Черновая редакция

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THE CONSCIOUS ACTION
its ORIGIN
and
its BRAIN ORGANISATION.

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The Origin and Brain Organization of the Man's
Conscious Action
The Origin and Cerebral Organization of the Control
of Human Behavior

1. The problem

Several years ago ~~one~~ two of the most ~~brillant~~ outstanding psychologists of our days B.F. Skinner, and after him D.O. Hebb proposed to de-code the well known term CNS ~~for Central Nervous System~~ as „Conceptual Nervous System". That was firstly ~~right~~ used as a joke, but we can earnestly accept it:

~~(as the human brain certainly is a device for re-organization of sensory input in a system of concepts, and so is a means to transforme human behavior to a higher level of self regulation.~~

~~[We choose for the topic of our lecture highest forms of conscious action, its origin and its brain mechanisms, and this new de-coding of the old term is of a special significance.]~~

: Conceptual Nervous System does not only re-code the sensual information we obtain; it is responsible for in making it free from ungrounded impressions, in establishing plans and programs and in controlling human behavior. It makes the man brain an organ of freedom, - and it would be unwise to ignore that fundamental quality and to approach the Man's CNS with the same ideas, as the brain of a rat.

Now an important question arises: how can we find propper ways of a scientific interpretation of these qualities, not repeating the mistakes of the classical mentalism and not continuing the ways of a mechanistic approach so modern ~~to~~ a generation ago and so discredited now? How can we provide an objective and scientific solution of the old riddles of the free activity of conscious behavior?

The propper way to a solution of this problem doesn't lay in the field of purely biological speculations; nor does it lay in the well known attempts to find the ~~route to~~ pathways of consciousness, ~~conduct~~ and freedom in the depths of a single ~~nervous~~ neuron with its synapses. To find this way one has to leave offpoint the purely biological field, ~~and~~ to go outside of the organism and to sift neglection the attention to the analysis of the concrete relation of the growing subject to the ~~concrete~~ historically chronologically social environment which can be the only instance responsible for the origin of human consciousness and free action.

That was the way started by the late L.S. Vygotski, the famous Russian psychologist, and we shall make our best to follow this way.

A newborn comes in the world with a series of self-regulating activities, but these activities are of an elementary level – breathing and sucking, primitive orienting reflexes and a ~~so~~ battery of motor reactions ~~the child~~ which appear when the ~~small child is to~~ mother takes the child in her hands. All these forms of activities were carefully studied by a series of eminent scholars, and I can only mention such names as Minkowsky in Switzerland, Schlovanow in USSR, Peiper in Germany and recently that of my friend Jerome Bruner in USA. But how far are their findings from the really conscious self regulating forms of the conduct of a schoolboy ~~of~~ or of an adult!..

Where have we to seek roots of this highest forms of voluntary regulation of behavior?

The newborn starts his life in a milieu of adults. The mother ~~speak~~ does not only help him in his every step; she is permanently in a verbal contact with him: she shows him a ball ~~and~~ saying: „that's a ball", and the child turns its eyes towards this object and ~~try~~ tries to grasp it with his hands. His ~~voluntary~~ conscious actions are divided between two persons: they start with his mother's speech and they end with his own actions. That is the origin of his ~~late~~ following self sustained forms of activity, and after a short period of several months the child begins to say „a ball" ~~and to try to grasp it~~ thus making important ~~after~~ changes in the outer field – and tries to grasp it. The function formerly divided between the adult and a child becomes now an organization of a self-sustained ~~inner proc~~ psychological process. That is the origin of a new ~~level~~ type of behavior – social by origin, mediated by structure and self linked by function. We are approaching to a new level of problems – ~~that~~ that of the free conscious ~~beh~~ human behavior.

2. The earliest stages

However it would be unwise to suppose ~~this~~ mastering of this highest form of conscious action is a simple process and that the evolution of this level of behavior achieves its final forms in the early, pre-school age. As a matter of fact this is only the start, but in no means the end of the development of the man's higher psychological functions, ~~and~~ and we have to ~~pass on~~ follow up the exciting a dramatic history of the evolution of these basic forms of ~~beha~~ behavior.

Let us turn to some simple experiments and to try to show on simplest models the basic steps of this complex process.

It is well known that an adults verbal order can evoke in a child of

6-8 months an organized orienting reaction and in a child of 12-14 months even a simple motor action. Name an object which lies in the immediate field of the child's sight - and he will turn his eyes towards the object and grasp it; say him: „lift your hands" and he certainly will do it.

It is obvious that the verbal instruction can start the childs action; but at this stage it is still unable to overcome the influence of an immediate impression, to stop an action the child already started or to replace a certain action to a different one. The more it is impossible on this stage to use a verbal instruction for a construction of a system of inner codes which can form an inner field decisive for the control of the child's further actions.

Let us place in front of the child a small plush rabbit, and after he becomes habituated to this object let us say to the child: „give me the rabbit!". The child will look in the direction of the toy and take it in his hands.

Let us now change the situation, and place in front of the child two objects: the same rabbit and a new hen. Now our verbal instruction: „give me the rabbit" can fail: the eyes of the child turn towards the rabbit, but they meet the hen, the hands grasp to this new toy, and he grasps the hen, following his immediate orienting reflex which blocks the influence of the verbal instruction.

The same can be observed if we try to use the verbal instruction to block an action which was formerly established and to change it for another one.

To prove it we can place near the child of 14-16 months two objects - a rabbit and a hen and several times to repeat a verbal order: „give me the rabbit", and - without any changes of voice change the order to the other one, saying now „give me hen!". The inertia of formerly evoked action is at that stage so intensive that the change of a verbal instruction is unable to change the action and to overcome the formerly established stereotype (A.R. Luria a A.G. Polyakova, 1959a)

A second series of experiments can show that the verbal system receives its controlling functions only gradually.

Two well known objects are placed in front of the child: a wooden cup on his right and a wooden brick on his left. The child observes that a penny is placed under the cup, and then he is ordered: „give me the penny!". The child of 1;6 - 1;10 easily fulfills this command; some difficulties are seen if the realization of the command is postponed by 10 or 20 seconds; in this case the command can easily lose its regulatory

function and the child begins to observe both objects and only in a half of cases grasps the object named: the immediate orienting reaction overcomes the tracy of the verbal command; only in children of 3;0 – 3;6 the delayed action becomes stable (A. R. Luria and A. G. Polyakova, 1959-6)

The unstability of the controlling function of the verbal command in small children can be seen in a last series of experiments, when the verbal instruction loses its immediate perceptual base.

The same two objects are placed in front of the child, but this time the penny is put under one of the object when the child closes his eyes; then the verbal command is given: „The penny is under the cup; give me the penny!". In this cases the influence of the verbal instruction becomes unstable in younger children of 1;4 – 1;6 and insufficiently plastic in older children of 2;0 – 2;6. The first group of children do sometimes fully ignore the instruction and try to grasp both objects (~~the second group~~) replacing a conscious action by an elementary orienting reaction; the second group start by fulfilling the command, but when after 3-4 repetition of the same instruction – a new command: „The penny is under the brick," give me the penny" is given – the child ignores it and continues the former reaction. ~~Only close to the~~ This unstability begins to disappear only in children of 3;0, and only at this period the verbal command ~~begins to~~ becomes sufficiently stable and independent from its visual base.

It is clear that at this early ages the verbal command can start an action but is unable to become stable and to overcome the immediate visual experience or the acquired motor habit.

3. Some experimental proofs.

The rule we mentioned can be easily shown by recording of the experiments with the simple motor reaction

Let us place in the hand of a child of 1;8 – 2;2 a rubber balloon connected with a pneumatic recorder and give him a command: „press the ball!". The results we shall observe will be not so simple as we could expect. If the holding of the elastic balloon itself will not evoke some grasping reflexes – starts to press the balloon but is unable to stop this reaction, and a series of involuntary pressures will be recorded during a considerable time (Fig. 1). All efforts to stop these uncontrolled reactions became futile, and if we instruct the child to press only when he was told – don't result in an arrest of his movements and listening to the voice of the command – the child even increase his uncontrolled movements (Fig. 2) The verbal command acquires its starting function pretty early has not yet acquireds its blocking role.

Fig. 1.

Fig. 2

The insufficiency of the controlling function of the verbal command

at that stage can be seen even more ~~clear~~ distinctly in experiments with conditional form of verbal instruction.

The instruction: „When you see a light - you will press the ball" seems extreemely simple; but as a matter of fact it requires a complicated algorythm of actions: a system of preliminary connections has to be established; the immediate orienting reaction towards the stimulus has to be blocked; the stimulus has ~~to be~~ obtain a conditioned meaning, and a ~~mo~~ conditional movement has to be started after the signal appears. This complicated system of conditions is impossible for a child of 2;0 - 2;6, and after he perceives the words „when you see a light.." - he immediately begins to seek a light, stopping his movements, and when he hears the end of the instruction - „you will press the ball" - he ~~does it~~ starts the pressure independent from the signal. Thus - the instruction ~~results~~ leads to a paradoxical result: blocking the movements when the light appears and starting the ~~move~~ motor reaction
Fig. 3. when it is absent (Fig. 3). In this case the command „do press only when you see the light" is of a little help, and it ~~even~~ results in a strenthening of the motor reaction or in a total arresting of the child's
Fig. 4. motor activity (Fig. 4).

The selective influence of the verbal instruction is not yet ready in this period when the starting function of the verbal command is fully established.

The same can be observed even in older children of 2;8 - 3;0 if ~~the~~ we complicate the instruction and if we try to establish a more complex program of future action, such as a <u>choice reaction</u>.

Let us give to the child a command: „when you will hear a sound - press twice!" or: „when there will be a red light - you will press the ball; when you see a green one - you will do nothing!". In ~~the~~ such cases the child of 3;0 or even of 3;6 will easily preserve the verbal instruction but will be unable to follow this command, and in the first experiment will answer the sound by a series of uncontrolled motor
Fig. 5 reactions (Fig. 5), and in the second - will press after both - positive
Fig. 6 and negative signals (Fig. 6). ~~To~~ The task to follow the instruction and to build a stable program of actions according to a given rule - is impossible for the child of that age.

Only by 3;6 - 4;0 the child becomes able to ~~mo~~ follow ~~so~~ this complicated program, blocking the immediate influence of the signal, but even for a slight complication of the experiment results in a destruction of ~~the~~ the first forms of child's organized behavior.

4. Verbal control of the action.

Now we come to the question: is it possible to speed up this process ~~of the natural growth development~~ and to find means to improve the conscious control of the child's own actions even on its early stages of development?

All attempts we made to improve the child's own control of his behavior at the stage of 1;0 – 1;6 failed, and all methods except one we shall not mention here – remained futile. However ~~some~~ experiments with the children of 2;6 – 2;8 gave some results and enabled us to find some ways for the solution of our problems.

At this stage of development ~~the child was not yet able to use his own speech for the control of his own behavior~~ we were still unable to organize the child's compensated reactions by means of our verbal instructions; but ~~he~~ we could come to a good regulation of his ~~reaction when motor~~ behavior if the child's motor reactions ~~resul~~ evoked a ~~signal~~ feed-back signal. So, if we instructed the child to press the balloon and thus „put out the light" ~~super~~ additional pressures disappeared (Fig. 7). The same result could be observed if every motor reaction of the child who fulfilled the instruction: „If you will see a light – press twice" resulted in a feed-back signal – for example a click. (Fig. 8)

Fig. 7

Fig. 8

Thus, at this stage, a verbal instruction was able to evoke an organized action and to block superfluous reactions only if the whole process was constructed according a scheme of a feed back system, otherwise if every reaction of the child resulted in reinforcing or a „sanctioning" ~~afferentation~~ feed-back afferentation

Now a question arises: couldn't we replace this feed-back afferentation, which blocks the child's excessive movements by a higher and more specific verbal activity ~~by~~ of the child and to turn to the child's own ~~speech~~ verbal commands as a means for a control of his behavior?

Our first experiments with children of 2;4 – 2;8 gave negative results. A child of 2;4 – 2;8 could easily answer to each stimulus ~~e~~ with a simple verbal reaction „go!"; but if we instructed him to answer every signal with a simple motor reaction pressing the balloon and simultaneously by pronouncing the word „go!" we could see that the verbal reaction did block every motor reaction, and no ~~e~~ controlling influence of the ~~verbal~~ child's verbal command was possible (Fig. 9)

Fig 9.

Different results were obtained when we turned with the same experiments to the children of 3;4 – 3;8: introduction of the child's

own verbal commands „go!" ~~to~~ didn't result in any success on the first stages of the experiment, but after a certain training became able to control ~~a~~ his motor activity, and giving himself verbal commands „go!", „go!" → he begun to give organized motor reactions, blocking his ~~successi~~ excessive movements; the elimination of such verbal auto-commands resulted in re-appearence of such disorganized motor reactions (Fig. 10). ~~The verbal system which acquired at the stage a more concentrated neurodynamics - begun to be able to control the motor activity of the child.~~

Fig. 10.

The same results could be seen if we included the child's own ~~co~~ verbal commands in a more complex task, asking the child to press twice to each signal, saying a double command: „go! go!" (Fig. 11)

Fig. 11.

In all these cases the verbal system of the child which was now based on a more concentrated neurodynamic processes, acquired here a new controlling function, and it was the first time we could observe the appearence of the most simple and overt form of ~~this~~ what Pavlov called „the highest regulator of the human behavior".

It would be however erroneous to think that the data we have mentioned ~~signify a full that~~ means ~~the~~ „conceptual nervous system" is already ready in ~~a~~ (controlling function of the). ~~These d~~ All we have described is only the start of its regulatory ~~role~~ in the conscious action.

To prove that we have ~~to~~ only to make our experiments a little more complicated and from simple motor reaction pass to the reaction of choice. Here the psychological structure of the behavioral control changes totally: one - positive signal (e.g. red light) has to evoke a motor reaction, and the other - positive signal as well (e.g. green light) has to block it. The same remains if we turn towards the child's own verbal signals, which was of a considerable help in simple reactions. Here - the positive verbal command „go!" has to start the motor reaction while another verbal command - with the same positive innervation ~~- „no!" h~~ characteristic - „no!" - has a negative semantic contents and has to block it. This conflict between an immediate positive and semantic blocking significance brings significant difficulties for the child; the immediate excitatory ~~influence~~ action of the signal becomes a stronger influence that its negative meaning, and ~~saying to the green light,~~ the verbal command „no!" does not block, but even ~~does~~ distinhibits the ~~children~~ child's motor reaction (Fig. 12). The same can be seen even in a more grotesque form in ~~a~~ an imbecil child, where the ~~immediate~~ influence of an immediate ~~process~~ discharge ~~is ex~~ of the verbal reaction „no!"

Fig. 12.

Fig. 13. results even in an intensification of his motor responce (Fig. 13)

~~Only~~ All this changes only by 4;6 – 5;0 years, when the establishing of inner programs of complex actions becomes ready and when every the ~~external~~ help of ~~this~~ the child's own loud verbal command becomes useless. At this stage the semantic organization of the internal fields can become dominant and a plan formed by the adult instruction can receive an ultimate controlling role. That is why a child of 4;6 – 5;0 ~~can~~ becomes able to fulfill the adult's instruction without any help of its own loud reinforcement, – and this stage may be considered as a real consolidation of the controlling function of the „Conceptual Nervous System" we mentioned in the very beginning of this paper.

5. Some considerations about the ~~Brain~~ Organization of the CNS.

We shall stop ~~for a while~~ over further analysis of the ~~further~~ development of ~~the highest form of~~ the conscious control of actions; it intimately depends on the further formation of conceptual coding of external impressions and the formation of ~~inner speech~~ the child's inner speech. L.S. Vygotski and J. Piaget have contributed to the analysis of this process so much that any attempt to add some significant data would be only superfluous.

Let us turn now to the second problem of our discussion: ~~t~~ what could be the cerebral organization responsible for the control of the man's own behavior? The idea of the „Conceptual Nervous System" gives us only some general frames for the understanding of this highest level ~~of the brain organization~~ of behavior, but it does not yet describe the concrete structure and the mode of ~~its mechanism~~ the work of this complicated mechanism

Which are the systems of the human brain which ~~can are the base of the~~ can form our plans and the real programs of our ~~actions~~ behavior, provide a stable and selective attention, ~~and~~ control the ~~effects~~ outcomes of our actions and block all diversions from ~~the~~ plans, ~~be~~ resulting in errors or mistakes? Which are the mechanisms of such control of behavior?

In our ~~approach to~~ discussion of this problem we don't lose the sense of reality, and we know all right that all we can say will be only a first ~~approach step~~ approach to this basic question. But nearly fourty years ~~of our work in in this~~ of an analysis of focal brain ~~lesi~~ lesions gave us an opportunity to collect a series of facts, ~~wh~~ and we shall try only to bring them in ~~a system~~ an order rather to construct ~~an~~ a clear and ultimate theory

To say that the brain which is a base of the „Conceptual Nervous System" works as a ~~a~~ whole means to ~~say~~ make a correct and at the same time an erroneous statement.

It is true because ~~this their most complicated & kind of activity~~ such complex the human actions ~~can be based only on the~~ the most complex forms of the human actions we discuss ~~can be based only~~ require the activity of all ~~cerebral systems~~ systems of the brain – this ~~higher~~ highpoint of evolution; it is false because we hardly can suppose the human brain works as an undifferentiated whole and that its work depends only on ~~the mass~~ active mass of its excited tissue.

Modern data of brain morphology, physiology and clinical observations made it impossible to stick adhere on the idea of the brain as a homogeneous whole, which was possible a generation ago, but which is untenable now. But ~~the~~ the fact that we refuse to sustain the idea of a brain holism does not mean we return to the old concepts of isolated nervous areas responsible for complicated psychological processes. The ideas of Gall and Kleist ~~ex~~ are as far from us as the ideas of Goltz and Lashley.

Now we have all grounds to understand the human brain including its cortex – as a complex functional system which includes a joint work of different levels and areas, each of which ~~enters~~ plays in this system ~~an~~ its own role. The concept of "working constellations" of A.A. Ukhtomski, of "functional mosaics" of J.P. Pavlov or of "cell assemblies" of D.O. Hebb received in the latest time a much more definite meaning than they had before. We have not to forget that the scholars trying to solve the riddle of the human brain are digging the tunnel from both sides, and the achievements of the modern work on single neurons we can only admire come in a close harmony with the modern studies of ~~a~~ the functional architecture of jointly working ~~levels of the hum~~ interrelations of the ~~human~~ stem and the cortical formations of the human brain.

What can we await from these branches of the Neuroscience if we ~~try~~ shall try to investigate ~~a~~ our ~~man~~ basic problem – that of the brain structures responsible for the organization of the conscious action?

Data collected during the last few decades give all grounds to single out ~~distinc~~ at least three basic blocs which take part in the common work of the human brain, each of them – ~~or~~ ~~co~~ making its own contribution to this work.

The first block may be called the block of Energy or Tone; it includes hypothalamus, the formations of the upper brain stem, the reticular formation and to a certain degree the ancient parts of the mesial limbic cortex and hippocampus. It is responsible for a stable tone of the cortex and that state of vigilance which the psychiatrists erroneously call consciousness. It would be at least unwise to discuss the activities of this block in

details: the well known brilliant works of Magoun and Moruzzi, Jasper and Lindsley and last but not least of Olds and McLean make it unnecessary and the ~~decisive contribution~~ discoveries of these authors to the theory of sleep and wakefulness, arousal and drives have to be considered as the most significant contributions of our science.

We have to take in account the role this block plays in the activity of the „Conceptual Nervous System"; but it would be a fatal error to ~~think~~ suppose that ~~the~~ in providing the general vigilance of the cortex it can be regarded as an organ of the man's conscious activity.

As it was shown by a group of outstanding scholars this block contains a considerable amount of unspecific neurons which Jasper called „attention units" ~~and different authors~~ and which serve as important devices for supporting the wakefulness of the cortex.

Observations we could make during the last years on a series of ~~vas~~ tumors and aneurisms of the mesial parts of the ~~brain~~ hemispheres gave us every reason to suppose that these deep lesions of the brain disturbe general wakefulness of the subject, result in a loss of selectivity of his stream of thought, lead to a marked derangement of the short term memory (A.R. Luria, E.D. Homskaya, S.M. Beznov & M. Critchley, 1967, A.R. Luria, A.Ya. Podgornaya, A.N. Konovalov, 1969, A.R. Luria, N.K. Kyiaschenko, unpublished) - but they never result in a stable disturbance of the system of concepts neither in a loss of a voluntary regulation of human actions. It is obvious that a small reinforcement can result in these cases in an increase of active state of the cortex and thus in a certain compensation of the defects observed (E.D. Homskaya, 1969). All that means that ~~a~~ the intactness of the first block is of course one of important conditions of the higher forms of behavioral control, but that we have no grounds to consider this block as ~~its~~ a specific ~~an~~ device of this regulation.

The <u>second block</u> of the Brain includes posterior parts of the hemispheres with occipital, parietal and temporal regions and their conductive paths; it can be designated as a block of <u>input, ~~recoding~~ elaboration and preservation of the information from the external world</u>. I had many occasions to discuss the problems of its functions in a series of books (A.R. Luria, 1947, 1962, 1966, 1968) and I shall dwell on its activities only shortly.

It is well known that the systems included in that block are ~~of a~~ highly modality-specific: the occipital lobe does not take part in elaboration of acoustic signals being a central apparatus of visual analysis and the temporal lobe participates only to a limited degree in the elaboration of acoustic information.

It is ~~you~~ known as well that each system of this block has a

hierarchical structure and that every primary (or extrinsic) zone is followed by a superimposed secondary (intrinsic) zone which ~~is superimposed~~ has a highly developed second and third layer of so-called associative neurones and which enables to elaborate the immediate somato-topic signals in a functionally organized dynamic structures.

A series of very important studies conducted during the last years on neuronal level showed that only a minority of the neurones of these zones ~~have~~ are of a non-specific type ~~or~~. While the major part have a highly specific function ~~and~~ firing to single or ~~combined~~ group influence of modality-specific receptors.

The specificity of these areas decreases ~~with~~ with the transition to the "Tertiary" zones or the "overlapping areas" which include elements of ~~opi visual, e~~ different modalities and which provide a multi-modal simultaneous synthesis of successively series of signals. An important role played by this area in elaboration of the highest ~~logico~~ spatial and conceptual structures is now well known (~~Cf. A.R. Luria, 1946, 1962, 1963 etc.~~)

-We had shown that in a series of publication where we tried to analyse disturbances of ~~perception~~ psychological operations included in perception and action, speech and thought in lesions of these parts of the brain (Cf. A.R. Luria, 1962, 1963, 1966 etc.) and to ~~men~~ discuss some ways of recovery of disturbed functions in these cases (Cf. A.R. Luria, 1948, 1963 etc)

One ~~typical~~ basic feature has to be mentioned in these cases: patients with lesions of the posterior parts of the brain can lose some important operations - but they never lose their conscious ~~actions~~ forms of activity; ~~they are aware of their defects~~, they can retain their plans and programs, they preserve their strategy, they are fully aware of their defects and ~~they~~ as a rule they can work very actively to overcome their deficits. They are human beings with tragical fate but they remain human beings in the full meaning of this word. One can never speak here about any loss of the control of their conscious action.

Thus - we come to the conclusion that the second block takes an important part in the construction of the "Conceptual Nervous System", but it is in no way responsible for a regulation and control of ~~human~~ the human conscious ~~acto~~ activity

The third block includes the Frontal Lobes of the brain, and

its functions ~~are~~ have an immediate relation to the main problem of our discussion.

The Frontal Lobes of the brain occupy ~~a~~ nearly a third of the human hemispheres and they are the last acquisition of the Evolution. They preserve a typical vertically organized structure relating them to the motor cortex (G.I. Polikarov, 19) and their prefrontal parts ~~have~~ are of the same type as all other tertiary zones. They have an intimate relation to the reticular formation ~~having~~ including a dense system of ascending and descending fibres and serve as an important structure superimposed ~~on~~ to the systems of the higher brain stem (Penz, 1955, Hagga, 1964, 1968 и др.); ~~-~~ thus they can be considered as a system which plays an important role in regulation of the apparatuses of the first block. They have intimate connections to all parts of the posterior and motor cortex, but unlike the ~~st~~ high specificity of the second block its work ~~has no~~ is no more modality specific.

There are ~~group~~ many reasons to suppose that these parts of the brain play an important role in establishing plans and programs of human actions and in regulating and control of human behavior. We discussed the problems of the functions of the frontal lobes in a series of publications (cf. A.R. Luria 1962, 1963, 1966, A.R. Luria and E.D. Homskaya, 1966 etc.), but here we have to resume ~~the~~ our findings and to discuss once more the role this part of the brain plays in the control of human conscious action.

~~6. The Frontal Lobes and the regulation of action states~~

6. Disturbances of Behavior in Lesions of the Frontal Lobes.

The Neurological Clinic knows very well the general disturbances of behavior following severe lesions of the frontal lobes (limited lesions can remain symptomless because of the high capacity of substitution of the tissues of this „latest and less differentiated parts of the human brain", as Hughlings Jackson formulated the Frontal Lobes).

Patients with massive lesions of the Frontal Lobes don't ~~exhibit~~ as a rule exhibit stable alteration of the cortical tone more marked disturbances in orientation in space and time typical for patients with lesions of the mesial parts of the hemispheres. They don't suffer any defects in perception or simple action, speech or ~~formal~~ logical operations. At a first glance one can suppose

that they preserve all basic functions of the „Conceptual Nervous System".

But that is not the case, and a thorough observation can show how deep is disturbed the regulation and control of the conscious actions of these patients.

As a rule - only a ~~a~~ limited part of these patients are able to formulate plans or to follow programs; neither do they show any complicated motives or higher ~~deriv~~ conscious drives. No strategy can be observed in their behavior and they do not try to find proper means for realise their conduct. They do not show any future-linked outlooks which are decisive in the behavior of a normal ~~sub~~ subject. Realisation of given plans or programs is easily replaced in these patients with primitive „field-actions", impulsive responses to immediate impressions or with inert reproductions of former stereotypes which formerly ~~was~~ had a sense but in new conditions became totally senseless. The ~~ex~~ classical observations of Sh. J. Franz and Bianchi, ~~Bekt~~ Bekhterev, ~~and~~ Pavlov and Anokhin ~~to~~ on animals with resection of the frontal lobes became many times enriched in observation on patients with massive lesions of the frontal lobes. We cannot forget a woman of a high culture with a massive bilateral tumor of the frontal lobes who ~~started~~ in the ~~first~~ early period of her disease began to ~~mean~~ the burning straw using a broom, and who ~~put~~ tried to cook ~~a st~~ noodles putting in the saucepan pieces of bast. We cannot forget a soldier with a massive gunshot wound in frontal lobes who was instructed to ~~operate~~ saw plane a plank and who continued automatically his work till he planed a half of the ~~lathe~~ crano.

It is easy to see that the ~~a~~ regulative influences of the inner plans and programs - otherwise of the „Conceptual Nervous System" became severely deranged, ~~and are~~ in these case, the whole organisation of behavior is switched on a lower level and is replaced by uncontrolled reactions to immediate impressions or by uncontrolled repetition of former stereotypes.

The decisive role of the Frontal Lobes in the control of conscious actions is out of question. But the problem remains: what are the causes of such a role of the Frontal Lobes?

7. Frontal lobes and the regulation of active states

Let us turn to some experimental data which could ~~be of a considerable~~ help ~~us~~ to answer this question.

To fulfill a complicated program of behavior one has to preserve

a certain level of vigilance; but a general active state of the cortex provided by the higher stem and reticular formation is in no case sufficient for a selective and programmed behavior. The kind of activity needed for realization of complicated programs has to have a strictly selective type evoked by the goal or by a problem given to the subject; a part of information, ~~seen~~ having immediate relation to the problem has to ~~become~~ ~~dom~~ be emphasized and to become dominant while every influences distracting from the goal have to be suppressed. It is obvious that such ~~a~~ organization of the active states can be provided only with close participation of the cortical areas and their descending pathways.

The Frontal lobes - and especially their mesial parts - are exceptionally reach with descending connections ~~with~~ of the reticular formation; this was shown by a series of works of French (1955), Nauta (1964, 1968), Zager (1962) ~~et~~ and others. That is why in case a goal ~~of~~ or a plan the subject formulates result in a rise of his active state - it can be only confirm our assumption on the role of the frontal lobes in the process of activation.

This assumption is well supported by a series of brilliant experiments made by Grey Walter in England and M.N. Livanov in the USSR. As it is well known Grey Walter giving his subjects a problem to await for some signals could see ~~slow~~ the appearence of slow ~~contingency~~ negative waves in the frontal cortex, which then were spreading to other parts of the hemispheres; they clearly ~~augmented~~ increased when the ~~subject was~~ expectancy state of the subject ~~increased~~ became intensif and disappeared when the appearence of the stimulus became less probable or when the task of expectation was removed. Grey Walter (1963, 1966) had every reason to call them „expectancy waves".

At the same time M.N. Livanow in Moscow - ~~also~~ using the technique of 50-channel electrodes - made some important observation. When giving to a normal subject a difficult intellectual task, requiring a stable activation of efforts (such as multiplication of ~~[illegible]~~ numbers by ~~[illegible]~~) he observed an appearence of a significant number of synchronously working parts in the frontal ~~lobe~~ cortex; this syn-chronous character of activity disappeared after the problem was solved or after the task was eliminated (Fig. 14). The same could be seen in recording brain potentials in an excited paranoid patients and the amount of correlation synchronous foci in frontal lobe disap-peared after a patients treatment with chlor-promazine (Fig. 15)

Fig. 14

Fig. 15

All that data make it very probable, that the Frontal Lobes ~~of the brain~~ take a considerable part in activating the brain when some difficult problems were given to the subject, and that the excitation originated in the region of the frontal lobes is spreading to the other parts of the cortex as well as to the underlying levels of the Nervous System, resulting in a regulation of the active states needed for this kind of actions.

If our assumption is right - we can find in patients with severe lesions of the frontal lobes clear ~~defects~~ alteration in any attempts to evoke selected activation of their most complicated forms, and especially any activation according a verbal instruction, giving to the patient a certain goal or a certain problem.

That was just the question my collaborator Dr E.D. Homskaya tried to answer in her long series of studies using a battery of different approaches to one problem.

Let us mention only ~~a~~ some of her findings.

It is well known that an appearance of every stimulus result in a normal person in a series of vegetative reaction which can be evaluated as vegetative components of an orienting reflex (constriction of peripheric vessels simultaneously with a dilatation of the vessels of the head, ~~&~~ galvanic skin reactions etc.). These reactions can be traced for a period, ~~and~~ are extinguished after the subject is habituated to the stimuli and can become fixed if a special instruction (such as: „Count the stimuli" or „pay attention to any change of the stimuli" or „press the key when the stimulus appears" etc.) are given, in other words when a stimulus receives its „signaling meaning" (E.N. Sokolov, 195 , O.S. Vinogradova, 195 , D. Lindsley, 19 et al.) (Fig. 16).

Fig. 16

Such exageration and fixation of vegetative symptoms of the orienting reflex is seen in patients with lesions of the posterior parts of the hemispheres; but it does not exist in patients with lesions of the frontal lobes and especially of its mesial or basal parts (Fig. 17); ~~a~~ this ~~symptom~~ is of a high significance and sometimes remains the only symptom of the disturbance.

Fig. 17

Similar data can be obtained by recording the EEG ~~changes~~ components of the orienting reactions.

It is well known that every new and unexpected stimulus result in a depression of the alpha diapasony of the EEG and especially in depression of the higher frequencies of this diapason; it is known as well that a verbal instruction giving a signalling meaning to the stimulus makes this depression more marked and more stable (Fig. 18)

Fig. 18

The same is seen in patients with lesions of the posterior parts of the cortex, although the background of EEG can be considerable changed in these cases; no such effect is observed in patients with lesions of the frontal lobes and especially in patients with lesions of their mesial parts. A verbal instruction to count the signals or to await their changes does not alter the EEG waves or - in some cases - results in some depression of the lower frequencies or even in a paradoxical exageration of the electrical activity (Fig. 19)

Fig. 19.

During the last years we payed attention to a new EEG symptom of arousal which proved to be of a high reliability. As it was shown by A.A. Genkin (1962, 1963), and then by E.D. Homskaya and E.Yu. Artemieva (1966, 1967, 1969) a systematic examination of the EEG waves in a normal person shows a peculiar alteration of the relation of the ascending and descending fronts of the alpha waves with a rhythmical change of this asymmetry index every 6-7 seconds; this regularity is clearly observed in steady states of the subject and becomes broken when an activation or an intellectual arousal takes place (Fig. 20).

Fig. 20

The same can be seen in patients with lesions of the posterior parts of the brain, but it is not observed in patients with frontal lobe lesions. Here any activating instruction does not result in any change of the regular changes of the asymmetry index (Fig. 21)

Fig. 21

Perhaps the most important is a series of data showing that the activation of cortical processes evoked by a verbal instruction are of a selective type and that this selectivity is lost in patients with lesions of the frontal lobes. That was shown by Dr E.G. Simernitskaya (1966, 1969) in her experiments with evoked potentials.

It is well known that each specific stimulus (visual or cutaneous) evokes specific potentials changes in occipital or sensori-motor parts of the cortex, and that every expectation of such stimulus result in an exageration of the evoked potential (Fig. 22)

Fig. 22

The same effect of a verbal instruction to await the signal is seen in patients with lesions of the posterior parts of the cortex; but no such effects of verbal command is observed in patients with lesions of the frontal or mesio-frontal parts of the brain (Fig. 23)

Fig. 23

All these data obtained by Dr E.D. Homskaya and their co-workers show that the frontal lobes take part in the regulation of the active states of the brain, and that this influence comes from the influences of verbal instructions, which formulate a plan or a program evoking the subjects active effort.

It is easy to see how important are these data for the understanding of

some ~~acti~~ basic mechanisms of conscious actions.

8. Frontal lobes and the ~~control of conscious actions~~ realization of programs.

Disturbances of the regulation of active states observed in patients with massive lesions of the Frontal lobes have a far reaching result for the structure of man's purposeful actions. Being unable to sustain a selective ~~acta~~ attention patients of this group became unable to realise complicated programs of actions according the instruction given.

Let us turn to a series of experiments.

If a patient with severe lesion of the frontal lobes is asked to fulfil a simple action imitating the movement of the physician – no difficulties are seen: ~~If~~ he lifts a fist when the physician is making the same movement and ~~imit~~ lifts his finger when a finger is shown.

Let us now change the experiment and arrange it so that the verbal instruction comes in a conflict with the immediate perception of the physician's movement: let us instruct the patient: „When you see a fist – you will lift your finger, – and when you see a finger – you'll lift the fist." ~~The~~ The realization of this instruction is now impossible, and even if the patient – who preserves the verbal instruction during the whole experiment – starts in ~~a~~ correct reactions, loses them ~~after~~ and after 2-3 trials begins to give imitative, echopractic reactions: the immediate perception of the experimenter's movements is now blocking the influence of the verbal instruction and the ~~plannu~~ programmed ~~reaction~~ action ~~&~~ is substituted by an immediate one. The ~~same~~ can be observed if we ask the patient to react to every single knock with two knocks, and to every pair of knocks – with one knock. The reduction of a programmed action to an imitative one in both cases is obvious.

The breakdown of a programmed action ~~be can~~ in patients with severe lesions of the frontal lobes can take ~~an~~ a different form and can be replaced by a primitive behavior directed by an inert stereotype. If we instruct the patient to lift his right hand in response to one knock, and the left hand in response to two knocks and ~~then~~ after repeating several times the same order of both signals will break this order (1-2-1-2-1-1), the patient who has already established a stereotype of alternated ~~now~~ reaction will continue that stereotype instead of the changed order of signals, and no correction of this order will follow, although the contents of verbal reactions remains preserved. In cases of more severe lesions of the frontal lobes ~~this~~ the inertia of nervous processes can be seen even in the

verbal level, and if the patient is instructed to realize a rhythmical program giving one strong and two slight knocks, repeating his own verbal commands: „Strong-slight-slight!" – the pathological inertia of his nervous processes result in a gradual augmentation of slight knocks, and the patient ~~can~~ begins to alter his commands, saying: „Strong-slight-slight!.. Strong-slight-slight-slight... Strong-slight-slight-slight-slight..." realizing the ~~pers~~ perseverative programs. (Fig. 24)

Fig. 24.

Both times the ~~regulative~~ controlling role of the „Conceptual Nervous System" is fundamentally deranged and the patient's behavior is shifted to a lower uncontrolled level.

A substitution of programmed conscious action by primitive ~~e~~ imitative or perseverative ~~for~~ reactions can be seen in a series of very remarkable facts which are never encountered in ~~less~~ patients with lesions of the posterior parts of the brain.

It is well known that a realization of a very simple instruction – for exemple a drawing of a simple scheme is based on a complicated ~~prog~~ algorythm of actions: the subject has ~~to draw one line, then to block all~~ preserve the goal and to block all ~~outside~~ ~~move~~ actions; drawing a component of the scheme he has to arrest this movement, shift his hand to another position, draw the next component etc.

~~Such~~ Realization of such complicated algorythm of successive actions is impossible for a patient with a severe lesion of the frontal lobes, – and we can easily observe that the realization of a complicated meaningful program becomes easily replaced in these cases by a series of uncontrolled actions or unblocked excessive movements.

We shall show that only on two exemples

Fig. 25

~~The~~ A patient with ~~severe les~~ a traumatic cyst of the frontal lobe is instructed to draw a quadrangle. He begins to do it (Fig. 25), draws three quadrangles and then a large quadrangle following the boards of the sheet. ~~During this action~~ Meanwhile the psychologist leading this experiments ~~says~~ whispers to his colleague: „Did you know about the pact signed to-day?" ~~– and the~~ That is enough to link the ~~further~~ patient's further action and he writes ~~a~~ in the middle of a large quadrangle: „Act N...". „What is the patient's name?" – whispers the psychologist, – and the patient ~~writes~~ writes immediately „Yermolin". „Look, that is so similar to the behavior of animals after ~~frontal~~ resection of the frontal lobes!" whispers the psychologist, – and the patient ~~writes~~ adds ~~immediately~~: „~~Concerning~~ to the formerly written „Act": „on Animal breeding..." We can hardly find an exemple which would better express the whole strange of the patient's ~~consciousness~~ controlled

actions..

Another example is seen at the same figure. A patient with a massive tumor of the left frontal lobe is asked to draw a triangle; ~~t~~ at once he draws it and ~~places~~ adds a second triangle to the first. He is asked to draw a minus. He draws a figure which being a kind of a minus preserve the closed structure of the former triangle. He is asked to draw a circle. He does it but he ~~pla~~ adds the same oblongue figure in the middle of the circle. „Draw only a circle" says the command. The patient repeats the same drawing adding a subscription „Entrance strongly forbidden!" Can you guess what was the patients former profession?...

In both cases a selective conscious actions is broken by some uncontrolled associations; in the next case (fig. 26) the execution of a given program in a patient with a ~~tum~~ bilateral tumor of the frontal lobes is broken by an inert perseveration of a former action.

Fig. 26

We discussed all possible forms of the breakdown of the realization of given programs in patients with severe lesions of the frontal lobes elsewhere (cf A.R. Luria, 1962, 1963, 1966, 1969 and A.R. Luria and E.D. Homskaya, 1966) and shall not continue our examples.

All we have observed during a long period give us all rights to believe that severe lesions of the frontal lobes results in a breakdown of the realization of behavioral programs given by verbal instructions, and that in these cases ~~the~~ we are able to observe ~~a~~ ~~no~~ ~~clear~~ marked disturbances of the ~~systems of a~~ conscious control of human actions which becomes ready in children of 4-4;6 years ~~old~~ old, when the ~~sy~~ systems of the frontal lobes became functionally ripe.

9. Frontal lobes and the strategy of purposive actions.

Up to now we ~~discussed~~ described the disturbances ~~of the~~ realization of action programs given to the patients with severe lesion of the frontal lobes. It is obvious that even more massive defects are seen in ~~more~~ complex forms of their behavior where patients have to choice their own plans of conduct and to construct their own programs. That can be easily seen in a series of experiments with complex perceptive actions requiring an active elaboration of the information given to the patient.

Several years ago E.N. Sokolov (1958) proposed a technique of investigation of such elaboration of perceptive programs

followed by special experiments by L. Azana (1961) and O.K. Tikhomirov (1966). A subject is given a pattern of checkers building one of the two possible letters – H and E or H and M, where only some decisive points give an information which letter is presented. The subject has to close his eyes and to touch successively the checkers with one finger. As it was observed a normal subject begins with an expanded system of trials, but very soon restricts his trials and touches only the points which give a decisive information (Fig. 27)

Fig. 27.

No such process of preliminary search with a gradually abbreviation of information is seen in patients with lesions of the frontal lobes. As a rule they begin with touching all successive checkers, but they don't even start any attempts to single out the decisive information nor to they abbreviate their activity. Their touching the checkers don't at all serve as a means for preliminary basis of their ultimate decision, and they come to a "conclusion" which has nothing to do with their preliminary activity (Fig. 28).

Fig. 28

It becomes clear that the structure of a complex action becomes totally changed in these patients and that the phase of preliminary exploratory activities is totally excluded in patients with severe lesions of the frontal lobes, which is never the case in the behavior of patients with lesions of the posterior parts of the brain.

This basic difference in behavior is clearly seen in experiments with observation of complex thematic pictures

Let us present to a normal subject a complex thematic picture – such as a well known picture of the outstanding Russian painter J.E. Repin – "The Unexpected Return". Here we see a prisoner who returned home after many years he spent in a Czar's prison. Let us fasten to the sclera of the subject a little mirror, which reflects a beam of light to a photo-sensible paper, recording the subject's eye movements (Yarbus, 1966, 1967). Let us now ask the subject different questions such as: "How old are the members of the family?", "How are they dressed?", "Are they poor or reach" and last but not least: "How long was the prisoner imprisoned?". Recording of the ocular movements during 3 minutes of observation can show us, how complex is the exploratory period of each observation and how profoundly this process changes in different instructions (Fig. 29)

Fig. 29

No such complicated structure of perceptory action is seen in patients with severe lesions of the frontal lobes. The evaluation of a

thematic picture does not include any preliminary exploratory eye movements; the patient fixes some parts of the picture which are chosen by chance ~~and~~, his ocular movements preserve their chaotic or perseverative character (~~fig. 30~~) and the instruction given to the patients ~~to~~ don't result in any change (Fig. 30). It becomes obvious that the phase of preliminary ~~experime~~ exploratory phase doesn't simply exist in the perceptive activity of these patients, and his evaluation of the picture becom purely accidental characters.

Fig. 30

Here to we have every ground to conclude that the ~~"Concepto~~ patients behavior ~~becomes~~ receives a much more primitive level and that no inner plans or programs are controlling his behavior.

After all we have said it becomes clear that the more complicated forms of intellectual activity is highly disturbed in patients with severe lesions of the frontal lobe, and that time - not because they lose their abstract concepts or logical operations, as it was supposed by K. Goldstein (the observation show they are preserved), but because the "elaboration process or re-coding of the information is ~~have severely~~ here eliminated and because the controlling function of the "Conceptual Nervous System" is no more included in the organization of their behavior.

I have discussed this problem in several special publication ~~which~~ analysing the constructive activity of these patients and the disturbances of their problem solving behavior (cf A.R. Luria and E.D. Homskaya, 1966, A.R. Luria and L.S. Tsvetkova, 1967), and I shall not dwell further on these problems.

10. Conclusions and outlook.

We have finished a review of some our data concerning the problem of the origin of conscious actions and their brain organization, and we can now turn to some general conclusions.

We can fully agree that the basic function of the "Conceptual Nervous System" is an elaboration of some inner codes which provide a general ~~rep~~ reflection of the ~~outer~~ external world, ~~and~~ make it possible to abstract our behavior from some accidental influence ~~or~~ and to subordinate our actions to special plans and inner programs. ~~which are mostly formulated by the means outer or inner speech~~. That really makes the Human Brain an Organ of Freedom.

We know as well that such a controlling function of the brain originates with the development of the pragmatic or ~~contr~~ regulatory function of speech, and that the source of this controlling function can be found not in the depths of the brain but in the some complicated relation of the child to its social environment and its acquisition of language.

We know finally that one of the important apparatus of this control can be found in the Frontal Lobes of the Human Brain and their intimate relation with the underlying brain stem structures, and that the human Frontal Lobes play an important role in singling out the most important cues of inner programs of action, blocking the outside no decisive cues which can disturb the organized execution of these programs. The inner mechanisms of the role of the „Conceptual Nervous System" in the control of conscious actions becomes clearer that it was before.

~~And~~ However - after a long work - we have to admit that we are only on the very first stages of our way, and that the amount of the ~~p~~ centrolved problems is many times tribune than the ~~quantity of questions we~~ amount of our actual knowledge.

We don't yet know ~~what~~ on the ~~phys~~ intimate neurophysiological mechanism of the controlling activity of the frontal lobes nor the role of the inner speech in ~~this controll~~ the control of our conscious action. ~~to~~ Our ~~to~~ conceptions on the ~~complicated~~ functional organization of the frontal lobes remains too vague, and only during the last years we begun to collect data of very different contribution of different parts of the frontal lobes to the organization of the human behavior.

~~to So~~ Thus - we are yet very far from the solution of our basic problem - the psychological and neurological organization of the man's conscious action, - and coming to the end of this presentation we can only look forward - with envy and hope - to the work of further generation of psychologists who will once take place on this tribune and carry to the end the observation ~~the~~ our generation has only started

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