

# HISTORY OF NEUROPSYCHOLOGICAL REHABILITATION

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## ABSTRACT

The article reviews the history of neuropsychological rehabilitation. It begins with the description of first rehabilitation programs developed by Paul Broca and Shepherd Franz. Franz's experimental work for motor recovery in monkeys and correlation between active movement or affected limb immobilization and rehabilitation outcomes are described in further details. Special focus is given on ideas of famous German neurologist and psychiatrist Kurt Goldstein, who laid the foundation for modern approach in rehabilitation. Goldstein developed the idea of connection between rehabilitation and patient's daily life. He also pointed out the necessity of psychological care of patients with brain damage.

Russian neuropsychological approach is presented by its founders L.S. Vygotsky and A.R. Luriya. Aspects of higher mental processes structure and options of its correction such as "cognitive prosthesis" are described in the sense of the approach.

Y. Ben-Yishay, G. Prigatano, B. Wilson represent neuropsychological rehabilitation of the second half of the 20<sup>th</sup> century. The idea of a holistic approach for rehabilitation consists of such important principles as patient's active involvement in a process of rehabilitation, work of a special team of rehabilitation professionals, inclusion of patient's family members. The short review of a new rehabilitation approach for patients in coma, vegetative states and critical patients under resuscitation is given.

## Keywords:

neuropsychological rehabilitation, history of neuropsychological rehabilitation, S. Franz, K. Goldstein, L.S. Vygotsky, A.R. Luriya, Y. Ben-Yishay

Comprehensive rehabilitation of patients with brain injuries defined by the World Health Organization is based on the biopsychosocial model, which defines health as physical, psychological and social well-being of man. Obviously, a single specialty physician cannot cover all aspects of rehabilitation. Therefore, in order to address the whole spectrum of problems, the multidisciplinary team manages a patient and includes professionals such as a rehabilitation specialist, a neurologist, specialized nurses, a physiotherapist, an exercise physiologist, a neuropsychologist, a clinical psychologist, a speech therapist, an ergotherapist, while rehabilitation involves the patient, his family and friends.

Scientific history of neurorehabilitation begins with the speech restoration program of the famous French clinician and scientist *Paul Broca* for adult patients with aphasia [1, 2]. *Broca* said that his rehabilitation program had began with a kind of phonetic approach, when the patient learnt to read the letters, then syllables, and only in the end to put syllables together to compose words. This approach proved to be unproductive, since having learnt to read letters and syllables, the patient could not quite read the words longer than one syllable. Then *Paul Broca* modified the program, concentrating on the technique of learning to read whole words at once: he showed the patient the whole word, bypassing syllabic reading (what is now called the technique of global reading). And *P.* quite succeeded in this approach: he was able to teach his patient reading (recognition) quite a lot of words. It was a big surprise for *P. Broca* that when the patient read the words aloud, "he did not recognize them by their syllables or letters, and it was only their overall shape, length, their appearance" [1]. To support his hypothesis that the patient used a strategy of reading whole words at once, *P. Broca* was presenting the patient an incorrectly written word by replacing one or two letters in the word, similar in spelling to the desired, for example, *m* and *n*, *p* and *q*, *e* and *s*. According to *P. Broca*, when reading misspelled words, the patient "did not even notice it", [1]. From this experience, *P. Broca* concluded that the patient with brain damage and impaired reading learnt to read in a completely different way than he did in childhood, and that he recognized the word in the same way as we recognize the person or landscape, the details we never analyze.

Another prominent person in the early period of neurorehabilitation is the American psychologist *Shepherd Franz* (Fig. 1). Among his other achievements are the use of experimental psychological approach to the study of aphasia therapy effectiveness, and the development of a special system of motor rehabilitation in hemiparesis, which principles and results are included into current programs for the restoration of movements.

The first studies of *S. Franz* concerned the restoration of speech functions. In 1905, he gave a presentation on the rehabilitation program for patients with aphasia as resulting from the recurrent stroke [3]. Developing a skill, his patient practiced, in particular, naming of familiar colors and ten numerals from 1 to 10 by numerous repetitions.

*S. Franz* noted that the patient could poorly name colors and numbers on admission to the clinic. For example, he could name the wrong color of an object or name the color instead of the name of the object. *Franz* developed the following procedure of learning colors and numbers. To re-teach the patient the color name, he prepared ten color cards. The cards were shown to the patient and he was asked to name the color of a card that lied before him. If the patient named the correct color, he was told "right", if not – "wrong" and was given a second and sometimes a third attempt. If he still couldn't give the correct answer, he was told it, and he tried to repeat it. Sometimes the patient realized after the first time that he didn't not know the color name, and reported it. Then he was told the correct name, and he repeated it (though not always successfully). Every day before class cards were reshuffled thoroughly, in order not to raise any connection between the order of presentation and the color name. After three weeks of this training the patient did no mistakes when naming the color of a card (the name of the color matched the color itself), and what is more important, he could name these colors without regard to the cards. The curve of the effectiveness of its training grew gradually, slowly. The experiment on teaching numbers passed on a similar principle.

Interpreting the results of the research, *S. Franz* came to the conclusion that the recovery of naming numbers and colors looked like not so much on the actualization of the existed skill, but on the formation of the new one. He said, "This may indicate the fact that not all of the old brain links have been restored, but that there formed new relations". [3] He believed that this fact agrees with the replacement

of brain function ("vicariate"), when one part or one hemisphere of the brain could take up the lost functions of the other part, or hemisphere.

To prove his position about the origin of new functional pathways in the brain, *S. Franz* trained his patient with aphasia completely new knowledge for him – few German words (his patient never studied German language). Although this experiment was not fully completed due to external reasons, the dynamics of learning pointed to the fundamental possibility of forming new speech pathways in the brain in aphasia.

In 1917, *S. Franz* reported the results of his work on restoration of movements in monkeys with hemiparesis, deliberately induced by surgery [4]. He supposed that adequately taught animals with experimentally obtained hemiplegia would recover faster and more completely than those left to itself. To support his hypothesis, *S. Franz* conducted a series of experiments involving macaques aged about one and a half years. Hemiplegia was obtained by breaking the motor cortex with the electric current. Of course, this is different from the damage of human brain damage in stroke, because it affects the cortical zone only. However, damaged areas of the cortex cannot be reversed, so *S. Franz* considered such an experimental model was quite satisfying to verify the hypothesis. [4]

*S. Franz* organized the recovery process as follows. In the first experiment, the healthy arm of a monkey was attached to the body by means of a jacket so that the monkey could not use the hand for any important manipulation, feeding and climbing. Healthy leg's movements appeared to be unavailable to restrict. The idea of these restrictions was to provoke the animal into moving the paralyzed limbs. In addition, other methods were used, provoking a monkey to use the injured limb. For example, the arm was tied to the strap, which was put on the monkey's waist. The macaque got angry trying to free from the annoying straps and lifted a hand to grab it. Also, the monkey underwent a special massage and mechanical stimulation of muscles of arms and legs.

Restoration of a leg was provoked with even more unpleasant sensations: the monkey was put on the table so that the heavily scratching surface was under the affected leg and caused pain. During that period, it was also taken by the belt and encouraged to use the paralyzed leg when walking and paralyzed hand to help to get out of the room. Not immediately, but gradually the animal began to react correctly. Two weeks later, the monkey could move the paralyzed limbs well, and three weeks later it could pick up small objects off the floor and put in a mouth, used both legs well – together and separately, and there were no externally observable difficulties when walking or climbing. Thus, three weeks later, movements of the monkey with paralyzed limbs were as accurate, precise and voluntary as in healthy animals. When the monkey's unaffected arm was released, the movements were less accurate than in the restored paralyzed hand. This phenomenon illustrated the harm of immobilization. Medical examination of the monkey two months later confirmed the complete recovery of disturbed movements resulting from the experiment.

The second experiment was performed with the same monkey a week after her full recovery. This time, destroyed parts of the motor cortex were in the right hemisphere of the brain. And the monkey was left to itself, no special training was performed. In contrast to the natural conditions, the monkey was kept in a large cage and 1-4 hours a day it was released to a special room where the animal could show some activity. The restoration of the movement in the paralyzed limb did not occur even six months after the operation, while in the first case, it took three weeks. In other experiments different types of stimulation and the load were used (e.g., only massage without incentives or muscle stimulation triggering the use of the affected limb or total / partial interruption of therapy). The most efficient and fast recovery occurred during the first experiment, when the monkey did not only passively receive massage and stimulation, but was also provoked to move paralyzed limbs voluntarily.

The described research of *S. Franz* on forced use of the affected limbs and stimulating movements with obstacles and restrictions in monkeys inspired further development of therapy for hemiparesis in people and formed the basis of a number of modern programs to restore movements. Furthermore, the idea of the compulsory use of the affected areas of the brain is used for rehabilitation of visuospatial neglect in the form of limitations of visual stimulation: closing the eyes (*eye-patching*) [5].

We must say that this type of training programs, where the basis of recovery is grounded on the ideas of peculiar speech gymnastics – training and repetition, rote learning, were typical of the early attempts to restore speech in aphasia [6]. *Franz* illustrates well the logic of the first rehabilitation programs, their methodology, and the very structure of the experiment.

The basis of modern approaches to rehabilitation of patients with brain injuries was founded in Germany during and after the World War I, when many German cities deployed special military hospitals for soldiers with brain injuries. One of the first who founded the institution of this type was a German neurologist and psychiatrist *Walter Poppelreuter* [7]. Patients arrived at the hospital 3-6 months after the injury. They were not bedridden and could more or less independently perform small everyday affairs. The hospital had equipped rooms for examinations, psychological laboratory and classrooms for different classes, workshops and seminars. The task was to make rehabilitation process as much as possible similar to the everyday life that awaits the patient after discharge.

Another important approach was developed by *Kurt Goldstein* (Fig. 2). He developed the idea about orientation of rehabilitation on real life, believing that real market conditions had to be created for it, products had to be sold and their prices had to be equivalent to the prices in stores. Also, patients had to receive money for their work, and the results of labor should be genuine. *K. Goldstein* considered the work as the most important component of rehabilitation programs, as only in recreating real life, patients could identify and compensate existing cognitive impairment [7].

Moreover, *K. Goldstein* thought it necessary to focus the attention of researchers not so much on the results of the test execution but rather on methods of performing, on the analysis of pathways helping the subject find a solution, on the analysis of tactics of action. Such an approach allowed making a qualitative analysis of the patients' activity and evaluating not only their current cognitive level, but also rehabilitation potential. Understanding of the fact that no recovery is impossible without motivation of a patient, without elaboration of the emotional issues that accompany brain damage and disability caused by them, was no less important [8]. *Kurt Goldstein* had not succeed to implement the approach in Germany: he was forced to emigrate to the United States with the advent of the National Socialists rule, where he studied the scientific and teaching activities, and qualified a series of top scientists and clinicians to develop his ideas in modern rehabilitation approaches.

Fundamentals of Russian neurorehabilitation were laid by the leading Russian psychologist Lev Semenovich Vygotsky. In the 20-ies of XX century, relying on the created cultural-historical theory of the development of higher mental functions, Vygotsky with his student and colleague A.R. Luriya conducted a series of brilliant experiments on restoration of movements in patients with parkinsonism [9, 10].

It is commonly known, that basal ganglia are affected in parkinsonism, which leads to impaired fluidity of movements and hyperkinesia. When the researchers asked their patients to walk around the room, patients could make only one or two steps, then tremor amplified and patients stopped walking. However, the paradoxical fact had been noticed: those patients who were not able to take two

steps in a row, walking on level floors, could walk up the stairs well enough at the same time. The authors suggested that when a man was walking up the stairs, he considered each step as a separate motor task, which was more conscious and voluntary against walking on a flat surface. L.S. Vygotsky used a simple method to reorganize the movement on a flat surface. He put pieces of paper onto the floor and asked the patient to step over each of them. There had been a surprising phenomenon. The patient, who could not do more than two or three steps, was able to walk around the room for a long time, stepping over pieces of paper, as if he was walking up the stairs. Compensation of movements disorders was possible on the basis of reorganization and restructuring of mental processes. Authors "expanded" the process of walking and having isolated weak, broken link (involuntary act of walking), with the help of external aid (pieces of paper) replaced it with a retaining element (voluntary act of lifting / stepping over). These experiments illustrate well the characteristics of the organization of higher mental functions and the possibility of restructuring, reorganization by means of so-called "cognitive prosthesis" [10].

Further development of rehabilitation both abroad and in our country was associated with the tragedy of the Second World War. Without a doubt, the most important figure of this period is the great Soviet scientist and psychologist, Alexander Lurija who received a medical degree and a higher doctorate in medical sciences in the field of neurology and founded neuropsychology (Fig. 3).

During the first months of the war, A.R. Lurija was instructed to arrange the rearward rehabilitation hospital. He organized it in Kisegach village near Chelyabinsk. Under the direction of A.R. Lurija, the small group of professionals was engaged in the development of diagnostic methods and restoration of disturbed mental functions in various wounded patients with the damage to the nervous system.

Continuing to develop the ideas L.S. Vygotsky, A.R. Lurija sought opportunities to reorganize disturbed mental functions by restructuring the functional system. One of the perfect and most amazing example of such a research was his book "the Lost and Returned World" (Fig. 4, 5), which described restoration of writing in a patient with a penetrating gunshot wound of the left and right parietal-occipital regions, complicated by inflammation [11].

The patient, who had gone off to war after the 3rd year of the Mechanical Institute, lost the ability to read, write, orient in space, keep many types of information in memory. Rehabilitation failed to restore reading and a visual image, however, A.R. Lurija found another way to compensate for a defect: restoration of writing with an aid of motor, kinetic skills, i.e. basing on a preserved "motor" image of the word. It was a long-term work, and the patient learnt to write again, but never was able to read what he'd written. Description of his struggle with the disease became a new meaning of his life and formed the basis of the book inspiring professionals and other patients with brain damages after more than half a century (Fig. 6).

Another center of neurorehabilitation during the Second World War was in the United Kingdom. In Edinburgh, the neurologist *Edna Butfield* and the psychologist *Oliver Zangwill* worked on restoration of speech in patients with aphasia, as well as studying perception and memory disorders [12]. They conducted a comparative study of spontaneous and deliberate restoration of speech in patients enrolled in special rehabilitation classes in order to reveal the effectiveness and necessity of rehabilitation in various types of disorders.

Gradually, rehabilitation centers were opened in different countries. The post-war period was characterized by the emergence of numerous studies in the field of neuropsychology and development of neurorehabilitation programs, primarily for patients with traumatic brain injury and stroke.

Specialized neurorehabilitation programs designed by neuropsychologists of the Medical Center of the New York University were emblematic in this regard [13]. Initially, some of them focused on rehabilitation of certain types of cognitive deficit. Thus, special setting and cycle tasks were developed in order to overcome the left-sided visuospatial neglect.

Gradually, it became clear that rehabilitation should focus not only on the recovery of cognitive and motor capabilities, but also on the behavioral and social interaction of patients with brain damages. The creation of rehabilitation program by the American psychologist *Y. Ben-Yishay* designed for the Israeli military in 1974 who had received brain damages as a result of the Yom Kippur War in 1973 appeared to be an important event which determined the direction of modern neurorehabilitation development in many ways [14]. Following the ideas of his teacher *Kurt Goldstein*, *Y. Ben-Yishay* developed the method of "therapeutic environment" (*Therapeutic Milieu Concept*), which focused primarily on issues of personal transformation – the key to successful rehabilitation of patients with brain damages.

The key factor in the program of *Y. Ben-Yishay* was the work on interaction in small groups, where patients together with each other, family and clinic staff trained to understand and overcome the existing shortage. Many patients began to realize limitations and their capabilities through this command psychotherapeutic work. Interaction of patients in groups was based not only on the discussion of their emotional or cognitive problems, but also on the joint planning and implementation of various life goals (from cooking to helping organize a wedding for a relative or obtaining a bank loan). And, despite the fact that each of the participants was busy with his own rehabilitation, he could assist the rehabilitation of others, thereby improving his self-esteem and finding new life meaning. At the end of rehabilitation, which had lasted for two years, 14 of the 15 most "bad" patients in terms of behavioral rehabilitation prognosis were able to return to work, to establish family and social life.

Back in New York, *Y. Ben-Yishay* modified the program for young patients with brain injuries, and later for other categories of patients [15].

Programs and approaches developed by *Y. Ben-Yishay*, are referred to programs of a holistic approach to rehabilitation [16, 17]. The holistic approach is characterized by a combination of individual and group therapy, interchanging restoration of cognitive functions with psychotherapeutic influence. Thus, individual rehabilitation often includes psychotherapy, restoration of cognitive functions and speech. There are classes in the group work, focusing both on cognitive rehabilitation, and on building the skills of social interaction.

Another major component of psychotherapeutic rehabilitation of patients suffering from brain damages is the work with the family, relatives and friends. It is undoubtedly difficult to a patient with a brain damage and related disorders in a family, as relatives are usually scared and want to make sure that everything is done. Moreover, they do not know exactly what they need to do, and the future frightens them. Relatives are often not ready to fully understand and accept what happened. The important mission of the psychologist working with families is helping realize the changes that occurred in the life of their loved ones and their own lives, in understanding and recognition of the "non-return" to the old life, the need for alteration within the new life script.

In recent decades, another direction of neuropsychological rehabilitation has emerged – the work of neuropsychologist with patients in coma, vegetative and minimally conscious states. The main objectives of this stage are the general activation, disinhibition of the patient, finding ways of interaction and restoration of effective contact, reduction of anxiety, depression and other negative emotions associated with the disease, isolation from family and the stress of hospitalization [18].

Summarizing historical review of the neurorehabilitation development, it should be said that many of the previously developed programs and approaches are used in modern rehabilitation in one form or another. Thus, the teaching of reading in patients with aphasia, as well as in children with disabilities, is based not on the letter-sound analysis, but on using the technique of "global reading." Restoration of movements and actions is initiated in a patient right in the intensive care unit in order to reduce the negative effects of immobilization. The principles of the reorganization of functional mental systems with reliance on external or internal auxiliary aids are the basic methodology of domestic neuropsychological rehabilitation and important technique in foreign rehabilitation. Today, the idea of a comprehensive, holistic approach to a person involving physical, physiological, cognitive and emotional-personal components is the basis of most modern rehabilitation programs. Thus, we observe the continuity of the achievements made in classical studies and experiments in the framework of new approaches.

In conclusion, it should be noted that nowadays neuropsychological rehabilitation is a process of bilateral cooperation between the patient and the staff of the rehabilitation team, family, friends and society in general. It is important that interaction itself is a partnership between all the participants of rehabilitation, where all of them discuss and plan goals, objectives, milestones and expected results collectively [19].



Shepherd Ivory Franz (1920)

Fig. 1. Shepherd Ivory Franz (1874–1933), an American psychologist, a pioneer in the systematic study of the impact of brain injury on the training of animals



Fig. 2. Kurt Goldstein (1878–1965), a German psychiatrist and neurologist, founder of the holistic approach in neurorehabilitation



Fig. 3. Alexander Luriya (1902–1977), the leading Soviet psychologist, founder of the neuropsychology



Fig. 4. A.R. Luriya. Lesson on rehabilitative training with the patient — the co-author of the book

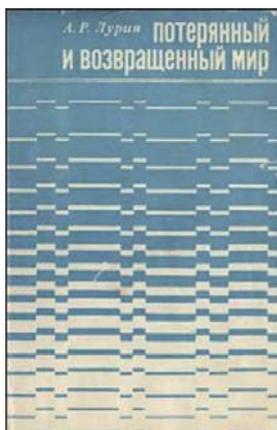


Fig. 5. *The Lost and Returned World* written by A.R. Luriya

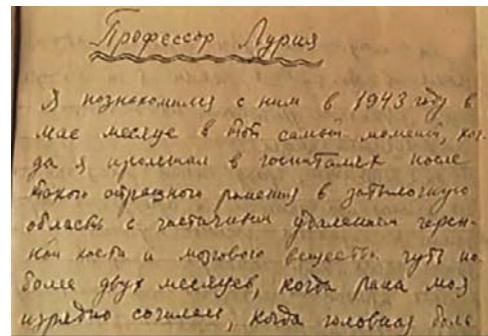


Fig. 6. Lines of a patient's diary, which formed the basis of the book *The Lost And Returned World*

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