The Theory of the Organism-Environment System: II. Significance of Nervous Activity in the Organism-Environment System

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Abstract—The relation between mental processes and brain activity is studied from the point of view of the theory of the organism-environment system. It is argued that the systemic point of view leads to a new kind of definition of the primary tasks of neurophysiology and to a new understanding of the traditional neurophysiological concepts. Neurophysiology is restored to its place as a part of biology: its task is the study of neurons as living units, not as computer chips. Neurons are living units which are organised as metabolic systems in connection with other neurons; they are not units which would carry out some psychological functions or maintain states which are typical only of the whole organism-environment system. Psychological processes, on the other hand, are processes always comprising the whole organism-environment system.

Introduction

IN CONTRAST TO MANY present psychophysiologists and brain researchers, the first person to present a comprehensive theory about the mind and brain, the French philosopher and mathematician René Descartes, did not think that mind is located in the brain. According to Descartes, mind consisted of another substance than brain, a substance which was immaterial and nonextensive and was especially characterized by thinking and consciousness. However, there was a connection between the mind and brain through the pineal gland, the vibrations of which transmitted information from the outside world with the help of the nerve tubes and brain cavities. The mind could also cause movements of the body by vibrating the pineal gland and thus causing the pumping of vital spirits into the muscles (Descartes, 1637).

Although Descartes would never have agreed with the idea that mental functions are located in different parts of the brain, his dualistic thinking laid the basis for the idea of localization of mental functions in the brain. When the mysterious substance of the mind was abolished from the growing discipline of neuroscience in the last century, it was only consequent to assume that mind is actually distributed in the brain in such a way that its different functions have different sites in the brain matter. Many neuroscientists of the present still adhere to this way of thinking. It is thought that the brain consists of centers or modules of mental functions: memory has its place in the hippocampus, emotions are buried in the limbic system, the visual cortex draws pictures of the outside world, etc. (see e.g., Naatanen, 1990). From the point of view of mental activity the brain is considered to be the most important part of the human body.

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The Problem of Localization of the Function

But is mental activity not located in the brain? Isn't the brain precisely that organ which carries out all those functions which make it possible for man to perceive his environment and to be conscious of himself and of other fellow humans? If we destroy a certain part of the brain and get distortions of thinking, personality, or learned actions, does this not show that these functions were really located in the distorted places?

However, what do we mean exactly when we say that a certain function has a location in space?

Let's look at the action of an artist when he is preparing a piece of art. Where is "painting" located when the fine movements of the hand and fingers create a picture on the canvas—in the brain, in the hands, in the paintbrush, or on the canvas? If we destroy some of these elements it becomes more difficult to create this piece of art. Some of these elements may be more easily substituted than some other, but in the act of painting they all are necessary. Can we say that the process of painting is located in the part which seems to be most active or important?

No, of course not, because painting is a process which is realized as a whole organization of elements which are located in different parts of the world. This organization is realized as a totality in the painting. If some element, even a very tiny one, was missing the painting would not be the same or it would not be ready at all. Therefore, all elements are active in relation to the result of action; none of them is passively participating in the result.

If we kick a ball only one leg seems to be active, because we see its movement. However, the other one, the supportive leg, is also an active part in relation to the result of action, which we will see at once if we remove this leg. Similarly, it is one of the most common mistakes to regard as active in the study of the brain only those parts in which we may find responses or other kinds of changes with our recording methods. From the point of view of the result of action all other parts (in which seemingly nothing happens) are also active if they are prerequisites for the behavioral result. From the point of view of the whole system this is also true of all environmental parts joining in the result. Thus, if all elements together form the result how could we say that the result is located in only one element of the system.

From this it does not follow that mental activity does not exist at all in reality. This would be similar to maintaining that the "steering" of the car does not really exist, because we cannot locate this action in any single part of the car (or road). Although we cannot locate "painting" in any part of the painting process and cannot determine it in any other way than through an inspection of elements participating in the organization of the action, the concrete result of this process may be seen in the ready-made painting on the canvas. "Painting" is not something "fictional" or an epiphenomenon, but real behavior which is realized in the co-operation of many concrete elements. Therefore, painting cannot be something related only to the brain or body, because all behavior is a process in which parts of the body and environment intertwine. The basic mistake in any locating of mental functions to the parts of the brain is very simple: some part of the complicated system is equated with the whole result of the system.

If it is thought that mental functions are located in parts of the brain, this does not make brain research easier, but more difficult, because such a theory, in fact, mystifies both neural and mental activity. If a thought or consciousness is located in the brain what does it exactly mean? Is it located in the cells or between them? Or is it simply activity of the

neurons? Moreover, if it is a property of the activity of neurons, do all neurons have such a property? If not, how then do the neurons which have "conscious" properties differ from other neurons? Do only certain kinds of neurons have mental activity? Such questions are practically impossible to solve with any experimental method.

Mental Activity as Activity of the Organism-Environment System

According to the theory of the organism-environment system (Järvilehto, 1994, 1998), mental activity is a form of action of a living system, developed during evolution. The nervous system has an important role in the appearance of this form of action, but it is only one part of all those structures which make the joining of the organism and environment possible in one unitary system. The role of the nervous system is based on the possibility of the neuron influencing other neurons and parts of the body, especially senses and muscles. The appearance of this highly specialized cell, the neuron, laid the basis for new forms of action and a new kind of dynamic organism-environment system.

From the systemic point of view the neurons or parts of the brain are not specialized in relation to certain mental functions, but in relation to the ways of producing action results. To be able to survive, a living being must develop different forms of behavior and produce different types of results which make its life process possible. The neurons are specialized in producing useful results for the organism when the environment offers the possibility for such an organization. The most important feature of the nervous system (which as such is no system at all) is its ability to organise, together with all other parts of the body and environment, systems producing useful behavioral results.

Therefore, the behavior of man (or other animals) is not based on the selection of separate psychological functions, but on such forms of behavior which make possible the continuation of the co-operation between man and environment. Such forms of behavior are possible through the joining of action of specialized neurons into systems involving parts of the body and the necessary parts of the environment which render useful results of behavior possible. It is just the result of behavior which is important from the point of view of neurons, because this makes the continuation of their metabolic processes possible. The neurons are not "interested" in perceptions, thoughts, or features of the environment, but in their metabolism. If their metabolism does not work properly they are destroyed. This is, in fact, true of a tremendous number of neurons all the time, of neurons which cannot join the appropriate systems to maintain their conditions for survival. The neurons do not analyze features of the environment, carry out mental operations, or build models or representations, but they make possible the dynamic joining of the organism and environment into one system and through this they also secure their own metabolism. The development of the nervous system is not the development of mental functions, but selection of such systems which are able to produce behavioral results. Edelman (1987) states that evolution is not the selection of organisms, but of forms of behavior. We may express the same in different words by maintaining that, in evolution, organism-environment systems are selected, not any single structures or mental functions.

Common Mistakes in Thinking

When presenting the results of brain research the impression is often given that the discovery of the location of an event would somehow also give an explanation of this event. In fact, the majority of brain research consists in the effort to find out the locations

of activity connected with certain kinds of behavior or mental acts. However, if the researcher is able to state that with attention some parts of the temporal cortex are activated, what has actually been explained by this finding? As we already stated, the fact that we find activity somewhere does not render other parts of the brain inactive. Such an explanation would have some significance only if we could show that the mental action studied is located only in this one part of the brain and nowhere else.

Let's take another look at our example on painting. The typical situation in the localization experiments (with EEG or microelectrode techniques, for example) is that some electrodes are placed in a certain part of the brain and the subject carries out a specific task. Then, if for example after an auditory stimulus which the subject may hear the cells close to the electrode are activated, it is stated that the site of hearing has been found. This would be the same as to say that the process of painting is located at the tip of the painting brush, because it is just here where we may see the most conspicuous changes during painting. The basic mistake here is that an element the activity of which we may most clearly observe is substituted for the whole system producing the result of action.

There also seem to be many simple linguistic mistakes in relation to the considerations of brain and mental activity. "I have a thought in my head" is an expression which is unproblematic in daily use and has the same form as "I have money in my pocket." However, in the former sentence the expression of place is not similar to that in the latter sentence. When I go into another room the money is also moving into this room. However, the same is not true of thought. When you tell a dear one in a far-off country that "my thoughts are with you," you do not mean that the thoughts have traveled a distance to be with your loved one, but that s/he is now the object of your thoughts. We may also turn around the whole spatial relations by saying that, "I am now in my thoughts." Where are the thoughts then? It seems simply that many brain researchers base their considerations and interpretations of experimental findings on the wrong use of the meanings of the words.

It is, of course, clear that the basic idea behind any localization of mental functions may be traced back to the misunderstood Descartes and to the idea that there is some sort of homunculus in the brain that observes, thinks, and has mental functions. The same way of thinking may be seen in many common explanations in which mental functions are explained with neural functions couched in the semantics of the original question. For example, if we ask how perception of a word is possible and answer that there is a "word detector" in the central nervous system, we have not answered anything, but only moved the original question from psychology into neurophysiology. For a neurophysiologist, however, there exist no such concepts as "word" or "perception," because he is interested only in constellations of neurons, their co-operation and metabolism. Therefore, there is nobody then to answer the original question; it has been simply abolished or left open. The situation is similar if a physicist tries to explain why a table is a table by explaining that actually the molecules are like small tables. The basic mistake is the same as above: the properties of the whole system are equated with the properties of its elements.

Neurons are, of course, important from the point of view of mental activity, but not in the sense of localization or their assumed mental abilities. Mental activity cannot be explained by looking at the properties of neurons. Mental activity may exist, because neurons have physiological properties which make it possible for them to form dynamic systems producing behavioral results. However, the behavior cannot, of course, be found in the neurons, but in the whole organism-environment system.

The dynamics of the nervous system

If mental activity is not located in the nervous system, why in that case are neurons so important from the point of view of this activity? Why is mental activity not possible before the development of the nervous system? What kinds of new features can we see in the organization of the organism-environment system with the appearance of the neuron?

Every organism-environment system has been formed during evolution so that it may achieve useful results. This is the basis of the development of any system and in this sense every system is perfect or optimal. The action of any organism-environment system is continuous. However, in this process every new result means a point from which the action is reorganized and gets new direction. With primitive organisms such points are rare. Perhaps we may say that for many primitive organisms there is only one result of action: reproduction and the disappearance of the original system. The life process of such organisms is a continuous metabolic process, one act, the end of which means the appearance of a new system.

The development and the differentiation of the structure of the organism-environment system meant also development of the structure of the behavior. The more complicated the structure of the system, the more possible forms of organization and action alternatives there will be. This corresponds to the development of phases of action and action results. The potentialities of action are in a way stored in the structure of the system. The less the structure may be reorganized, the fewer different action possibilities there are and the more dependent the living system is on fixed parts of the environment. If the environment undergoes drastic changes no new organization is possible and the living system disappears.

With the development of the neurons and the nervous system, quite new possibilities appeared for action in a constantly changing environment. Before the existence of the nervous system, the relations between the cells of the organism were relatively fixed and static. Therefore, plants, for example, cannot vary their actions much when the environment is markedly changed. Only neurons made possible the development of dynamic systems joining parts of the environment and the organism. With these cells, which could influence directly other neurons and other cells of the body, it was possible to form systems which dynamically changed their organization in accordance with varying life conditions in different parts of the world.

Information Processing and the Nervous System

According to the theory of the organism-environment system, the basic principle of nervous functioning is not that of information processing, but creation of such constellations of neurons which—joined to the other parts of the body and environment—may achieve behavioral results which are useful for the metabolism of neurons and through this for the whole organism. The neurons are in many ways the most sensitive cells in the body and their large-scale destruction leads necessarily to the restriction of the action possibilities of the whole organism.

From this point of view it is clear that neurons do not create maps of the environment, inner models or representations which would somehow correspond to homuncular perceptions. Such reproduction of the properties of the environment in the nervous system is simply not important from the point of view of appropriate behavior, and must be assumed

only if the starting point of the theory of nervous functioning is based on the absolute separation of the organism and the environment.

The necessary condition for forming systems leading to useful results is not from the systemic point of view that nervous organization should reproduce the organization of the environment as some sort of representation or model. The only essential is that a system may be formed in which elements belonging both to the body and to the environment are fitted together. The structure of the body, of course, "reflects" the structure of the environment in the sense that by inspection of the bodily structure we may also conclude something about the possible structure of the environment. When looking at the body of an organism we may speculate on what kind of environment would be appropriate. The study of the organism is simultaneously the study of the environment.

Let's make our point clear with one further example. The system for cutting wood consists of a saw and a tree. In order to have a well-functioning system the properties of the saw and those of the tree should not be the same, but rather different in the way which makes a result possible. In a system consisting of two sets of elements one set need not to reproduce the properties of the other in order to create, as a whole, a functioning system. On the contrary, to have a good system for cutting the saw must be hard and the tree soft, otherwise the system will not function properly. The structure of the saw reflects in some sense the structure of the wood, but only from the point of view of the result (cutting).

If we think that the nervous system must somehow reproduce or represent the organization of the environment this would mean that the representations in the nervous system would always lag behind the events in the environment. However, if we think that the essential feature in nervous functioning is its fit with the environment this means that the environment and the nervous system have the same time. Perception, for example, is simultaneous with the object of perception in the environment. This means also that a stimulus does not precede perception, but perception is a process in which the fit of neural elements with the environmental events defines the stimulus. Therefore, reaction time is not the time for the processing of the stimulus, but the time for organizing the result.

The theory of the organism-environment system maintains that mental activity is realized in a system consisting of neural and environmental parts. As to the concepts of learning and knowledge this means that they are not based on transmission of information from the environment into the organism. There is only one system. Thus, all increase of knowledge means only the reorganization or widening of this system. Knowledge may be defined as the form of existence, because it is impossible to have any living system without knowledge. This means also that knowledge must be created; it cannot be transmitted or moved from one head to another.

Concluding Remarks

The theory of the organism-environment system involves quite different basic principles of neural functioning than those in traditional neurophysiology and psychophysiology. The concept of the nervous system is a similar abstraction to the concept of the atom: it is used as an explanatory concept in trying to understand the results of action of human beings. However, with an atom we cannot explain why a table is a table. To be able to do this, we must also take into account many features of human social activity. Similarly, with neuronal data only we will never be able to explain consciousness or any other human action. Such acts are not carried out by neurons, but by a system which consists of the neurons, of many body parts, and parts of the environment, including other human beings.

Furthermore, a neuron is an abstraction, the existence of which is completely dependent on the theory we have about the brain. A neuron is magnified by the microscope into our scale of observation so that we may describe its anatomical structure with such everyday concepts as fibers, walls, particles, etc. In reality a neuron is something which we cannot directly observe with any such properties. We see neurons as we see them, because we have a cell theory, a theory according to which the cell is the basic architectonic unit of any organism. If our theory was that of chemical fields, for example, we would see in the microscope only those fields and no cells at all.

The registrations from the brain may be compared with the registrations of traces of elementary particles in the cloud chamber of the accelerator. Such traces alone could not help us to understand why a table is a table. We think that an EEG recording, for example, reflects changes in the activity of neurons. Such changes do not, however, reflect any processing of the environmental stimuli or even less perception or changes in some inner models, but simply some changes in metabolic relations of the neural elements. If perception is conceived as an organization of the organism-environment system, it is clear that no simple measurement (amplitude of the potential, for example) may reflect perception in the sense of the whole organization of the system. Therefore, there are no "cognitive" components in the event-related potentials, "mismatch" potentials, or anything similar. Such conceptions represent very crude mistakes in thinking in which the properties of the whole system are confused with the properties of its individual elements.

When measuring changes in the nervous system we may get some kind of impression of how the brain is organized as one part of the organism-environment system in the behavior. In such research, however, the essentials are not stimuli or their physical measurement, but the control of action of the subject as a whole. The most crucial point is that we should be able to determine what the subject is really doing, how his action is divided into phases and behavioral results. This gives us the possibility of describing the human organism-environment system as a whole and only then may we relate some individual measurements to this whole organization. It is, however, unfortunate that in most neuroscience it is just this part of the control which is missing. Therefore, most results of—even ingenious—EEG investigations are such that they do not much help us to understand the determinants of human behavior.

The theory of the organism-environment system makes it possible to combine a neurophysiological point of view with psychological theories which stress the active character of mental activity. This means that we may formulate a real psychophysiology without reducing psychology to physiology or giving psychological phenomena some independent existence at the side of physiological processes. In fact, those researchers who have held it impossible to combine neural data with psychological theories have been right, not because this would be really impossible, but because the combination of linear information processing or stimulus-response principles with the active character of human behavior is impossible—not only at the psychological, but also at the neural level.

The theory of the organism-environment system leads to a new kind of definition of the primary tasks of neurophysiology and to a new understanding of the traditional neurophysiological concepts. Neurophysiology is assigned its place as a part of biology: its task is the study of neurons as living units, not as computer chips. Thus, the "transmitters," for example, are not information transmitters, as commonly thought, but chemicals which may distort the metabolism of other neurons (in the excitatory synapses) or supply them with useful metabolites (in the inhibitory synapses). Neurons are living units which are organized as metabolic systems in connection with other neurons; they are not units which

carry out some psychological functions or maintain states which are typical only of the whole organism-environment system.

From this point of view we may also understand why there is spatial order (topography) in the nervous system—the fact which has especially led to the idea of localisation of function. It is clear that some cortical neurons are more related to the eye and some to the ear, for example. Such organization of cells is, however, not due to the need to form pictures or representations of tones in the brain. If the cells are specialized so that they use the same body parts in the achievement of their metabolic results it is probably useful for them to be closely spaced, because organized thus they may give the best mutual support to each other.

When looking at the principles of brain function it is usually forgotten that neurons are living entities which try to maintain their metabolism in a similar way to that of all cells. In this process they have, however, several advantages in relation to other cells of the body: they may influence other cells, they may move around in the brain, they may grow their dendrites and axons to get useful connections, etc. If, however, they fail in the maintenance of their metabolism they will be destroyed.

The comparison of the brain with the telephone network or computer is a metaphor which has led thinking up a wrong trail: to the ideas of nerves as communication cables or neurons as electronic relays determining the information flow. Neurons would really be very badly suited for information transmission, and it would actually be surprising if such a system had really evolved for this purpose during evolution. With all its slow synapses, tremendous number of contacts, and slowly conducting fibers, the nervous system would be a miserable information transmitter if compared to the simplest telephone network or computer, for example.

The technical metaphors, so common in neurophysiology, may at the first glance make it easier to understand complicated nervous functioning, but simultaneously they lead to many misunderstandings and simplifications which restrict fruitful thinking. The application of cybernetics and especially information theory to the study of human behavior and nervous functioning always means restriction of the rich characteristics of the human being and an interpretation of the living organisms as automatic systems.

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