Free motor skills

Free motor skills is the ability of the organism to perform targeted, will-controlled movements. Almost all structures of the CNS are used in it. The stimulus to perform free movement usually comes from Association cortical areas. The basis of every movement are movement patterns stored in subcortical structures, especially the basal ganglia and the cerebellum. The movement itself is then realized through the motor cortex areas. The final stimulus descends through Spinal pathways to α- and γ-motoneurons and interneurons of the anterior spinal horns (or cranial nerve ganglia), where it is connected to individual motor nerves.

Motor cortical areas

For more information see cerebral cortex. In the implementation of free movement, **motor cortical areas** are used:

- **primary motor area** (MI, Brodman area 4, gyrus precentralis);
- **premotor area** (PM, area 6, gyri frontales);
- **supplementary motor area** (MII, area 6, medial surface of the superior frontalis gyrus). [1]

Motor areas are disproportionately somatotopically arranged – muscle groups that are used in fine motor skills (hand muscles), facial expressions or voice production have a significantly larger share than the areas for axial and limb muscles. This arrangement is referred to as a **motor homunculus**.

Individual areas represent either individual muscles, but more often entire movements. The motor cortex is plastic – learning a complex movement causes the corresponding cortical area to enlarge. [2]

Neurons are arranged in columns acting as a functional unit stimulating a muscle or a group of synergistically working muscles. As a rule, 50-100 pyramidal cells need to be stimulated to realize a muscle contraction. [3]

Functions of motor areas

The primary motor area is active during the realization of the movement itself, it is mainly under the influence of the cerebellum [1].

The premotor area, on the other hand, is triggered already when planning a movement (and even just imagining it) and is un the strong influence of the basal ganglia [1]. It is reported to be used in the execution of more complex movements and complex movement patterns [3].

The supplementary motor area sis involved in the activation of axial muscles and proximal muscles of the limbs (postural muscles), during the implementation of bilateral movements [1], it realizes more complex movement patterns. It is also under the influence of the basal ganglia. It is also reported to integrate sensory information, use memory traces [1] and participate in eye and head movements [3].

There are also specific cortical areas designated for a specific activity, e.g. Broca's speech center, frontal oculomotor field, head rotation area, manual skills area [3].

Motor planning

The primary stimulus for movement usually comes from the prefrontal association area (area 9, 10, 11, 12, 46, 47), which receives from the parieto-temporo-occipital association area information about the position of the body coming from visual, auditory and sensitive areas [3].

Two circuits are used in movement planning:

- **basal ganglia circuit** – implements basic movement patterns;
- **the circuit cortex – pons– cerebellum– cortex**– ensures precise coordination, smoothing of movement, implementation of more complex learned movements (e.g. dancing).

Basal ganglia circuit

For more information see basal ganglia.

The basal ganglia circuit consists of:

- direct path: přímá dráha: **cortex – striatum – globus pallidus medialis (pallidum internum) – thalamus – cortex ;**
- indirect path: **cortex – striatum – globus pallidus lateralis (pallidum externum) – ncl. subthalamicus – globus pallidus medialis – thalamus – cortex.** [1]

Cortical projections to the striatum come from most areas of the cerebral cortex. There are 4 different basal ganglia loops that provide different functions: oculomotor, association, limbic and sensorimotor.

It is the **sensorimotor loop** that is involved in the realization of movement. The input nucleus here is the *putamen*, which receives fibers from the primary motor area, the supplementary motor area, the premotor area and the primary sensitive area. The output from the *globus pallidus medialis* (output nucleus) is to the *VA nuclei of the thalamus*. Subsequently, the information continues to the premotor and supplementary motor areas - area 6. At the same time, the basal ganglia send impulses to the trunk, mainly to the reticular formation, via the *substantia nigra - pars reticularis*. [1][4]

In a resting state, the thalamus is suppressed by the spontaneous activity of the globus pallidus medialis. If a stimulus for movement comes from the cortex, the striatum is activated, which is inhibited by the globus pallidus medialis and the substantia nigra – pars reticularis. This disinhibits the thalamus and it can activate the premotor area.

Furthermore, the influence of intermediate - intrinsic cores is applied:

- globus pallidus lateralis, ncl. subthalamicus – they inhibit the thalamus through an indirect pathway;
- substantia nigra - pars compacta - by producing dopamine, increases activity in the direct pathway (D1 receptors) and decreases activity in the indirect pathway (D2 receptors). [1]

The basal ganglia store basic movement patterns. They transmit stimuli via the thalamus to the motor cortex, but also directly via the reticular formation to the spinal cord. A disorder of the basal ganglia is manifested by hypokinesia (Parkinson's disease - degeneration of the nigrostriatal dopaminergic projection) or, on the contrary, by hyperkinesia (chorea, hemiballismus - large, uncoordinated jerky movements). [2]

Cerebellar circuit

Cerebellum acquires through tr. corticopontocerebellaris information from association areas, premotor and primary motor areas, sensitive areas, gyrus cinguli and parahippocampalis. In the cortex of the cerebellar hemispheres, these fibers end as mossy fibers. At the same time, he receives via tr. spinocerebellaris anterior, posterior and rostralis and tr. cuneocerebellaris information from proprioceptors and γ-loops and via the tr. vestibulocerebellaris directus et indirectus from the vestibular apparatus. [1][5]

The cerebellum inhibits most incoming information. By integrating incoming signals, it coordinates movements, is involved in fine motor skills and complex movement patterns, adjusts motor activity in feedback and participates in movement planning.

The resulting information is transmitted by:

- via ncl. fastigii and interpositi to the brainstem and spinal cord – tr. vestibulospinalis, reticulospinalis, rubrospinalis to activate antigravity muscles and proximal limb muscles;
- via ncl. dentatus and thalamus (VL nuclei) to the primary motor cortex and via the tr. corticospinalis to activate the distal limb muscles. [5]

Management

Free movement is then the result of the synthesis of the influences of all these structures. The planned movement is realized mainly through tr. corticospinalis, secondary motor pathways ensure the correct position of the body when performing movement and ensure correction by the cerebellum.

Tractus corticospinalis

For more information see Corticospinal tract.

In humans, the main motor pathway is the **tractus corticospinalis**. Threads come from [2]:

- 30 % – area 4 (primary motor cortex);
- 30 % – area 6 (premotor area);
- 40 % – area 3, 2, 1, 5, 7.

It runs from the center of the semiovale through the capsula interna (crus posterior), crus cerebri, creates fragmented bundles of pyramids in the bridge and raises the pyramid in the medulla oblongata.

- 80% of fibers cross in decussation pyramidum and continue as tr. corticospinalis lat. ending on interneurons and α-motoneurons of the anterior spinal horns. These neurons mainly activate the distal limb muscles.
- The remaining 20% leads uncrossed as tr. corticospinalis ant., crosses as far as the spinal cord at the appropriate level (commisura anterior) and ends mainly on interneurons. Controls axial and proximal limb muscles [2].

Other tracks

- **Tr. corticonuclearis** going together with tr. corticospinalis to the motor nuclei of the cranial nerves.

- **Tr. corticotectalis** and subsequent tr. tectospinalis conducting fibers from the visual oculomotor field (area 8), area 6, visual areas (17, 18, 19). It is used to coordinate the movements of the eyes, head and neck.
- **Tr. corticoreticularis** with fibers from area 4, 6 and the primary sensory area (area 3, 1, 2) to the reticular formation [2]. After connecting with threads from ncl. interpositi cerebellum follows tr. reticulospinalis to activate the γ-loop, flexors and proximal limb muscles [5].
- **Tr. vestibulospinalis medialis and lateralis** originates from the ncl. vestibularis lateralit Deitersi, which receives fibers from the ncl. fastigii cerebellum, and leads to the antigravity muscles (extensors). [5]

Through the last two pathways, the vestibular cerebellum regulates the realized movements and adjusts them based on the current situation. [6]

Links

Related articles

- Basal ganglia
- Cerebellum
- Motor system
- Cerebral cortex

External links

- Canadian Institutes of Health Research. *The Brain from Top to Bottom* [online]. [cit. 2011-04-23]. <http://thebrain.mcgill.ca/flash/index_a.html>.

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