Lurian Journal. 2021. Vol. 2, No. 2. P. 109–113.
DOI 10.15826/Lurian.2021.2.2.8
УДК 612.821(091) + 616.133.33 + 57.024

To the 100th Anniversary of E. N. Sokolov

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К 100-летию Е. Н. Соколова

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Abstract. September 23, 2020 is the 100th anniversary of the birth of E. N. Sokolov, one of the founders of Russian psychophysiology. A significant role in E. N. Sokolov's research career belongs to A. R. Luria, who collaborated extensively with E. N. Sokolov in the 50s and endorsed the establishment of the Department of Psychophysiology and the development of international collaborations.

Keywords*: history of neuroscience; vector psychophysiology; psychophysiology of focal brain lesions*

Аннотация*.* 23 сентября 2020 г. исполнилось 100 лет со дня рождения одного из основателей российской психофизиологии Е. Н. Соколова. В становлении Е. Н. Соколова как ученого немалую роль сыграл А. Р. Лурия, который активно работал с ним в 50-е гг., поддержал создание кафедры психофизиологии и способствовал развитию международного сотрудничества.

Ключевые слова*: история нейронауки; векторная психофизиология; психофизиология локальных поражений мозга*

Eugene Nikolayevich Sokolov was born on September 23rd 1920 in Gorky (Nizhny Novgorod). In 1939, he graduated from Public High School No. 2 in Gorky and enrolled in Gorky Institute of Industry, specializing in naval engineering. On his first year of studies, he enlisted in the Red Army and got posted as an interpreter in the investigative unit of the intelligence service of the 3rd Army Division. From 1941 to 1945, Sokolov fought

in the Second World War on the Western, Kalinin, 2nd Baltic-state and First Belarusian fronts, where he served as an interpreter in the intelligence divisions (Chernorizov & Danilova, 2019).

Studentship and doctoral studies. In 1945–1946, Sokolov got an external degree in contemporary German language from Maurice Thorez Moscow State Pedagogical Institute of Foreign Languages.

In those years, Sokolov began to develop his interests in the physiology of higher nervous activity and enrolled in the doctoral program of Psychology section of the Institute of Philosophy, USSR Academy of Sciences. He started working on his doctoral thesis in the psychological laboratories of Prof. Sergey Vasilyevich Kravkov.

Work at the Lomonosov Moscow State University. In 1950, Sokolov defended the doctoral thesis in Philosophy entitled *Problems of Psychology of Perception in the Context of Pavlovian Conditioning*. Upon the completion of the doctoral degree, he was invited to work at the Department of General Psychology of the Faculty of Philosophy. He continued his work on visual perception (Sokolov, 2003).

Collaboration with A. R. Luria. E. N. Sokolov and A. R. Luria started to work together in 1953 when the laboratory of Sensory Receptors at the Department of General Psychology was established (Luria, 2003). At the same time, A. R. Luria invited E. N. Sokolov with his colleagues and students to join his laboratory at the Institute of Defectology, USSR Academy of Pedagogical Sciences. The laboratory employed objective methods of registering vegetative and electroencephalographic reactions in diagnostics of vision and hearing impairments. E. N. Sokolov and his colleagues from the Institute studied the mechanisms of perception and orienting activity, along with the interaction of the two signal systems in normal and pathological conditions (Sokolov, 2003).

In 1950–1961, A. R. Luria was the Deputy-Director for Science at the Institute of Defectology and the Head of the division for clinical and pathophysiological studies of children with abnormal development. Among the techniques that A. R. Luria employed for studying patients with focal brain lesions and developmental retardations, were the methods developed by E. N. Sokolov and colleagues, including students, doctoral students and employees of the two researchers (E. D. Homskaya, M. Yu. Klimovskiy, A. I. Mescheryakov, E. N. Pravdina-Vinarskaya, O. S. Vinogradova, and others) (Luria, 2003). The orienting response is related to the changes in the brain's functional state, which can be reflected in the changes of bioelectrical activity of the cerebral cortex, as well as of the characteristics of the autonomic nervous system; it differs in normal and pathological conditions (Sokolov, 2003).

Research directions included: impairments of vegetative components of the orienting response in focal brain lesions, impairments of the semantic-fields perception, impairments of the general activation level, impairments of motor control (Homskaya, 2004).

The studies conducted at the Institute of Defectology were later published in three collections of works and a number of papers; they were presented as examples in textbooks and collections of works in neuropsychology. The collaboration between the two

researchers gave rise to a novel field of studies between psychophysiology and neuropsychology — psychophysiology of focal brain lesions (Luria, 2003).

Research. Comprehensive studies of the orienting response concluded in 1958 with the publication of E. N. Sokolov's main monograph, entitled *Perception and Conditioned Reflex* (Chernorizov & Danilova, 2019). In 1963, it was published in English by Oxford University Press in the UK and was further distributed in the USA, Japan, Argentina and Mexico.

In 1960, Sokolov defended the thesis (*Perception and Conditioned Reflex*) for the title of Doctor of Sciences in Biological sciences. In 1962, he was awarded the title of Professor of Psychology (Chernorizov, 2010).

In the beginning of the 60s, in the Sensory Receptors laboratory, E. N. Sokolov supervised the emerging psychophysiological studies on the role of memory in perception. The studies addressed not only the psychological functions of memory but also the mechanisms of memory at the cellular level. Sokolov was the first researcher in global neurophysiology to use the methods of extra- and intracellular recordings of the single-neuron reactions. This allowed discovering the specific neural mechanism of anticipatory reflection, i. e., the development of neural stimulus model. The studies resulted in the description of the habituation effect in a single neuron. The works in this filed placed E. N. Sokolov among the leading international psychophysiologists. Studying various sensory receptors and mechanisms of higher nervous activity allowed describing the general principles in the organization of sensory and executive systems. This, in turn, led to creating a theory of sensory-receptor functioning in form of a generalized model called *conceptual reflexive arc*, which can be employed in the development of artificial sensory receptors, for example, in robotics. This model later became the foundation for the vector paradigm of information processing in neural networks (Sokolov, 2003, 2010). The vector paradigm unifies detector and ensemble theories of sensory information encoding within a single self-consistent system. Accordingly, the vector encoding principle applies also to the neural mechanisms of executive and modulating processes, which allows explaining the surprising coherence in the interaction between the sensory domain and the behavior. Within the bases of vector psychophysiology, E. N. Sokolov supervised fundamental studies in comparative biology of color vision in animals and humans (Chernorizov & Danilova, 2019).

In 1970, Sokolov started extensive psychophysiological studies of visual perception of color, shape and depth.

E. N. Sokolov envisioned the research strategy as a *human — neuron — model* cycle. A psychological phenomenon should be initially studied at a macroscopic level; then, its neural mechanisms are analyzed in animal studies, and finally, one creates a model that includes the specifics of the psychological process of interest and its adequate neural characteristics.

In 1971, the Sensory Receptors laboratory was transformed into the Department of Psychophysiology at the Faculty of Psychology. From 1971 to 2001, E. N. Sokolov was

the head of the Department, where he continued to lead and supervise research and academic work and developed international collaborations.

In 1995, E. N. Sokolov initiated the establishment of the Center for Magnetic-Resonance studies in the MSU that provided new perspectives for developing Russian neuroscience and conducting experimental studies.

Teaching activity. E. N. Sokolov was an outstanding teacher. His annually repeated courses at the Moscow State University included Physiology of higher nervous activity, Physiology of sensory receptors, and Psychophysiology. He actively developed specialized courses in Neural intelligence, Orienting response, Information processes in neural networks, and practical courses in Psychophysiology of memory and learning, Neural cybernetics, and Dynamic organization systems. Sokolov wrote guidelines and handbooks for students in such disciplines as *Physiology of Higher Nervous Activity* (part 1–1974, part 2–1981), *Psychophysiology* (1979), *Theoretical Psychophysiology* (1986), *Psychophysiology. Neuron. Computerized Course* (1988). He supervised many course projects and theses, over 70 doctoral theses and 12 theses for the title of Doctor of Sciences (Chernorizov & Danilova, 2019).

As a visiting professor, Sokolov taught at the universities of Cambridge, Oxford, Sofia, Budapest, Helsinki, Stanford University, MIT and Caltech.

International collaborations. E. N. Sokolov was a recognized scientist both in Russia and abroad. He was a member of the USSR Academy of Pedagogical Sciences (since 1984), a member of the Russian Academy of Education (since 1993), a visiting professor at MIT (since 1974), a member of the National Academy of Sciences of the USA (since 1975), an honorary member of the International Organization of Psychophysiology (since 1980), a member of the Finnish Academy of Science and Letters (since 1984), a member of the International Academy of Informatization (since 1993), professor emeritus of the Moscow State University (since 1998), a member of the Central Council of the International Organization for Brain Studies affiliated with UNESCO (Chernorizov, 2010).

In 1984, he was awarded the Pavlov Gold Medal Award for the studies of higher nervous activity. In 1988, American Society for Psychophysiological Research presented E. N. Sokolov with a special diploma "For outstanding contributions to psychophysiology," which is awarded to researchers whose works of fundamental nature have a significant effect on the development of science. In 1989, he received a distinction award from the Society for Psychophysiological Research (USA). In 1993, E. N. Sokolov was awarded the Lomonosov medal for high quality of teaching courses and lectures. In 1997, he received "the medal of the century" from the International Organization of Psychophysiology, and in 1998, the same Organization presented him with the Prize of the Century-1998 (the highest award of the Organization) (Chernorizov & Danilova, 2019).

E. N. Sokolov died on May 14th 2008 at the age of 88.

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Original manuscript received September 04, 2020
Revised manuscript accepted September 15, 2020

To cite this article: Nikonova, E. Yu. (2021). To the 100th anniversary of E. N. Sokolov. *Lurian Journal, 2*(2), pp. 109–113. doi: 10.15826/Lurian.2021.2.2.8