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A.R. LURIA, E.G. SIMERNITSKAYA ^{and} V. TUBYLEVICH

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THE STRUCTURE OF PSYCHOLOGICAL PROCESSES IN RELATION TO
CEREBRAL ORGANIZATION

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Modification of the Structure and Cerebral Organization of Psychological Processes - A.R. LURIA, E.G. SIMONITSKAYA, B. TUBYLEVICH.

ABSTRACT

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Every attempt to analyze the cerebral organization of a psychological process has to take in account not only its stable structure but the change of this structure during the ontogenetic and functional development as well.

This presumption is illustrated by an analysis of the disturbances of writing in two cases of left parieto-occipital lesions where copying and slow writing was impossible but quick writing based on automatised writing skill remained intact.

← In modern psychology, it is now widely accepted that each kind of mental activity has a distinct psychological structure and is effected through the joint activity of discrete cortical zones.

Thus, a number of researches carried out during the last decades established that the accomplishment of certain movements is based on a strict system of afferent syntheses (~~H.A. Bernstein~~, [1]), ~~that~~ the process of writing makes it necessary to effect a preliminary acoustic analysis, to single out the phonematic composition of the words, to recode the phonemes into graphemes and to preserve the order of the sound and letter elements (~~A.R. Luria~~, [2]), whereas the performance of arithmetical and geometrical operations has quite a different psychological structure, each of these forms of activity being based on the ^tinteraction of strictly defined zones of the brain cortex (~~A.R. Luria~~, [3]). It is precisely this proposition which lies at the base of the neuropsychological description of the mechanisms governing separate forms of mental activity, and which ^{turns} ~~lays~~ such analysis into a foundation for neuropsychological diagnosis of local brain lesions.

However, there exist some other well-known facts in the clinic which do not accord with these conceptions.

It is widely known, for example, that the accomplishment of one and the same kind of activity sometimes proves inaccessible to a patient with a local brain lesion, while sometimes, on the contrary, it presents no difficulty whatsoever. An example of this phenomenon is the classical observation of Gowers on a patient who was asked to utter the word "No" and who after many unsuccessful attempts finally said : "No, doctor, I am absolutely unable to say 'no'".

Every clinician will undoubtedly recall other instances of this kind, for example, when a patient, who is unable to touch his own nose to request, easily does so to dislodge a fly or when a patient who cannot recognize a single letter or read a single word at once recognizes a written name or a well-known designation of a country or town. But all attempts to explain such facts were usually reduced to the statement that in both cases the activity now bears a "voluntary", now an "involuntary" character, or is included now in "categorical", now in "concrete" behaviour (K. Goldstein). Such attempts presented a description of the above-mentioned phenomena rather than their actual explanation.

We are inclined to assume that with the gradual development of each kind of psychological process, the latter changes its psychological structure and is effected through the activity of a different system of cortical zones. We believe that precisely this assumption explains the facts described.

At one time this assumption was advanced with regard to the ontogenetic development of mental processes.

Observing the development of memorization in children, Soviet psychologists ^[4, 5, 6] (~~L.S. Vygotsky, 4, 5, A.N. Leontiev 6~~) found that with the transition from the younger (preschool) to the older (school) age, the direct impression of traces is replaced by mediated memorization, which involves coding of the material memorized and thus has an absolutely different psychological structure. Investigating

the development of memory in identical and fraternal twins, one of the authors (~~A.R. Luria~~, [7, 8]) established that with increasing age, not only the structure of memory changes, but also its relation to the genotype; whereas the elementary (direct) form of memorization exhibits a highly genotypical character, with the transition to complex (mediated) forms of memorization, it loses its genotypically determined character and comes to depend on external (paratypical) conditions. This fact indicates that, as development proceeds, not only the psychological structure, but also the inner nature of the psychological processes involves a radical change.

We have every reason to believe that the functional development of a variety of psychological activities is governed by this principle. There is a good deal of evidence suggesting that, as a result of frequent repetition, psychological operations not only become more rapid and cease to require special conscious control, but change their psychological structure and come to be organized by some other (i.e. differently located) system of cerebral control.

This assumption is well enough grounded and is corroborated by a considerable number of neuropsychological observations. The facts which confirm it boil down to the following : a local brain lesion disrupting the normal course of a certain psychological process may leave unaffected the course of more consolidated automatized operations ; this leads to the conclusion that well automatized forms of mental activity are based on quite a different cerebral control system.

Numerous observations of this kind were carried out on patients with local brain lesions manifesting disturbances in the process of writing.

As is known, this process includes an acoustic analysis of the sounds (phonemes) constituting the given word, elements of uttering the word (kinesthetic analysis), which clarifies its phonetic composition, and a spatial analysis of the elements of the letter which represents the given sound graphically and may therefore be disturbed by local lesions of the left temporal, left-post-central and left parieto-occipital regions of the cortex (A.R. Luria [3, 8]). However, observation showed that the recognition of familiar written words (signatures, addresses) may remain intact even in those cases in which the reading of unfamiliar words or writing ~~then~~ from dictation proves is markedly deranged. We cannot forget a case observed by one of the present authors many years ago, in which a highly cultured woman with a vascular lesion involving the speech zones of the left hemisphere was unable to write a single word from dictation, but could easily cope with the same task, when she was asked to write this word quickly, "without a moment's thought". Apparently, such rapid writing of a familiar word made unnecessary the acoustic analysis of its composition (which was disturbed in this patient) and allowed the expression of the intact kinesthetic stereotype.

We shall illustrate the fact of a profound change which takes place in the structure of a psychological activity as a result of its transition to more automatized forms, by two extremely distinct

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examples.

1. Patient Kul. (No. 46663), 50 years of age, an engineer, was hospitalized in the Institute of Neurosurgery in February 1968 with a suspected deep tumour of the posterior parts of the hemispheres.

Three years before the hospitalization she began to suffer from headaches and her orientation in unfamiliar surroundings became markedly impaired; she began to make serious mistakes in mental arithmetic, was unable to read or write, had difficulty in dressing and was unable to make her bed, or to use a knife and a fork. There was no speech disorder and personality appears to be relatively intact. As to the neurological picture, the following signs of a bilateral brain lesion were present: an increase of extrapyramidal tone in both arms, a paresis of the right nasolabial furrow, a tendency not to use the left hand, apraxia of gaze, simultaneous agnosia. The electroencephalogram showed diffuse slow waves (4-6, and sometimes 2-4 per second).

A neuropsychological investigation revealed very coarse defects of visual-spatial praxis, a disturbance of visual tracking, serious mistakes in copying and writing letters, and marked constructional apraxia. Apraxic disorders were particularly distinct in the left arm.

It was concluded from these findings that the patient had sustained bilateral lesions involving predominantly the parieto-occipital region.

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 An arteriographic investigation gave no evidence of a space-occupying lesion ; the patient was discharged from the Institute without any operative intervention, a dystrophic process being suspected in the afore-mentioned regions of her brain.

The basic fact of this case consists in the following : the patient who manifested a highly coarse form of spatial apraxo-
 gnosis could neither copy letters, nor write them from dictation, but was able to write these letters if they were included in whole, well-assimilated words. (See fig. 1).

fig. 1
 The patient proved fully unable to write such isolated Russian letters as "K", "X" and "R" ; she made futile attempts to establish the necessary disposition of the component strokes, the character of the difficulties indicating that optico-spatial defects made the graphic representation of letters impossible. The patient herself said, "If we take the letter "O", it is quite simple, but how to write the letters "k", "x", or "r", I don't really know... It proves impossible...". At the same time, however, the patient was able to write these letters without difficulty, if they entered some well assimilated words or phrases. Thus, it becomes quite evident that the process of writing the letters composing a well assimilated word does not require any optico-spatial analysis of the kind necessary for writing an isolated letter, and is based on kinesthetic stereotypes firmly consolidated in the patient (and not affected by the local brain lesion).

The following fact is likewise characteristic : a similar result may be obtained if the writing of isolated letters dictated to the patient is included in a well consolidated process of writing letters in their alphabetic order.

In this case too the phenomena of ^(en)optico-spatial agraphia and inability to find the necessary spatial correlations of the strokes which enter the composition of the letters disappear ; the patient begins to write quite easily those letters which she was unable to write when the sounds were dictated individually, (see fig. 1a).

It is easy to see that here too any change of task changes the sensory feed-back necessary for its fulfilment, and that the inclusion of the task in a well automatized activity modifies both its psychological structure and its underlying cerebral organization.

Similar facts were observed in another case, in which an abscess of the left parietal region provoked analogous disturbances in writing, which fully disappeared after the abscess was drained at operation.

2. Patient Zag. (No. 47886), age 43 years, a senior engineer, was hospitalized in the Institute of Neurosurgery in October 1968. The diagnosis was abscess in the left parieto-temporal region.

For one year the patient had a productive cough. In August 1968 a convulsive attack accompanied by loss of consciousness. This was preceded by a discharge of a considerable amount of fetid phlegm. On the 6th of September the patient was placed in a provincial hospital. Observations carried out in that hospital showed a slight right

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pyramidal insufficiency, a right-side hemihypesthesia, divergent strabismus and meningeal symptoms. The liquor manifested a heightened cytosis (120/3), the protein content being normal. An abscess was found in the left lung. However, the patient remained in a bad state and was transferred to the Institute of Neurosurgery with a suspected abscess of the brain.

56' An examination carried out at the Institute established the following : a paresis of upward gaze and of the right nasolabial furrow, impairment of cutaneous sensitivity on the right with elements of apraxia, bilateral pathological reflexes with a predominance on the right side, incomplete right-sided hemianopsia, intracranial pressure and no obvious papilloedema. The liquor showed a heightened cytosis (225/3).

Arteriographic investigation showed marked displacement of the left anterior cerebral artery and the deep cerebral vein from the left to the right and insufficient filling of the parieto-temporal parts with a contrast substance. These clinical symptoms strongly suggested an abscess of the parieto-temporal region.

On the 11th of October a puncture of the abscess was made and air was introduced into the cavity. X-Ray pictures revealed a large-abscess located in the left parietal lobe close to the midline.

Repeated punctures of the abscess accompanied by evacuation of 30-35 ml of pus resulted in regression of the clinical symptoms : the meningeal signs disappeared, the symptoms of a lesion of the opticomotor pathways deep in the left hemisphere decreased, and the fields of vision became normal.

A neuropsychological analysis of the patient revealed the following picture. Against the background of general cerebral symptoms (sluggishness, exhaustibility) coarse optico-spatial disorders were observed in the patient, he experienced considerable difficulties in accomplishing tests for postural, spatial and constructive praxis ; he proved absolutely unable to orientate himself on a watch or a map, and could not make a simple drawing. He neglected his right hand as well as the right half of extrapersonal space. The investigation also revealed paragnosia, colour agnosia and inability to recognize and to write letters and figures. There were defects in the perception and reproduction of rhythms by ear, though this could be accomplished on the basis of verbal instruction.

A repeated investigation carried out 3 days after drainage of the abscess showed that the patient had become more active : he performed more quickly on tests, and alexia, colour agnosia and paragnosias disappeared. However, the accomplishment of tests for postural, spatial and constructive praxis remained grossly impaired and the patient proved unable, as before, to make a simple drawing or even to copy one. He was already able to recognize letters and figures, and sometimes, under certain conditions, could even write them properly ; nevertheless, on the whole his writing remained grossly defective.

The basic fact of this case consists in a symptom which fully duplicates the effect described in the first case : the patient experienced considerable difficulty in writing isolated letters to instruction ; he made futile attempts to find the proper spatial disposition of the elements constituting the letter, sometimes manifesting

fig. 2

a complete loss of the ability to reproduce a grapheme, and sometimes certain signs of a change in the spatial location of the elements with their mirror or inverted disposition (fig. 2a). It is characteristic that when the patient was asked to write the same letters rapidly (without any conscious analysis of their spatial structure, i.e. exclusively on the basis of his automatized writing skills), the accomplishment of the task became very much easier (fig. 2b). Much the same is seen in writing from dictation : when the patient was instructed to write a given word slowly, consciously analysing its components, he experienced great difficulties (fig. 2c) ; but when he was asked to do the same thing rapidly, likewise basing himself on his previous writing skills, he could often do it (fig. 2d) ; the process of writing phrases proved to be still easier, since in this case the patient utilizes to a considerably greater degree his previous automatized writing skills (fig. 2e).

It is noteworthy that when the abscess was drained, all the aforesaid difficulties disappeared (fig. 2f).

The above example convincingly shows that the inclusion of a given task in a new and different system changes the afferentation on the basis of which this activity can be performed, and that with the shift to well automatized forms of activity. The performance is brought about through the activity of some other cortical system. In other words, with the functional development (or exercise), not only the psychological structure of a given operation changes, but also its cerebral organization, i.e. the system, and, probably, also the level of the cerebral apparatus involved.

Our example with the writing process applies to other forms of activity.

The clinic knows numerous facts of the following kind : patients who are unable to repeat a word (or to pronounce it at will), easily utter this word when it is used in the context of an assimilated and well automatized phrase ; some patients who unsuccessfully attempt to read a relatively rare word, easily recognize "by sight" a habitual "ideogram" ; patients who cannot successfully accomplish the operations of addition and subtraction, easily cope with a well automatized operation of multiplication, etc.

These facts show that a highly automatized activity (which results from "functional development") proves to be intact when a local brain lesion makes the accomplishment of a less highly automatized activity impossible.

All this makes highly probable our initial proposition, according to which a psychological operation changes not only its structure, but also its cerebral organization in the course of its functional development.

There is no doubt that the neuropsychological method - the method of investigating patients with local brain lesions - may make a substantial contribution to the further analysis of the changes, which psychological processes undergo in the course of their establishment or exercise and of the concomitant changes in their underlying cerebral organization.

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~~A.R. LORIA et coll.~~

~~RESUME~~

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Tout essai d'analyser l'organisation cérébrale d'un proces-
sus psychologique doit tenir compte non seulement de sa structure fi-
xée, mais des changements de cette structure pendant le développement
ontogénétique et fonctionnel.

Cette *affi*rmation est illustrée par l'analyse des troubles
de l'écriture dans deux cas de lésions pariéto-occipitales gauches
dans lesquelles la copie et l'écriture lente / étaient
impossibles, tandis
que l'écriture rapide, basée seulement sur les habiletés graphiques
automatisées, restait intacte.

Veränderung der Struktur und der cerebralen Organisation
psychologischer Vorgänge

von

A.R. LURIA, E.G. SIMERNITSKAYA, B. TUBYLWICH

Deutschsprachige Zusammenfassung:

Jeder Versuch, die cerebrale Organisation eines psychologischen Prozesses zu analysieren, muß nicht nur dessen stabile Struktur, sondern auch die Veränderungen dieser Struktur während der ontogenetischen und funktionellen Entwicklung berücksichtigen.

Diese Annahme wird illustriert anhand einer Analyse von Schreibstörungen in 2 Fällen von parieto-occipitalen Läsionen, bei denen Abschreiben und langsames Schreiben unmöglich waren; Schnellschreiben, auf automatisiertem Schreibgeschick beruhend, war ungestört.

FIG. CAPTIONS - small type centred

FIG. 1. Writing of patient Kul.

FIG. 2. Writing of patient Zag.