ON NEURON MECHANISMS USED TO RESOLVE MENTAL PROBLEMS OF IDENTIFICATION AND LEARNING IN SENSORIUM

G.S. Voronkov, Z.L. Rabinovich

Abstract: The paper considers some possible neuron mechanisms that do not contradict biological data. They are represented in terms of the notion of an elementary sensorium discussed in the previous authors' works. Such mechanisms resolve problems of two large classes: when identification mechanisms are used and when sensory learning mechanisms are applied along with identification.

Keywords: sensory learning, identification, task solution, elementary sensorium.

Introduction

The main component of thinking quite probably consists in the problem (task) resolution. The question of how to simulate the brain function of thinking becomes more and more urgent.

The paper represents some viewpoints related to arrangement of neural mechanisms implementing two large mental problem classes, viz. how the mental identification and learning tasks are solved.

The above viewpoints follow from the general description of sensory systems and of the sensorium in all. This general description is based on the model paradigm [1]. According to this paradigm, the sensorium is the neuron model of the familiar sensory environment. The model paradigm notion is actually the projects of the ideas, mostly known and taken from various spheres of knowledge about the brain and information processes, onto the unique hierarchical neural network. This network comprises the elementary sensory system [2], the memory medium [4] and the intelligent medium [4]. It is proposed as the generalized result obtained when data about structural and functional arrangement of sensory systems are analyzed [2, 5]. The paper collects and develops the fragments of the model paradigm notion, related to thinking.

Elementary sensorium: some basic notions

1. The long-term memory (LTM) is the very model from the neurons (the very sensorium; see the right part of Fig. 1), it reflects the potential familiar sensory environment (about unfamiliar environment, see below, # # 1 and 2). In the typical structure (TS; see the left part of Fig. 1), the complex familiar potential object is submitted as a whole by symbolic neuron and its elementary properties – by the receptors and quasi-symbolic neurons. In the sensorium, the complex familiar potential object is submitted as a whole by the neuron on the upper most synaptic level; here the different modal key properties of this object are submitted too. At the lower levels, its complex subproperties and their traits are submitted. The most elementary indecomposable properties are submitted in the very first sensory systems TS of the sensorium.

Being influencing, stimulating, the object is submitted in the model by the same neurons, but already in the excited state. The characteristics specific only to the stimulating object (force, duration, importance) are submitted in functional parameters of neurons (force and duration of excitation), the memory of them is kept for some time as a changed excitability of the formerly activated neurons and the changed conductivity of the ways to them, in other words – in the changed synaptic weight. It is the short-term memory - STM. Its mechanisms are rather investigated neuro-physiological mechanisms of the plasticity.

The presentation of unfamiliar object activates the neurons of low synaptic levels, only that of the neurons matching the familiar properties and subproperties of this unfamiliar object. They are remembered for some time in STM with the help of mechanisms described above. As it is possible to see, the storing in STM is not accompanied by formation of the new connections. The storing in LTM is the arrangement of the symbolic neurone to match the new object (as a whole), the new symbolic neuron and formation of its TS connections.

The mutual positive connections inside TS (between symbolic and quasi-symbolic neurons) provide rhythmization of activity, its quantumization, amplification and contrasting. The latter is provided by the lateral inhibition characteristic for biological neuro-networks.

The rhythmic process, in the separate TS, develops, lasts for some time and attenuates. The attenuation occurs due to the collecting recurrent inhibition. All these processes occur in the olfactory bulb, TS prototype, and the bulb computer model [6]. The descending connections in the elementary sensorium provide synchronization of rhythmic activity of appropriate TSs. The activity of the uppermost TS plays a leading role in this.

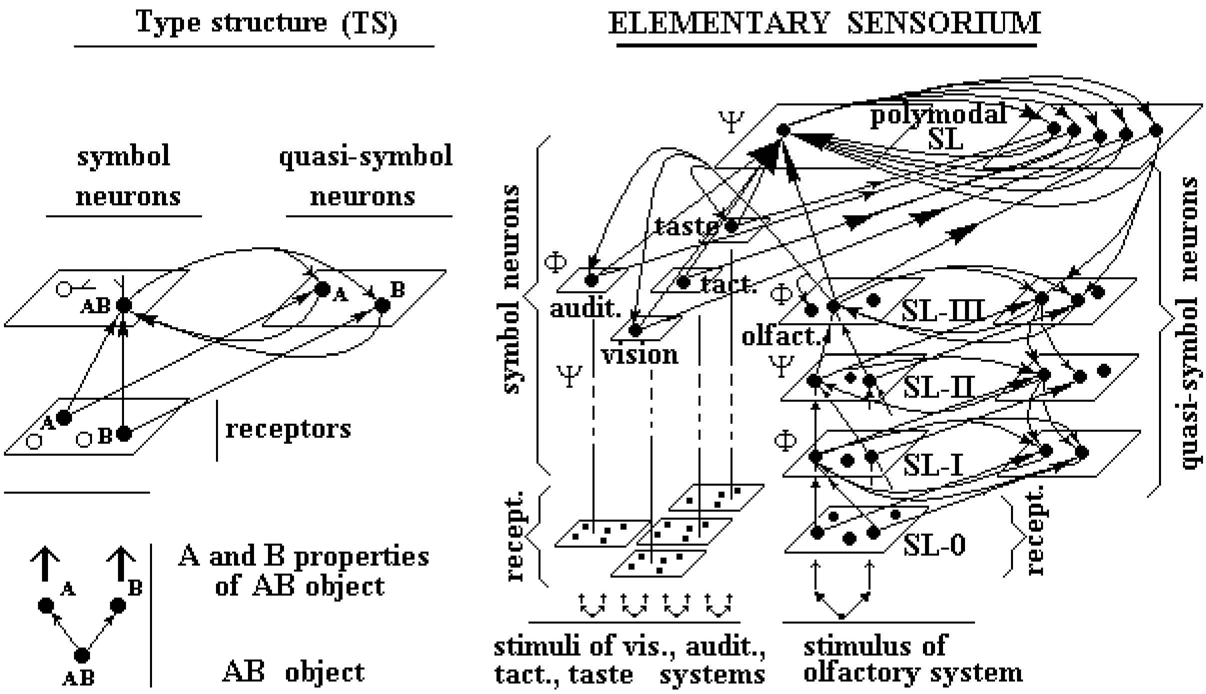

Fig. 1.

Task and solution: general notions

2. The task here is a complex object (situation, picture, phenomenon) of the sensory environment, shown to the elementary sensorium for identification; the solution is the identification of this object. The absence of identification is absence of solution. The familiar object can be unidentified due to several circumstances: or due to it is insufficiently distinct among the environmental objects, or it is shown insufficiently full (fragmentary), or due to combination of these circumstances. We also believe, that any presentation (actualization) of the environment is "presentation with the purpose of identification" since identification is the basic function of the sensory systems. The identification process is initiated by influence of adequate stimulus on the receptors, then the process is directed by the network architecture, the neuron connections, their present excitability state and others.

The stated question can also be a part of the task condition (if the task is also shown in the verbal form), it is the important component of the task condition, in fact, the major "help" making the object distinct in the background.

Note, that the examined elementary sensorium (Fig. 1) is isolated from motivation, emotional and other systems of the brain. So, by its example, we actually analyze only the own possibilities of this simple circuit (in terms of the tasks solution) and only occasionally we take account of its communications with other brain structures. In this analysis we imagine that this circuit works by the known neuro-physiologic mechanisms. This analysis is limited by the use of only biological mechanisms and model paradigm framework.

The shown unfamiliar (new) object cannot be identified in principle, since it is not submitted in the sensorium as a whole. Identification of this object in the sensorium is possible only after formation of its neuron model (see below, # 6).

This understanding of the "task" and "task solution" is followed by classification of the tasks, being the large share of all mental tasks in all, to two classes. The first class involves the tasks, solved by the identification mechanisms only. This is the class of "identification tasks ". The second class involves the tasks, solved, by the mechanisms forming new "concepts" in addition to the identification mechanisms. The concept-forming mechanisms are similar to or are the sensory learning mechanisms. It is the class of "learning tasks". Note here, that the identification and sensory learning differ from the comparative process; the latter is not considered in the work.

3. The presented identification task, if it is not solvable at once, is submitted in the brain by the activated sensorium part. This part consists of the activated neurons, matching the background objects and their properties including the task object and its properties. However, the latter (viz. the neurons matching the task object) do not reach the condition of activity, appropriate to identification (see below # 7). Thus activated part of the sensorium is the initial situation.

To the solution of identification task there corresponds the final situation (identification state). It is a steady, for some time, special dynamic activity state of neurons matching the task object only. These activated neurons represent simultaneously both the task object as a whole and its major properties. The feature of the dynamic state consists in the fact that the activity of these neurons is amplified and rhythmical, and their rhythms are synchronized (see below, # 8). In the period, when the final situation takes place, the neuron rhythmic activity dominates the activity of others neurons of the elementary sensorium. The neuron domination is expressed in priority influence of their activity on the effector and other brain systems. In the stated representation, the domination state is correlated with the phenomenon called by the standard term "attention".

4. The process of transition from the initial situation to the final situation is the process of task solution.

By definition, the identification task assumes, that the final situation neurons are submitted in the sensorium a priori; they are the part of the neuron model (long-term memory), representing the potential environment in the brain. Thus, the process of the solution consists in selective activation of the final situation neurons. In addition to "the matching realization mechanism" in the direct sensory pathway, during selective activation, other elementary sensorium mechanisms (see below, # # 7, 8) act; the set of the selective activation mechanisms is possible to designate as mechanisms of identification.

The moment, when the final situation is reached, correlates, according to the stated representation, to the subjective emotional sensation, insight (eureka). Here, it is possible to note, that, since the problem of sensation remains a principle “blank space" in the brain problem, this subjective display of biological sensorium work, used here in interpretation of the elementary sensorium work, is only formal.

If the task is not solved (i.e. the final situation is not reached, the insight is not shown), for continuation of the solution process, it is necessary to expand the task conditions by entering the additional fragments or different-sort helps making object distinct in the background.

5. There may be the following identification tasks, for instance. 1) A game for children. It is necessary here to look for and identify a known contour within a web of lines (branches). Task statements are: a represented picture proper (e.g. branches of a bush); a question asked in some form; other prompts. The solution is vision and identification of a desired (known) contour. 2) Examination school tasks. The task solution means here to identify a task type (scheme) since the solution of each task type (description or model in the most generalized form at upper levels) is already present in the sensorium (or the linguistic system) of a person being examined on the basis of a passed program. 3) Tasks solved by analogy. As in the case of school tasks, gist of solution consists in identification of the general scheme characterizing both an initial situation

and another but the known one, i.e, it is necessary to identify a scheme already represented in the sensorium. 4) In essence, solution syllogisms (i.e. deduction process) also possibly come to identification.

It is obvious, that being similar in principal, the task solution processes in the given examples 1) -4) should differ among themselves with TS activation sequence.

6. For the learning task, the final situation cannot, in principal, be reached with the help of only the identification mechanisms since the absence of the uppermost (uniting) TS and other TSs, which potentially would represent the task object (and its properties), does not allow the solution process to reach the identification state (see # 2).

To solve this task it is necessary to add the missing TSs into the initial situation. This can be carried out only by formation of new TSs. At the first synaptic level, the new TS formation is initiated by influence of a new stimulus of on the receptors (sensory learning). To initiate TS formation at a high level, it is necessary to activate TS symbolic neurons of the previous level. The latter can proceed in two ways: through the sensory learning and/or through the influence of activating brain systems on the sensorium symbolic neuron fields. Evidently, the neuron model formation in the second way largely proceeds from the "internal resources" of the sensorium, from LTM. Note here, that formation of TS symbolic neurons in the elementary sensorium has some formal similarity with formation of new tops in pyramidal networks [7].

The model formation proper (new TSs formation) can be considered as a really creative process since it singles out a new object (or property) in sensory environment (or in its neuron model) and models this object (viz., matches the new TS symbolic neuron with the new object). In linguistic terms, the singling-out of the new object in the environment (and the formation of the new "object" on the basis of knowledge) is formation (birth) of the new concept.

Neuron mechanisms of identification and sensory learning in the elementary sensorium

7. In the elementary sensorium (Fig. 1), matching the potential sensory environment, the initial situation is represented by the activated neurons of typical structures (TS), paired with the presented task (see # 3).

Thus if any of the key stimulus appears presented," the matching realization mechanism" of the sensory direct pathway selectively activates the symbolic neuron of the uppermost TS (the neuron input is organized as disjunction). This neuron matches the task object as a whole.

It activates the matching quasi-symbolic neurons. The latter match the single key properties of the task object. By descending projections, these quasi-symbolic neurons activate the lower TS quasi-symbolic neurons matching the subproperties of the key properties.

The neuron activation of all lower TSs can be facilitated by the activities of the ascending pathways. By associative (signification) projections, the TS symbolic neurons of the initial situation sub-activate (or activate) the symbolic neurons of other TSs.These neurons play the role of the context. As a result, the quantity of the activated neurons (and TSs) involved increases. The quantity of the involved TSs determines the depth and detail of identification.

8. Every TS is rhythmically active because of an arrangement of neuron bonds in TSs (Fig. 1, [2], [5]). *Initial situation* TSs are not yet united by the uppermost TS and, therefore, their operation is autonomous to a significant extent. Their rhythms may also be not synchronized at this moment. If the uppermost TS is activated, it synchronizes an operation of every final situation TS according to the above bonds. The synchronization in neuron rhythmic activity of all TSs is reached for some time period. And here is the “completed pyramid” making up and corresponds the final situation, viz. task solution. This period of the most intensive neuron rhythmic activity of the completed pyramid runs along with the highest neuron inhibition of all the neighbouring TSs not matching the final situation. The above activity domination is thus provided. The above inhibition occurs due to lateral inhibition bonds. This period runs for some time. It is limited by a recurrent summed inhibition accumulated inside the TS (see # 3). Therefore, the *task solution* is the synchronized rhythmic neuron activity of the complete TSs pyramid, stable for some time. The synchronized rhythmic activity is, so to say, the dynamic attractor where the rhythmic activity of the pyramid vertex TS acts as the order parameter. According to the above idea, this very state is correlated with sensation of

identification (understanding) of the complete picture as whole and simultaneously with modal perception (vision, hearing) of the picture details.

9. What is a possible mechanism of new TSs generation (their symbol and quasi-symbol neurons, bonds between these neurons and their bonds with other TSs) when the learning task is being solved? One can make the assumptions close to the truth so far, proceeding, in particular, from the following. 1). The data, derived from the sensory learning in ontogenesis, show that these mechanisms really exist. This can be exemplified by generation of detectors of vertical lines for kittens grown up in the environment with vertical lines and the absence of the detectors when kittens are grown up in the "horizontal" environment (Hubel, Wisel, 1962). 2). So called stem cells are shown in nervous system. They are generated into new neurons. 3). The constant "searching" growth of the neuron processes is illustrated. The growth is terminated when a contact with a target has been established. 4). Some hypotheses about the targeted growth mechanisms (e.g., it may be the chemical affinity principle) and about the selective bond formation principles (the Hebb principle) are advanced. 5). A host of neuron mechanisms have been studied that provide the selectivity of neurons and plasticity of the neuron inputs. 6). The targeted axon projections, including convergence, on neurons of sequence synapse levels is shown.

10. Consider the hypothetical elementary process of generation of the very first sensorium TS (Fig. 1). A set of various-type receptors is formed according to the genetic program. The sensory learning for an object supposes a reiterated activation of a certain set of different-type receptors. This activation initiates the growth of axons to the next level neurons. The first contact of any axon out of a group of growing axons with one of the neurons makes this neuron a target for other simultaneously growing axons due to the Hebb principle, for instance. This is a possible way of the symbol neuron generation. The symbol neuron corresponds to a joint array of certain properties when a neuron input is generated according to conjunction or to a class of certain properties when the input is generated according to disjunction. Possibly, the targeted 1:1-projection of receptors onto quasi-symbol neurons is provided by the chemical affinity factor. The generation of positive mutual communications between a symbol neuron and corresponding quasi-symbol neurons may likewise be based either on chemical affinity or on the Hebb principle. Supposedly, the latter is also the basis for generation of significative communications between any symbol neuron and other particular symbol neurons. The same principles may also provide the generation of descending bonds of quasi-symbol neurons. Since the symbol neuron fields act as receptor fields for TSs of the next synaptic levels, the above process can provide the generation of the second-, third- and higher-level TSs. The TSs generation process is initiated by activation stimuli: the sensory stimuli occur at sensory learning, and, the stimuli from activation brain systems occur at learning based on remembering. The process is directed by genetically provided growth, the target selection mechanisms and by the network architecture.

It is clear that the new TS generation in the neuron model, proceeding from only inner sensorium resources, calls for additional mechanisms to involved, in particular, the short memory mechanisms for identified fragments of the initial situation as well as their periodic recurrence (withdrawal from the memory). Likewise, the tasks may differ by the significance of the initial situation fragments: the higher the level of TSs, being the fragments of the initial situation, and the more fragments are involved; the greater is the possibility for the sensorium to solve the problem. This argument is true for the problems of both classes.

It is evident from the above description that the learning problem solution process needs more energy and more time than the solution of identification problems.

Conclusion: the role of tutor and language system in identification and sensory learning

11. The described way, where the concepts are derived in the elementary sensorium, is possibly basic providing the emergence of the concepts in fauna evolution and in the creative human thinking. Likewise, the sensorium concepts in ontogenesis in animals are generated more efficiently, namely, via learning by tutor. In fact, the tutor-involving method consists of the sensory learning supplemented with the important prompt into the initial situation. The prompt helps single out the object as a whole from the background. When higher animals bring up their progeny, the behaviour of mature animals acts as the prompts. Humans also have this

element, but prompts are implemented largely verbally through the language system associated with the sensorium [2,8]. The language system matures in ontogenesis faster than the sensorium. Thus, in addition to the genetic factor, the volume of the formed sensorium (LTM) is incomparably larger than that in animals; the human sensorium is actually of another quality. It may well be, the role of the language system was as much important in development of the sensorium (genetically fixed) due to their communication function in the unusually rapid evolution of humans.

Likewise, there occurred the evolution of the language system proper. In addition to the communication and simulation functions, the intelligent function (task solution) was also developed in it. There is a ground to assume that the above description fragments of thinking neuron mechanism in the sensorium are also applicable for the language system.

In addition, the interaction between the sensorium and the language system is a new factor in thinking, including the creative one, and adds new additional mechanisms there. This makes the qualitative level of thinking even higher.

It is evident that, the working-up of the aspects, in addition to the whole number of other ones not considered in this paper can make an essential contribution into the development of the model paradigm notion about thinking mechanisms.

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Author information

Voronkov Gennadi Sergeevich – The M.V. Lomonosov Moscow State University, Leninskie Gory, Moscow, 119899, Russia; e-mail: gsv@gvoronkov.home.bio.msu.ru

Rabinovich Zinovi Lvovich – V.M. Glushkov Institute of Cybernetics, Prospect Acad. Glushkova, 40 03680, Kiev-187, Ukraine; e-mail: eco@public.icyb.kiev.ua