***Institute for Information Transmission Problems***

# LABORATORY 9

## *Laboratory of Neurobiology of Motor Control*

Head of Laboratory – Full member of the Russian Academy of Sciences,
Dr.Sc. (Medicine), Prof. Victor Gurfinkel
Tel.: (095) 209-28-95, (095) 951-09-60; E-mail: lab9@iitp.ru

The leading researchers of the laboratory include:

| | | | |
|---|---|---|---|
| Dr.Sc. (Biol.) | M. Lipshits | Dr. | Yu. Levik |
| Dr. | A. Grishin | Dr. | K. Popov |
| Dr. | Yu. Ivanenko | Dr. | V. Selionov |
| Dr. | O. Kazennikov | Dr. | V. Shlykov |
| Dr. | G. Kozhina | Dr. | B. Smetanin |
| Dr. | V. Talis | Dr. | I. Solopova |

## DIRECTIONS OF ACTIVITY

Laboratory of neurobiology of motor control investigates the mechanisms of control of posture and movements for more then 25 years. At present time the efforts are focused at study of system of internal representation and its role in motor control and at the investigations of reference systems used by brain for organization of motor behavior. During last years it was shown that in situations with discrepancy between real and perceived position of body segments many motor reactions such as vestibulo-motor and neck influences on leg muscles or oculomotor reactions are determined not by real body configuration but by its description in the system of the internal representation.

In the activity of laboratory the studies of neural mechanisms of locomotion in cat traditionally took an important place. Now we begin to study stepping automatisms in humans. These studies successfully advance.

Manned spacefights open a possibility for studying how the human central nervous system adapts to the microgravity, to what extent the gravitation is essential for processing of proprioceptive information and for motor control. A series of joint research projects with France and other countries was accomplished in this direction during 1982-2002 under conditions of real spaceflights.

## MAIN RESULTS

Studies of a role of proprioceptive feedbacks in control of voluntary movements permitted to formulate theoretically important conclusion that the models of motor coordination can not be constructed only on the basis of analysis of one-joint (laboratory) movements, as in this case only a direct control, one feedback and one copy of a motor command are used. In an example of natural movement (rising when laying on a back without the help of hands) it is shown, that alongside with muscles realizing the basic pattern of movement, many more other muscles participate in movement. Their activity can have auxiliary character or to be useless. In realization of

natural movements the different physiological mechanisms are used simultaneously and consistently: a direct control, synergies, automatisms and reflexes. Feedbacks also are of complex character. The coordination provides the compromise of mobility and stability. It was shown, that the muscles of the trunk actively participate in dynamic stabilization of a pose. This dynamic stabilization is combined with fixating activity of muscles of a back.

The hypothesis is confirmed that the anticipatory eye movements in response to axial torsion of a spine are determined by changes in internal representation of body configuration, instead of direct proprioceptive inputs. Such anticipatory orientation probably helps in elaboration of stable reference system necessary for programming and realization of movements. It is interesting also, that these experiments clearly demonstrate the connection between higher (level of a spatial field) and lower (level of synergies) levels of motor control system (according N.A. Bernstein classification).

It was shown, that CNS can elaborate the system of coordinates connected to external space and used for perception of body movements, not only on the basis of visual and vestibular information, but also on the basis of proprioceptive signals. In this situation the domination of sensation of reciprocating movements or turns is directly connected to prevalence of signals from receptors of certain muscles.

Within the framework of cooperation with laboratory of motor systems of neurological of clinic of the Bern university headed by prof. M. Wiesendanger, and laboratory of neurophysiology of hearing and motor control of Institute of physiology of Frieburg university the analysis of the data on coordination of movements of hands during playing on a violin was carried out. With the help of ELITE system movements of fingers of the left hand and movements of a bow held in the right hand were recorded. The preliminary analysis shows, that the pressing of a string by fingers of the left hand occurs at the moment of change of a direction of movement of a bow. It was shown, that the interval between a point of turn of a bow and pressing of a string did not differ in different subjects, though techniques of execution of a musical phrase differed considerably.

With the purpose of finding-out, how the accuracy of internal representation of lengths of body parts varies during maturing of motor system, we measured the accuracy of the indication of characteristic points of a forelimb without the visual control in adults and children (4-11 years). It was shown that in children, as well as in adults, the apparent shortening of a limb occur, and the hand is shortened stronger, than forearm. In children of 4-6 years the length of a limb as a whole also decreased by 40%. It is connected with more expressed underestimation of forearm length in children. The dispersion of the data in the children is more pronounced than in adults. This, apparently, is connected with unequal speed of maturing of the appropriate brain structures.

The method of transcranial magnetic stimulation permitted to demonstrate the increase of a role of motor cortex in postural regulation after increase of complexity of the motor task. For study of supraspinal influences we applied transcranial magnetic stimulation to human motor cortex during standing on a steady or unstable support. After transition from standing on a firm floor to standing on an rocking platform absolute EMG – response on transcranial magnetic stimulation grew by 2,7 times. The amplitude of H-response reflecting the reflex excitability of spinal motoneurons, did not change. Thus, the increase of EMG – responses on transcranial magnetic stimulation is connected not to the increase of reflex excitability of spinal motoneurons, but with the increased involvement of cortical structures. The postural control on an un-

stable support represents a more complex task and consequently requires involving of high-level supraspinal structures in process of sensory-motor integration for maintenance of balance.

The studies of vestubular tonus of the man by a method galvanic stimulation of labyrinth were commenced. The experiments confirm theoretical predictions, according to which the level of tonic activity in vestibular nerves determines a difference in magnitude of postural reactions on unilateral galvanic stimulation of a labyrinth. The data obtained demonstrate high inter-individual distinctions in the level of vestibular tonus.

In 2002 two dissertations were defended:

– M. I. Lipshits – for degree of the doctor of biological sciences in biomechanics "Sensory-motor interaction and system of internal representation of the man (research in ground conditions and in weightlessness)".

– I. A. Solopova – for degree of the candidate of biological sciences in biomechanics "Structurally functional features of the system of maintenance of human vertical posture".

## GRANTS FROM:


- **Russian Foundation of Basic Research (No. 00-04-48156):** "The investigation of supraspinal control and adaptive mechanisms mechanisms of equilibrium maintenance on unstable support" (head Yu. Ivanenko).
- **Russian Foundation of Basic Research (No. 02-04-48234):** "Proprioceptive perception and calibration of internal model of a body" (head Yu. S. Levik).
- **Russian Foundation of Basic Research (No. 02-04-48302):** "The study of vestibular tonus in man by a method of galvanic stimulation of labyrinth" (head K. E. Popov).


## PUBLICATIONS IN 2002

Articles


1. Grishin A.A., Lenskiy A.V., Ochazimskiy D.E., Panin D.A. About synthesis of management of unstable object. The inverted pendulum // Bull. Russ. Acad. of Sciences. Theory and control systems. 2002 No. 5. P.14-24 (in Russian).
2. Roux K, Gentil C, Grishin A. Modeling of human posturokinetic movements by a linear feedback system: relations among feedback coefficients, Percept Mot Skills. 2002 Aug; 95(1):308-18.
3. Lipshits M. I., Gurfinkel V.S., De Shonen S., McIntyre J., Bertoz A. Gravitation and hemispheric specialization of a brain in a task of detection of bilateral of symmetry // Human Physiology. 2002. V. 28. No. 2. P. 5-11 (in Russian).
4. Lipshits M.I., Gurfinkel V.S., Lestienne F., Roll J-P. Neurophysiological research in weightlessness. I. Regulation of posture and movements. – In: Orbital station "MIR". Space biology and medicine. V. 2. Published by State Scientific Center of Russian Federation "Institute of Medical and Biological Problems", 2002. P. 479-494 (in Russian).
5. Lipshits M.I., McIntyre J., Bertoz A. Neurophysiological research in weightlessness. II. Sensori-motor interaction and internal reference system. – In: Orbital station "MIR". Space biology and medicine. V. 2. Published by State Scientific Center of

Russian Federation "Institute of Medical and Biological Problems", 2002. P. 495-510 (in Russian).
6. Smetanin B.N., Popov K.E., Kohzina G. V. Human postural reactions on the vibratory stimulation of shank muscles under conditions of visual inversion // Human Physiology. 2002. V. 28. No. 5. P. 53-58 (in Russian).
7. Solopova I.A., Ivanenko Y.P., Levik Y.S. Postural vibratory reactions in man in a frontal plane during standing on various types of unstable support // Human Physiology. 2002. V. 28. No. 3. P. 76-81 (in Russian).
8. Solopova I.A., Kazennikov O.V., Deniskina N.V., Ivanenko Y.P., Levik Y.S. Comparison of the responses of leg muscles on transcranial magnetic stimulation during standing on a steady and unstable support // Human Physiology. 2002. V. 28. No. 6. P. 80-85 (in Russian).
9. Kazennikov O., Perrig S., Wiesendanger M. Kinematics of a coordinated goal-directed bimanual task // Beh. Brain Res. 2002.V. 134. P. 83-91.
10. Solopova I.A., Kazennikov O.V., Deniskina N.B., Levik Y.S., Ivanenko Y.P. Postural instability enhances motor responses to transcranial magnetic stimulation in humans // Neuroscience Letters. 2002. V. 337. No. 1. P. 25-28.
11. Bresciani J.-P., Vercher J.-L, Blouin J., Popov K., Bourdin C., Sarlegna F., Gauthier G.M. Galvanic vestibular stimulation in humans produces online arm movement deviations when reaching towards memorized visual targets // Neuroscience Letters. 2002. No. 318. P. 34-38.
12. Cordo P, Flores-Vieira C, Verschueren S, Inglis T, Gurfinkel V. Position Sensitivity of Human Mascle Spindles: Single Afferent and Population Representation // J. Neurophysiol. 2002. V. 87. P. 1186-1195.
13. Hadges P.W., Gurfinkel V.S., Brumagne S., Smith T.C., Cordo P.C. Coexistence of stability and mobility in postural control: evidence from postural compensation for respiration // Exp. Brain Res. 2002. No. 144. P. 293-302.
14. Cordo P., Gurfinkel V. Motor coordination can be fully understood only by stadying complex movements // Prog. Brain Res. (in press).

Abstracts

1. Deniskina N. V. Changes of standing stability of the man depending on a configuration of his supporting contour in a frontal plane // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 121 (in Russian).
2. Kireeva T.B., Levik Y.S., Kholmogorova N.V. Accuracy of internal representation of lengths of body parts during maturing of motor system // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 142 (in Russian).
3. Levik Yu. S., I.L. Livshits. Elaboration of hapto-kinetic sensations in complex two-joint movement // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 144 (in Russian).
4. Levik Yu.S. System of internal representation in control of a posture and movements // The scientific-theoretical conference "Internal state and voluntary behaviour". Institute of higher nervous activity and neurophysiology. Moscow, April 10, 2002. P. 8-9 (in Russian).
5. Popov K.E., Smetanin B.N., Kohzina G. V. Application of a method of galvanic stimulation of a labyrinth for study of human vestibular tonus // VI All-Russia confer-

ences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 161 (in Russian).

6. Selionov V. A., Kazennikov O.V., Grishin A.A. Kinematical analysis automatic of stepping, activated by electrical stimulation of the muscles of the suspended legs // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 169 (in Russian).

7. Solopova I.A., Deniskina N.V., Kazennikov O.V. Involment of motor cortex in postural control during standing on a steady and unstable support // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 174 (in Russian).

8. Shlykov V.Y., Selionov V.A. A role of additional afferent input from hand in postural control under the conditions of moving support surface // VI All-Russia conferences on the biomechanics. Abstracts: Published by Inst. Appl. Physics of Rus. Ac. Sci., 2002. P. 195 (in Russian).

9. Belen'kiy V.E., Grishin A.A., Krivosheina E.N. Device and method for functional electric stimulation of the patients with diseases of muscular and nervous systems // Fifth Moscow's scientific-practical conference. Moscow, October 23, 2002. Abstracts of reports, p. 20 (in Russian).

10. Wiesendanger M., Baader A., Kazennikov O., Marro H., Milani P. Bimanual Coordination in Violin Playing // Symposium "Music, Motor Control, and the Mind" (Monte Verità, Ascona, Switzerland, 15-18 May, 2002). Abstracts. P. 33.

11. Kazennikov O., Baader A., Wiesendanger M. Features of Fingering and Bowing in Playing the Violin // Symposium "Music, Motor Control, and the Mind" (Monte Verità, Ascona, Switzerland, 15-18 May, 2002). Abstracts. P. 17.

12. McIntyre J., Lipshits M., Berthoz A. The neuroscience of perception and action in the absence of gravity: collaborative research aboard the MIR station // XII конференция по космической биологии и авиакосмической медицине (г. Москва, 10-14 июня 2002 г.). С. 518-519.

13. Solopova I.A., Kazennikov O.V., Deniskina N.B., Levik Y.S., Ivanenko Y.P. (2002) Involvement of the human motor cortex in postural control during standing on stable and unstable support // Society for Neuroscience. Session 407-610 (Orlando, Florida, USA, November 2-7, 2002). Abstracts. P. 75.

14. Talis V.L. Elbow joint position sense in elderly humans // International Congress "Movement, attention & perception" (Poitiers, France. June 19-21, 2002). Proceedings. P. 65.

15. Talis V.L. Elbow joint position sense in elderly humans // Society for Neuroscience (Orlando, Florida, USA, November 1-7, 2002). Abstracts. P. 74.