Investigation of the proprioceptive system by vibrotactile stimulation of the foot with fMRI

SM Golaszewski[1,4], M Seidl[1], A Kunz[1], E Gallasch[2], M Christova[2], R Nardone[3], E Trinka[1], F Gerstenbrand[4]

1 Department of Neurology and Neuroscience Institute, Paracelsus Medical University, Salzburg, Austria
2 Department of Physiology, Medical University Graz, Austria
3 Franz Tappeiner Hospital, Meran, Italy
4 Karl Landsteiner Institute for Neurorehabilitation and Space Neurology, Vienna, Austria

PURPOSE: The aim of the study was to investigate the human proprioceptive system in healthy subjects and in patients with severe brain damage and to develop a paradigm for the brain mapping of proprioceptive foot stimulation with vibration. Especially optimal parameters (e.g. vibration amplitude, amplitude, modulation, vibration frequency) should be elaborated for the functional diagnosis of the proprioceptive system in a clinical environment.

METHODES: 15 healthy male subjects (25–45yrs) and 22 patients (19-78yrs) were stimulated with a vibrotactile stimulus within the arch of the right foot by a fully automated moving magnet actuator system and at the first and second toe with a cuff-type pneumatic stimulator. The healthy subjects were examined using the moving magnet actuator. The carrier frequency was held constant at 100 Hz at a fixed modulation frequency of 25Hz and a fixed stimulus intensity of 0.05N throughout the fMRI run. The 4 vibration conditions were in detail: 0.25mm amplitude and a carrier frequency of 50Hz, 0.25mm amplitude with a carrier frequency of 50Hz and an amplitude modulation of 25Hz, 1 mm amplitude with a carrier frequency of 50Hz, 1mm amplitude with a carrier frequency of 50Hz with an amplitude modulation of 25Hz. The sequence of stimuli was randomized for each subject. Stimulus duration was one second. 2 patients were also examined with the moving magnet actuator system, but due to applicability reasons, the stimulation device was switched to a cuff type pneumatic stimulator. The hardware consists of the pneumatics with control unit to be operated outside the MR-room and the inflatable cuff connected to the pneumatics via 5- 7 meter flexible tubing. The pneumatics consists of a piezoelectric servo valve driven by a constant input pressure (2 bar) produced by a pressure regulator. Forward control of the servo valve allows the output pressure to be adjusted within a frequency range of 1- 40 Hz and amplitude between 0- 400 mbar. The cuff was made from a small rectangular air-bag to be wrapped around the toes with a Velcro strip. By the control unit various stimulus patterns are selectable. Twitch-like pressure pulses (rise time 10 ms) with a mean pressure below 70 mbar were implemented.

RESULTS: FMRI group data of the 15 healthy subjects showed brain activity within the main centers of the primary and secondary sensorimotor cortex. The between-group analysis 0.25mm versus 1mm amplitude showed significant differences within or near the pre- and postcentral gyrus bilaterally and the right inferior, medial and middle frontal gyrus. The between group results 1mm versus 0.25mm amplitude showed significant differences within or near the inferior parietal lobule, the superior temporal gyrus, the temporal transverse gyrus, the caudate nucleus, the middle cingulate gyrus, the insula and the hippocampus on the left side. Only in 7 out of 22 patients a specific response within the primary and secondary sensorimotor cortex could be elicited.

CONCLUSION: In this study it could be shown that vibrotactile stimulation of the foot in healthy subjects can elicit specific brain responses in main centers of the sensorimotor system and in centers of attention and arousal. With the presented paradigms for foot vibration in fMRI it was possible to map in detail the cortical representation of the proprioceptive system of the foot. The paradigms offer the possibility of a functional diagnosis and a monitoring of the proprioceptive system in neurorehabilitation, e.g. in subjects with degradation of the proprioceptive system (space disease, bedrest syndrome) and in patients with severe brain damage for the planning of specific rehabilitation strategies and the induction of arousal. It is currently under investigation whether the information about the proprioceptive system contains predictive value in patients with acute or chronic brain damage, e.g. in patients remaining in an unresponsive wakefulness syndrome.

Н.М. Фокина, А.А. Иванова, М.Г. Тавитова, Б.С. Шенкман
ГНЦ РФ – Институт медико-биологических проблем РАН, г. Москва

НЕИНВАЗИВНАЯ АКТИВАЦИЯ ГЕНЕРАТОРОВ ШАГАТЕЛЬНЫХ ДВИЖЕНИЙ У ЧЕЛОВЕКА

Ю.П. Герасименко[1,4], Р.М. Городничев[2], И.Б. Козловская[3], Р. Эджертон[4]
[1]Институт физиологии им. И.П. Павлова РАН, г. Санкт-Петербург
[2]Великолукская государственная академия физическойкультуры и спорта, г. Великие Луки
[3]ГНЦ РФ – Институт медико-биологических проблем РАН, г. Москва
[4]Департамент физиологических исследований Калифорнийского университета, Лос-Анджелес, США

Заседание 2. 14.00 – 16.30

COUNTERMEASURES TO ENHANCE SENSORIMOTOR ADAPTABILITY

J.J. Bloomberg[1], A.P. Mulavara[2], B.T. Peters[3], R.A. Brady[3], C.D. Batson[4], C.A. Miller[3], H.S. Cohen[5]
[1]NASA-Johnson Space Center, Houston, TX, USA
[2]Universities Space Research Association Division of Space Life Sciences, Houston, TX, USA,
[3]Wyle Integrated Science and Engineering Group, Houston, TX, USA
[4]MEI Technologies, Inc., Houston, TX, USA
[5]Bobby R. Alford Department of Otolaryngology Head and Neck Surgery, Baylor College of Medicine, Houston, TX, USA

A SIMPLE POSTFLIGHT MEASURE OF POSTURAL ATAXIA IN ASTRONAUTS

M.F. Reschke, D.L. Harm, I.S. Kofman, S.J. Wood, J.J. Bloomberg
NASA Johnson Space Center, 2101 NASA Parkway, Houston, TX 77058, USA

АКТИВАЦИЯ СЕНСОМОТОРНОЙ КОРЫ ПРИ ИСПОЛЬЗОВАНИИ АППАРАТА ДЛЯ МЕХАНИЧЕСКОЙ СТИМУЛЯЦИИ ОПОРНЫХ ЗОН СТОПЫ

Е.И. Кремнева, Л.А. Черникова, Р.Н. Коновалов, М.В. Кротенкова, И.В. Саенко, И.Б. Козловская
ГНЦ РФ – Институт медико-биологических проблем РАН, г. Москва

INVESTIGATION OF THE PROPRIOCEPTIVE SYSTEM BY VIBROTACTILE STIMULATION OF THE FOOT WITH FMRI

S.M. Golaszewski[1,4], M. Seidl[1], A. Kunz[1], E. Gallasch[2], M. Christova[2], R. Nardone[3], E. Trinka[1], F. Gerstenbrand[4]
[1]Department of Neurology and Neuroscience Institute, Paracelsus Medical University, Salzburg, Austria
[2]Department of Physiology, Medical University Graz, Austria
[3]Franz Tappeiner Hospital, Meran, Italy
[4]Karl Landsteiner Institute for Neurorehabilitation and Space Neurology, Vienna, Austria

АКТИВНЫЙ ТРАНСПОРТ ГЛУТАМАТА В НЕРВНЫХ ТЕРМИНАЛЯХ ГОЛОВНОГО МОЗГА В УСЛОВИЯХ ГИПЕРГРАВИТАЦИИ

Т.А.Борисова, Н.В. Крысанова
Институт биохимии им. А.В. Палладина НАН Украины, г. Киев

ФЕДЕРАЛЬНОЕ КОСМИЧЕСКОЕ АГЕНТСТВО,
РОССИЙСКАЯ АКАДЕМИЯ НАУК,
ФЕДЕРАЛЬНОЕ ГОСУДАРСТВЕННОЕ БЮДЖЕТНОЕ УЧРЕЖДЕНИЕ
«НАУЧНО-ИССЛЕДОВАТЕЛЬСКИЙ ИСПЫТАТЕЛЬНЫЙ ЦЕНТР ПОДГОТОВКИ КОСМОНАВТОВ имени Ю.А. ГАГАРИНА»,
УЧРЕЖДЕНИЕ РОССИЙСКОЙ АКАДЕМИИ НАУК
ГОСУДАРСТВЕННЫЙ НАУЧНЫЙ ЦЕНТР РОССИЙСКОЙ ФЕДЕРАЦИИ-
ИНСТИТУТ МЕДИКО-БИОЛОГИЧЕСКИХ ПРОБЛЕМ РАН

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20-21 октября 2011 г.
Президиум РАН,
Ленинский проспект, 32

20. - 21. October 2011
Presidium of the Russian Academy of Sciences
Leninsky Prospekt 32
Moscow

ГРАФИК