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The Life of the Brain

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SUMMARY

The main premise discussed in the present paper is that language provides an insight into how the human brain works. Language is therefore the main way to gain a better understanding of our mind. This is so despite the rapid development of such techniques as computerized tomography (CT), position emission tomography (PET) or regional cerebral blood flow (rCBF), since these depict the physical work of the brain and the mind. As a consequence, we still use an indirect way of investigation, such as clinical observations, animal experiments, and morphological studies. This has led to the formulation of various models of the mind, among which the computer analogy is most popular. Yet in contradistinction to the computer our minds work in a multidimensional, polymodal, and creative manner that is closely connected with the use of language. And language is also important for self-awareness, which is an intrinsically human characteristic. It is also shown that information is processed in the right and left hemispheres in accordance with its nature, in the case of both verbal and nonverbal clues. In our present state of knowledge the microgenetic approach provides a plausible explanation for the cooperation between the "analytic" left hemisphere and the "holistic" right hemisphere in processing internal and external information. Another plausible explanation of the way the brain works is the counter-current theory proposed by Deacon.

INTRODUCTION

As early as 1887 a well-known French physiologist, Fournié, stated that language is the only window through which a physiologist can view the cerebral life (cited after Lashley, 1970). That statement still holds true, despite the fact that we have developed a number of powerful brain imaging techniques, such as computerized tomography (CT), positron emission tomography (PET), regional cerebral blood flow (rCBF), etc. These technologies, however, only provide information on the work of the brain, and not on our mental life. Consequently, in our endeavor to obtain some insight into the working of our minds, we still rely on indirect methods of investigation. Two basic sources of information have proved to be useful: clinical observations and experiments on animals.

Clinical observations concentrate on disturbances of particular functions in individuals suffering from focal brain lesions. Among the very first, and at the same time best known reports, are those of Broca and Wernicke, which started a persistent dispute over the nature of the brain-language relationship. It may be worthwhile recalling here that Broca's work was to a considerable degree performed under the influence of Franz Gall, the founder of phrenology, whom Broca had the chance to hear in person. Gall (Pachalska 1999) based his speculations upon studies of the scalps and photographs of famous people. He came to the conclusion that differences in their shapes reflect the differences in the development of various brain parts, which, in turn, explain discrepancies existing between the abilities of individual people. Such an approach was in agreement with the notion of inborn capacities that dominated the psychological thought of that time. According to Gall, language and intellect were located in the frontal lobes, the development of which was responsible for the "high brow" of an intellectual. Phrenology was very popular at the time, as Gall's contemporaries were excited by the idea that by palpation of the bumps on the scalp of an individual person it was possible to tell what his/her mental abilities were. This "method" was also used in courts in order to tell whether the accused might have committed a crime, and descriptions of a typical criminal physiognomy can be found in nineteenth-century literature. Some of this has also been preserved in our everyday psychology, and most of us still associate a low forehead with mental dullness, hence the term "lowbrow."

Nowadays, the clinical approach has undergone much refinement, and the subjects are examined in quasi-experimental conditions. Yet clinical studies will never meet the standards of a laboratory experiment, since we are not able to control all variables. This means not only the range of the brain damage, but also the life experience of individual patients, which has a considerable impact upon the level of their premorbid skills. In addition, we do not know, and will never know, what the capabilities of a particular patient were before the brain injury was acquired. Some indications are provided by his/her educational level, occupation, and family history, but there still exist vast differences among persons from the same social groups.

The aforementioned difficulties may be overcome by neurophysiological experiments carried out on animals. Modern techniques enable very precise location of the brain area we are interested in. It is also possible to examine the functioning of an experimental animal before its brain is injured. Many valuable findings have been gained in this way, expanding our knowledge of the central nervous system to a considerable degree. As early as 1870 two German physiologists, Fritsch and Hitzig, demonstrated that an electric current applied to the motor area of the cortex produced movements in the limbs opposite to the stimulated hemisphere. In this way they proved the existence of the motor area in the brain. Later studies led to explanation of many other physiological factors, also making the "riddle of the frontal lobes' function" less mysterious (Perecman, 1989).

On the other hand, the use of longer electric pulses to stimulate the precentral gyrus proved to evoke complex well-timed movements. It was observed that stimulation of a definite spot caused a monkey to open its mouth or clench its fingers. Moreover, the hand movements evoked in this way were differently organized in space, which points to the importance of the traditional motor cortex in spatial orientation. In this way the traditional homunculus of neurological textbooks has to be changed, since the motor cortex "appears to be organized not just according to muscle groups but by positions in space where the animal's movements conclude" (Helmuth, 2002, p.1587-88).

In spite of the spectacular finding described above, animal experiments have one serious limitation. Namely, they do not allow us to examine the cognitive abilities that are specific for human beings, the most significant of which is linguistic communication. And after all, it is the characteristics of the human brain that we are really interested in. The limitations connected with the two approaches discussed so far increase the significance of studies on cortical cytoarchitecture and connections among brain areas. The use of more precise instruments, the electron microscope among them, has broadened the applicability of these investigations.

It is of interest to note that both clinical and experimental data often make anatomists look for connections between the brain zones that seem to function in a similar way. As a rule they find the connections they have been looking for. At the same time, better knowledge of neural connections makes possible the formulation of new explanations of how the brain works. Thus Deacon (1989) proposes a counter-current flow of information within the nervous system. This occurs in a way similar to the counter-current fluid diffusion of blood and water in a fish gill. The point is that the fluids interact with each other but remain separate. In the case of the human mind, the interaction between the internal information circuit and external information also plays a significant role. Yet we remain conscious of the difference between the exterior world and our internal thoughts and desires, while the intermingling of those two types of information results in psychotic illness (Kaczmarek, 1993).

Morphological studies, however, are mainly concerned with brain structure, while our main interest lies in function. It is certainly true that the structure of a given system (including living organisms) reflects its functions, but this is only one more indirect clue concerning a given brain activity.

UNDERSTANDING HOW THE BRAIN WORKS

We still do not know what accounts for the efficiency of brain work, but it is certainly not its size. For example, the weight of Anatol Frances's brain was only 1100 grams, while on the other hand the brain of another famous writer, Turgenev, weighed as much as 2021 grams. It has been observed that the weight of a normal brain oscillates from 820 to 2800 grams. A brain heavier than 2800 grams has been reported only in a profoundly retarded individual (Dryjski, 1948). Moreover, PET recordings show that the brains of bright persons show lower activation than those of less gifted individuals when performing various intellectual tasks. At the same time, the brain activity of the less gifted is more diffused within the cortex.

The efficiency of the cerebral networks is connected with selectivity. This occurs even at the lowest level, i.e. at the level of a neuron. Each neuron consists of a cell body and only one efferent (outlet) fiber, called the axon, but as a rule it has many afferent (inlet) fibers, or dendrites, that reach out towards other nerve cells. As a consequence, a great number of signals may enter an individual cell, but it is capable of sending out only one signal at a time. Furthermore, each nerve cell reacts to specific stimuli, which means that different sensations are coded within the brain in separate neurons. According to Young (1978), neurons constitute the meaningful units (words) of the cerebral code, while individual signals sent among them may be compared to distinctive but meaningless units, i.e. phonemes. Even if this conjecture is going too far, specialization within the neural network remains a fact.

Additional selectivity is secured at synaptic clefts which occur between fibers connecting nerve cells. At the synaptic cleft, the excitation running along the axon is converted from an electrical signal into a chemical one. A special chemical, a neurotransmitter enabling passage of the signal, is released only if a sufficient number of impulses arrives along the first neuron. Moreover, each neurotransmitter has its own receptor on the post-synaptic membrane, which will react only to that particular substance and not to any other.

To complicate the matter further, not every signal sent across the synapse to another cell is an order to fire. On the contrary, it may have an inhibitory effect on the other cell, making it less likely to fire. Thus, inhibition appears to play an important role in providing for the accurate work of our brain. The loss of the balance between excitation and inhibition leads to epileptic seizures, a disease that has troubled mankind since ancient times. This shows that the nervous system works in accordance with a complex code operating within its molecular structure on the neuronal level. This makes plausible the assumption that the neuronal mechanisms of our brain are close to the rules of quantum physics, where the predictable is mixed with the unpredictable.

A promising solution of the problem in question is offered by Sedlak (1979), a pioneer of bioelectronics, who proposed to make the soma more "subtle," and consciousness more "physical," in order to bring them closer to each other. Sedlak believes that this can be achieved by taking into account the fact that all tissues are piezoelectric in nature and that proteins as well as nucleic acids are semiconductors. Hence, if we consider our body at the quantum level, the differences between its structure and function become less distinct, and the body metabolism can be regarded as a complex system of information processing. At the same time, the basic traits of consciousness are the abilities to receive, store and send information. In a living system, however, the information is transformed within the system, which undergoes constant reorganization. And consciousness is first of all the reception of changes which are taking place in the system due to the information received from outside. In this way, both physiological (metabolic) and psychological processes may be conceived as complex communication systems using their own electrical codes.

Another way to deal with the overwhelming complexity of the brain is to compare it with the most complicated machine of a given time. Thus the metaphor of a mechanical device was used in the 19th century, while presently a computer is considered to be the closest approximation. At present, the modular organization of the cerebral cortex is emphasized by some neuroscientists. Eccles describes a module or a column as "a well – defined group of cells, perhaps up to 10,000, which are locked together by mutual connectiveness, and which have as a consequence some unitary existence, building up power within themselves and inhibiting the cells of columns nearby" (Popper and Eccles 1977, p. 243). Hence a module may be considered as the king of a power-unit, working in conflict with the nearby units, which make the modules comparable to the integrated micro-circuits of an electronic system. In order to perform their work well, they have to communicate with each other. It is the continuous exchange of information (the dynamic balance between excitation and inhibition) that is responsible for all variations of human behavior. In contradistinction to any man-made information processing system, the brain works in a multisensory parallel way. The simultaneous processing of information within the nervous system explains why we are able to perform our actions with far greater speed than would be possible if we did it in accordance with the stages described in most existing models. It is also of importance that the parallel transmission of signals gives rise to redundancy, which ensures a sufficient flow of messages even in cases when some parts of the system are injured. That explains why our nervous system is such a reliable "machine" despite all its insufficiencies.

Another important conclusion which follows from the above considerations is that we should rather talk about a set of interconnected centers controlling a given function, and not of separate centers responsible for each faculty. This is especially true in the case of such complex functions as speech, writing, or reading. At the same time, this makes possible the recovery of lost functions, due to the capability of other centers to assume them.

The most serious difficulty with behavioral methods of investigation is that their subject matter (the brain?behavior relationship) is so complicated and multidimensional that it becomes possible to point to the facts which are in agreement with the assumptions of a researcher, while other factors may be treated as insignificant. Examples of such interpretations are provided by the history of brain studies. In fact, the same data were used by two opposing groups, representing associationist and holistic theories, but they drew completely opposite conclusions from them (Luria 1980, Deacon 1989). The associationist (localizationist) perspective stressed the fact that lesions localized in different parts of the brain result in disturbances of different functions, and a number of their observations are still valid. We still speak of Broca's zone as the "motor center of speech."

On the other hand, the holistic theory treated the brain as an undifferentiated whole. It was presumed that the symptoms observed in patients depend upon the extent of brain tissue damage, and not on the location of the lesion. Nowadays a view taking into account both of these perspectives is accepted by most neuroscientists. They are inclined to believe that although the brain works as a whole, it is composed of separate regions (units), which work in cooperation with each other, preserving their own specialty all the same. Thence the injury of a definite region is followed by an impairment of the functions it is concerned with. A one- sided outlook may result in a discrepancy between theory and practice, as was the case with Goldstein (1948). After declaring himself to be a holist in the introduction to his book Language and Language Disturbances, in the clinical sections he presented precise information on disorders following damage to definite brain zones. In fact, he was the first to point out the functional differentiation of the frontal region, which was treated as a unity at that time.

Furthermore, so-called "thought disorders" are classified on the basic of what psychotic patients say. The most frequent abnormalities enumerated in this context are: (1) poverty of content of speech, (2) tangentiality, (3) derailment, and (4) incoherence. In fact all of these describe the way the utterances of psychotic patients are constructed. Hence poverty of content means also the simplification of grammatical structure, tangentiality means that the patients jump from one topic to the other, derailment means that he/she is not able to keep track of a narrative but is influenced by any associations that come to his/her mind, while incoherence is essentially incomprehensible verbal output which lacks any structure. Bearing this in mind, Andreasen and her colleagues conclude that in the evaluation of schizophrenic disorders "language is a highly desirable place to begin, because it is objective and lends itself readily to empirical study" (Andreasen et al., 1985, p.202).

LANGUAGE AND SELF-AWARENESS

As mentioned earlier, language is important not only for communicating with others, but for our internal communications as well. A significant differentiation in this respect can be observed with regards to the left and right hemispheres. It has been noted that patients with a split brain (after the structure connecting the two hemispheres is cut to prevent epileptic seizures) are often not aware of the information that comes to their right hemisphere. This can be demonstrated during specially designed experiments, when the patients are asked to look at a black dot placed at the center of a screen, so as not to move their eyes. Then two different pictures are flashed to the right and to the left of the dot with the use of a tachistoscope, a special device that allows a very short presentation (about one-tenth of a second).

As a rule, commissurotomy patients name the object viewed with the left hemisphere (i.e. with the right visual field due to the crossover of optic fibers). Moreover, if some special material, for example the picture of a nude woman, is exposed to the left visual field (i.e. the right hemisphere) the patients report they saw nothing, but they blush or giggle. When asked why they are laughing they say "Oh, it's a really funny machine" or something of that sort, evidently unaware of the sensations that reached their right hemisphere. Similar results are obtained with the use of composite pictures consisting of two different halves of faces of two different persons, for example of a child and a man. The split-brain patients state that they have seen the person whose half-face they perceive with their left hemisphere.

On the other hand, after they are asked to point to the picture representing the person flashed on the screen, they point to the face seen by the right hemisphere. In the same manner they obey commands seen by their left eye-field without being aware of it (cf. Bradshaw, 1989). The above findings are also confirmed in the syndrome of anosognosia, which is observed after lesions of the right hemisphere, especially its posterior parts. Such patients usually deny any illness, despite objective symptoms of neurological disorders.

Since it is the left hemisphere which is involved in language processing, at least in the majority of people, the studies described above point to the significance of language in self-awareness. That is also why the left hemisphere came to be regarded as the dominant one, while the right hemisphere was believed to be the minor one. Nowadays, neuroscientists have started to use the term functional asymmetry in place of dominance, as the right hemisphere proves to play a significant role in many socially important activities, such as perception of spatial relations, music, art, as well as imagination and the ability to look at a given situation from various points of view.

It is often stressed that the right hemisphere works in a generalized, holistic way in contradistinction to the left hemisphere, which is believed to have a more analytic character. This allows for the presumption that the right hemisphere is crucial for the creative activity of a man, which finds its confirmation in various reports on artists who lost their creativeness as a result of right hemisphere lesions. It is of interest that such artists as a rule preserve their technical skills.

Very instructive is a case of a well-known Polish painter, R.L. (Kaczmarek 1991). A characteristic feature of his premorbid creativity was symbolism. His pictures used to be done in a technique giving the impression of relief and chiaroscuro, done only in black and white, and they carried messages reminding people of the dangers encountered in the modern world. This is reflected in their titles: Exhumed, Requiem, Quo Vadis or Against the War, to mention only those which received awards. After a left-hemisphere stroke, which resulted in aphasia, he preserved his painting skills at the performance level, but he was no longer able to produce his symbolic paintings. Furthermore, a notable correspondence between a recovery of his linguistic capabilities and his artistic skills was observed. Namely, his ability to paint improved along with the restoration of his language. All the same, he was not able to produce any symbolic pictures, but painted various landscapes just to make a living. Though the landscapes were good enough to find many purchasers, the painter felt unhappy about having lost his previous capabilities. He was, therefore, offered Symbolic Thought Therapy at the Cracow Rehabilitation Center, a fundamental part of which include art therapy sessions (Pąchalska 1999). This therapeutic procedure helped him to come back to the symbolic way of painting, with which he was very satisfied.

One more word of comment is needed here. The patient described showed symptoms indicating damage to the anterior (frontal) region of the brain. Beside disturbances of motor agility, he was unable to reproduce and develop narratives, which manifested in confusing characters and events, digressions, and confabulations. He also manifested difficulty with planning and controlling his actions. This all pointed to an inability to process information in a sequential and at the same time hierarchical manner, which, as pointed out earlier, is typical of language.

The above observations as well as other studies reveal a much more complex picture of disturbances following injuries of the right hemisphere than has been believed. It is found that subjects with injuries of that part of the brain are not able to understand jokes or puzzles, to catch an irony, and to process any emotionally loaded material in general (Perecman, 1983; Code, 1987; Bradshaw, 1989). It has also been noted that the right hemisphere is better at recognizing facial expressions. Besides, facial expressions have been found to be more pronounced on the left side in about 80% of right-handed persons (Perecman, 1983). It is noteworthy that the ability to read emotions expressed in faces is much better in women, who – in contrast to men – also show a clear right-hemisphere superiority in this respect. On the other hand, the linguistic (sequential) versus non-linguistic (special) dichotomy is typical of men, while the female brain seems to be less specialized.

However, not only gender, but also the type of a task given to the examined subjects has influence upon the mode of work of the two hemispheres. Bradshaw (1989) writes that making the subject use different strategies while solving a specific task may lead to quite different results even if the same stimuli are applied. Thus, when the subjects are to differentiate target faces in terms of the "holistic pattern of special relationships" a left-sided (right-hemisphere) superiority is observed, but if they are asked to estimate feature shapes and to ignore the holistic interpretations, a right-field superiority appears.

The above points to the need to be very careful in interpreting the modes of processing of "verbal" and "nonverbal" material by our brain. It must be borne in mind that the same information may be processed in a different way depending upon the strategy taken by a given individual, which in turn depends on his/her age, sex and life experience. Thus, as Bradshow rightly points out, cerebral asymmetry is more of a continuum than a clear cut dichotomy. In a normal brain, the two hemispheres cooperate in accomplishing various tasks of both linguistic and non-linguistic nature. In the case of verbal messages, however, the left hemisphere appears to play a basic role in processing their phonological and syntactic structure, while the right hemisphere seems to take part in contextual processing. In other words, the right hemisphere is important for pragmatics, and the left one grammar.

The idea of the evolutionary substrate of language has been further developed by Brown (1988). His microgenetic model of language processing stresses the significance of subcortical structures in the "unfolding" of any psychological processes, such as perception, action, and language. In other words, the limbic system mediates early stages of language elaboration, and there is a transition from that as yet "undifferentiated speech act" to the laterally represented generalized neocortex, which is then encoded in the focal neocortex (traditional speech area). The final realization of the speech act is achieved through contralaterally represented motor and sensory cortex.

Brown writes: "... aphasia is the result of disruption of some level at either of two distinct (anterior or posterior, B.K.) systems. The disruption displays that level and does not destroy a specific language mechanism situated in the damaged side. An aphasic symptom is a fragment of a disturbed level that survives into the end stage, or the development of the level is attenuated" (1988, p. 67). He also believes that the role of pathways between different regions is to "maintain them in phase" rather than to connect particular "centers." The idea of regression is derived from Jackson, with the important modification that disruption of the lower level need not result in a more primitive mode of behavior. As Brown puts it: "Pathology in the adult exposes different moments or structure levels in the unfolding of action, while developmental stage is related to the maturational or the entire action" (1988, p. 7).

In his recent publications, Brown (1991, 2000) states that there is a continuous process of one action into another, therefore it is impossible to separate motor and perceptive functions. He also points out that brain processes are primary in our evaluation of the external world. In consequence, he places the self between the past and future as a potential of future acts performed on the basis of our previous experience. This can be compared to the knowledge of language. We may not be using it at the moment but our past experience makes it possible to speak it in case of future needs.

CONCLUSIONS

The above considerations point to the fact that there is no way to directly study the human mind. We have brain mapping techniques, but they tell us more of brain functions than of our mind. In consequence, we still know very little about how our mind works, since in order to learn about it we must use indirect methods of investigation, such as clinical observations, animal experiments and morphological studies. These provide the basis for creating various models of the mind, and presently the computer analogy is used most frequently.

There is an additional very strong reason for the spread of the computer analogy. This is the idea of an open versus closed mind. The idea goes back to Plato, and is widely accepted by modern scientists, often in an uncritical way. The best example is Chomsky's theory of language. He states that language is creative, but he understands this creativity as an ability to make a correct choice out of a very large store, in a way similar to supermarket shopping. Such an approach is appealing to most researchers, as it implies that it is only a matter of time to gain the knowledge of all the "items" stored in the mind, or at least the majority of them. This seems possible, since the number of such items is believed to be finite, though vast in number. That is also why studies on artificial intelligence have become so intense. Its students hope to build such a complicated computer that it will act in a human way. Some of them believe it will become possible to control emotional states as well.

However, the main difference between the computer and the brain is that the latter works in a parallel, multidimensional, and polymodal way. Moreover, our brain is capable of learning and restructuring its own "circuits," which provides for its open nature. On the other hand, a computer is the machine with a fixed program inserted there by a programmer. The creative nature of our minds seems to be closely connected with the use of language.

A closer look at language reveals that it is probabilistic, and its principles are far from the rules of formal logics. Our minds also use the principles of probability in our attempts to understand the world around us and to control our behavior. The capacity to use language for organizing information is intrinsically human, and makes possible not only communicating with others but also with one's own self, providing for the rise of self-awareness. As Katz (1953) puts it: "Man not only has awareness; he can also appreciate that he has it. We may call this awareness of awareness" (p.177). He also adds that some animals have awareness but they lack self-awareness.

It is no wonder, then that prominent brain scientists have become interested in language and its impairments as their research progressed. Among them are the English neurologist, Critchley; the Polish neurophysiologist, Konorski; the American psychologist, Lashley; and the Soviet neuropsychologist, Luria, who devoted the last years of his life to neurolinguistics.

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Episode 5 The Aging Brain: Through Many Lives. This final episode is appropriate for developmental, biopsychology, neuroscience, or aging courses.Â Dennis Selkoe discuss their work on the molecular causes. and treatments for AD. In summary, The Secret Life of the Brain series includes. many examples that demonstrate to students why an. understanding of neuroscience is important regardless of. â€œOther schemes of personality were invented without any knowledge of the brain,â€ says Davidson, who compiled his 30 years of research findings into new book The Emotional Life of Your Brain. â€œThis is the first neuroscientific conception of the emotional and social variations among people, based on a modern diagnosis of the brain.â€ Today In: Forbes Woman.Â Davidson says human emotions reach far beyond romance-novel fluff. They are central to the functions of the brain and the life of the mind. Unlike emotional states, fleeting reactions triggered by an experience and lasting only seconds, and emotional moods, feelings that persist for a few hours or even days, Davidson says it is our emotional styles that shape our lives and how we respond to the world around us. Along with real life footage, animation and human stories, this film explains to the layperson the functioning of the human brain and its resulting behaviour impact through various development stages. Related videos. icon02:40:00. Beautiful Minds: The Psychology of the Savant. 2006 2020. icon00:58:53.