front-end fragments* are discrete units broken off from the continuous processing at the boundary between the mental system and its environment. Attentional quanta and front-end fragments are the most primitive (elementary) and most general operands of cognitive processing. This means that in the mental pattern which constitutes the meaningful event "rhythm", these operands (q,f) and the operators (see next) which combine them are the minimal units of meaning.

5.2 From Discreteness to Unity and Systems

In the second and third group the most important functions are those which consist in the connection of *two* operands by means of an operator called a *biconnector*. One is *bisynthesis of microunits*, a function which requires as operands attentional quanta, front-end fragments or patterns of attentional quanta and produces as a result a new pattern, a so-called microunit, in which the two separate constituents (the two supplied operands) are indistinguished, melted into a new unit. Microunits constitute the basic structures of mental processing. Another function is *bisynthesis of assemblies*, a function which requires as operands microunits or patterns of microunits (assemblies= triads and networks of triads) and produces as a result a new assembly, an ordered cluster, a system of units in which the constituents (operands) are still distinguished. This operation can be performed in two modes, called the "infix" mode and the "postfix" mode (infix and postfix refer to the activation sequence of operands and operators, see below for details). The *infix connection mode* is the standard mode used in thinking. The *postfix connection mode* instead is the mode used to generate rhythm.

6. APE details

6.1 Discrete operands

Two general facilities support the other component functions of the APE. The first is the function which provides "attentional quanta" (q). Attentional quanta are like the building bricks of a house: they are discrete units, all identical to each others and can be combined. Attentional quanta are the most primitive (elementary) and most general operands of mental processing. This means that in the mental pattern that constitutes the meaningful event "rhythm" these operands (q) and the operations which combine them (see next) are the minimal units of meaning.

The second general facility is the function which provides the attentional focus, which is the unique momentary center of (conscious) processing.

6.2 Bridges to the environment

Two component functions are necessary at the boundary between the mental system and its environment (front-end processing). These functions provide passages from continuity in the environment to discreteness inside the boundaries of the APE.

The first is the function of selecting one of the different front-end processing, like touch, vision etc. For example perceiving rhythm in a painting requires that visual front-end processing be selected by shifting the attentional focus to vision.

The second is the function of making present the selected front-end processing. This means in the case of vision that the focus is maintained on visual processing, a situation usually described as "concentration".

Through the operation of these two functions any continuous front-end process in the environment is cut into discrete time units; this process can be described as "fragmenting"[viii].

6.3 Processing discrete operands

Inside the boundaries of the APE six component functions are involved in providing passages from discreteness to unity. From this processing of discrete operands result the basic structures of mental processing called microunits (bisynthesis of microunits).

The first function consists in the activation of the operands (units of meaning), which can be:

- an attentional quantum (q);
- a pattern of attentional quanta and their connections (microunit, MU);

The second function consists in the activation of an operator which can combine two operands (units) into one new operand (cross-correlator, attentional operator, biconnector of blending).

The third function is necessary for putting the operands in a temporal order. The fourth function gives a duration to the operands involved in the processing. The fifth function consists in the application of the operators to their operands and provides the fusion of 2 units into a single microunit. Finally, the sixth function consists in the application of a microunit to the fragments which come from the front-end processing.

6.4 Integrating units into systems

The microunits obtained by processing discrete operands can be further processed to obtain more complex structures (systems of units) called assemblies (bisynthesis of assemblies, faculty of thinking).

A mental assembly (knowledge assembly) can be:
- a system (pattern) of 2 microunits and 1 connecting operator (triad, TR)
- a system (pattern) of triads and their connections (network, NE)

Five component functions are involved in this processing stage. The first four are similar to the functions which perform the bisynthesis of microunits. The fifth function consists in the connection of two microunits by means of an operator. This operation can be performed in two modes, called the "infix" mode and the "postfix" mode. The infix connection mode is the standard mode used in thinking. This mode is characterized by having the connecting operator activated after the first operand and before the second operand. This can be represented schematically by the formula:

[infix-mode] = <1.operand> - <operator> - <2.operand>.

The postfix connection mode instead is the mode used to generate rhythm. This mode is characterized by having the connecting operator activated after the two operands. Schematically we can represent this case by the formula

[postfix-mode] = <1.operand> - <2.operand> - <operator>.

7. Conclusion

This rough sketch of the model of cognition suggested by the AQ model supports the following explanation of the perception of rhythm:

1. *Front-end fragments* [f] are broken off at the boundary mind-environment.
2. *Attentional quanta* [q] are generated by the mind.
3. Each microunit is made of *discrete units* [q,f] connected with operators.
4. The operands of the *postfix* mode of operation are *microunits.*
5.Rhythm is implemented in the mind as the *postfix mode* of operation.

As a consequence the rhythm perceived in an object - a painting, a piece of music or other - cannot be interpreted as a feature embodied in that object. Rhythm is made by a self-organizing mental activity and constitutes one of the main examples of the autonomy and of the creative power of mind/brain system.

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