Superior Frontal Gyrus

Synonyms
▷ Gyrus front. sup.

Definition
In the area of the frontal gyrus close to the precentral gyrus is situated the premotor cortex, which plays an important role in planning effector voluntary movements and has close interaction with the cerebellum, thalamic nuclei and basal ganglia.

At the level of the superior frontal gyrus is situated the frontal eye field, which is involved in planning voluntary eye movements. Hyperactivity of these neurons due to hemorrhage or tumors causes conjugate movements of both eyeballs (deviation conjugee). Conversely, destruction of tissue causes ipsilateral deviation conjugee, since now the activity of the contralateral eye field no longer has an antagonist.

▷ Telencephalon

Superior Longitudinal Fasciculus

Synonyms
▷ Fasciculus longitudinalis sup.

Definition
With its two branches (anterior brachium and posterior brachium), the superior longitudinal fasciculus establishes connections between virtually all cortical areas.

The part of the fasciculus connecting the motor (Broca’s) speech center with the sensory (Wernicke’s) speech center is called the arcuate fasciculus.

▷ Pathways

Superior Oblique Muscle

Definition
Superior oblique is one of the six eye muscles.

▷ Eye Orbital Mechanics

Superior Olivary Nuclei

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Synonyms
Nuclei of the superior olive; Superior olivary complex; SOC

Definition
The superior olivary nuclei are a group of nuclei located in the brainstem near the junction of the pons and medulla. It is the first auditory relay after the cochlear nucleus on the way to the auditory cortex and is the major point at which information from the two ears is integrated.

Characteristics
Introduction
The superior olivary nuclei or complex (SOC), as they are more commonly called, occupy an important and unique position in the ascending auditory pathway. The SOC lies at the ponto-medullary border. Acoustic information is conducted from the outer ear into the inner ear where the cochlea transduces the mechanical energy into neural impulses that are conveyed by the auditory nerve fibers, which compose one component of the VIII cranial nerve, into the central nervous system. The other component of cranial nerve VIII is the vestibular nerve which originates from the vestibular apparatus of the inner ear. All auditory nerve fibers
.synapse in the cochlear nuclei where there is some initial processing of the afferent information. Cells in the cochlear nuclei then project to the SOC of both sides so that the SOC represents the first major point at which cells combine the inputs from the two ears. Therefore the SOC is a critical point for processing of binaural information which is essential for accurate sound localization. To understand the neural processing, we must first consider what cues are needed for sound localization.

Imagine walking down the street of a town late at night and suddenly hearing a strange sound. In this situation, there are two important tasks that our auditory system must do. It has to identify the sound (a cat meowing or the footsteps of a possible mugger) and it has to tell us where the sound comes from. We understand very little about how the auditory system can identify sounds but considerably more about the neural processes that underlie the ability to establish where a sound originates.

Note that the problem of localizing a stimulus is quite different for the auditory system than it is for the other two major sensory systems, vision and somatosensation. In both of the latter systems the location of a stimulus is naturally encoded in the location of the sensory receptor since there is a map of the space in the sensory epithelium, in the retina for the visual system and on the body surface for the somatosensory system. By contrast, the inner ear contains a map of the frequency, not location, of the sound. The location of the sound must then be computed by the nervous system by analyzing the small differences between the sounds at the two ears, interaural time differences (ITDs) and interaural level differences (ILDs), also called interaural intensity differences, IIDs). A remarkable feature of the auditory system is its sensitivity to these interaural disparities: the maximum ITD for the human head when a sound is opposite one ear is about 800 μs while human subjects can detect ITDs as small as 10 μs.

The maximum ILD is heavily dependent upon the frequency of the sound since the head acts as an effective acoustic shadow only for sounds with wavelengths that are shorter than the dimensions of the head, i.e. for high frequency sounds. Thus maximal ILDs are on the order of 20–30 dB at 15–20 kHz at the upper end of human hearing and only a few dB at the lower end of human hearing. Therefore, we would expect ILDs to be an effective cue only at high frequencies. The width of an average human head is around 15 cm which corresponds to the wavelength of a 2,000 Hz tone. Therefore ILDs should be effective for frequencies above 2 kHz and ineffective for lower frequencies. On the other hand the phase-locking that encodes temporal patterns in the cochlea is also frequency dependent: in mammals auditory nerve fibers will only phase-lock to tones below about 2–3 kHz. Therefore timing information about the fine structure of sounds is only preserved at low frequencies and ITDs would only be effective at those frequencies. The frequency dependence of ITDs and ILDs is the basis for the classical duplex theory of sound localization [1].

Where in the nervous system are these cues encoded? The most likely candidates are the nuclei in the superior olivary complex (SOC) which occupy a unique position in the ascending auditory pathway: they represent the first major point at which cells in the auditory system combine the inputs from the two ears. These inputs arrive from the anteroventral cochlear nucleus of both sides and they are shown in Fig. 1 from a classical drawing of the left SOC [2] from Golgi stained sections of the neonatal cat. In Fig. 1 the midline is to the right and the three major nuclei can be discerned from lateral (left) to medial (right): lateral superior olive (LSO), medial superior olive (MSO) and the medial nucleus of the trapezoid body (MNTB). In the cat in coronal sections the LSO takes the appearance of a prominent S-shape while the MSO is a narrow nucleus. The LSO and MSO are the key players in the encoding of the two interaural cues of ITDs and ILDs.

Processing of Interaural Time Differences

Fig. 2 shows simplified versions of the circuits that are believed to be important for encoding the interaural cues of ITDs and ILDs. ITDs are believed to be encoded by cells in the medial superior olive (MSO). Anatomically, cells in the MSO receive excitatory inputs from the spherical bushy cells of the anteroventral cochlear...
nucleus of each side. MSO cells are unusual cytoarchitecturally in having prominent dendrites that extend to the lateral and medial side where they meet the afferents from the left and right side (Fig. 1). The afferents from the ipsilateral cochlear nucleus synapse on the lateral dendrites while those from the contralateral side synapse on the medial dendrites. Physiologically, the cells in the MSO have been shown to be binaurally excited and exquisitely sensitive to the time of arrival of sounds to the two ears [3,4]. MSO cells behave like coincidence detectors with very sharp temporal windows so that they respond only when the inputs from the two sides arrive coincidentally or nearly so. A widely accepted model of this circuit was first proposed by Jeffress [5] who hypothesized that the timing of the arrival of inputs from each side is governed by the delays associated with differences in axonal length and that there is a systematic change in axonal delays from one end of the MSO to the other, which would result in a map of ITDs across one axis of the MSO. Since the pathlength to the MSO is naturally longer from the contralateral ear, then a natural consequence of the coincidence mechanism is that MSO cells respond best when the sound source is in the contralateral sound field where the sound can reach the contralateral ear before the ipsilateral ear and thus compensate for the longer axonal path from the contralateral side.

Recent studies of the anatomy [6] and physiology [7] of the MSO have shown the existence of inhibitory inputs which originate from the medial nucleus of the trapezoid body (MNTB) and lateral nucleus of the trapezoid body (LNTB). The MNTB cells received input from the globular bushy cells of the anteroventral cochlear nucleus of the contralateral side while the LNTB receives input from the same cells on the ipsilateral side. The function of these inhibitory circuits is still controversial [8].

Processing of Interaural Level Differences

A parallel circuit in the superior olivary complex is believed to be responsible for encoding interaural level differences (ILDs) (Fig. 2, bottom). Cells in the lateral superior olive (LSO) receive excitatory input from the spherical bushy cells of the ipsilateral side and inhibitory input from the contralateral side that is relayed via an inhibitory interneuron in the medial nucleus of the trapezoid body (MNTB) [9]. The MNTB cells received input from the globular bushy cells of the contralateral side by way of a very specialized synaptic ending, the calyx of Held. In accordance with this circuit, cells in the LSO are excited by stimulation of the ipsilateral ear and inhibited by stimulation of the contralateral ear.

For binaural stimuli, LSO cells respond to the difference in intensity (ipsilateral intensity – contralateral...
intensity) of the sounds to the two ears. Thus for free-field sounds, LSO cells respond well to stimuli presented in the ipsilateral sound field where the level of the sound is greater in the ipsilateral than the contralateral ear and poorly when the sound is in the contralateral sound field.

The large calyceal synapses between the globular bushy axons and the MNTB cells are very unusual one and can be seen prominently in Fig. 1. It is often said to be the largest synapse in the brain. The presynaptic element is so large that recordings can be made from both the pre- and post-synaptic neurons so that this synapse has become a model for biophysical studies of synaptic transmission.

It is well-known that there is a systematic crossed relationship between the representation in the cerebral cortex and body part or sensory field in all sensory and motor systems. The right motor cortex controls muscles on the left side of the body, cells in the left visual cortex have receptive fields in the right visual field, and cells in the left somatosensory cortex respond to touch or pain to the right side of the body. Note that cells in the MSO respond preferentially to sounds in the contralateral sound field whereas cells in the LSO respond to sounds in the ipsilateral sound field. This apparent paradox is resolved by having MSO project to the ipsilateral inferior colliculus while most LSO cells project to the contralateral inferior colliculus (Fig. 2). The subsequent projections of the inferior colliculus to the medial geniculate and then onto the cortex are all predominantly uncrossed which then makes cells in the auditory cortex respond to sounds in the contralateral sound field, as with the other sensory systems.

All of the nuclei in the superior olivary complex, like those of other ascending auditory nuclei are tonotopically organized, i.e. there is a systematic map of frequency along one axis of the nucleus. In accordance with the expectations of the classical duplex theory, both the MNTB and LSO have a disproportionate representation of high frequencies, which are associated with ILDs, while the MSO is biased toward low frequencies, which are useful for encoding ITDs. In animals with different head sizes, the ability to localize low frequency tones appears to be correlated to the size of the MSO. Interestingly, humans have a very prominent MSO, which is correlated with the importance of ITDs for sound localization but a very small LSO, even though we are clearly able to encode ILDs.

Some animals they are the source of the olivo-cochlear efferents [10]. These efferent fibers project from to the cochlea and innervate primarily the outer hair cells, though there are also fibers that end on the inner hair cells. Since 90% of the auditory nerve fibers innervate a single inner hair cells, the action of the olivo-cochlear efferents must be indirect. Current theories center on the fact that the outer hair cells are motile and can contract which could affect the micromechanics of the basilar membrane motion and consequently modulate the inner hair cell response. In rodents the olivo-cochlear efferents originate from cells that are located within the lateral superior olive.

**References**


**Superior Olive**

**Synonyms**

- Nucl. olivaris sup.; Superior olivary nucleus

**Definition**

The superior olivary complex comprises the nuclei:
- Nucleus of the trapezoid body
- Nucleus of the superior lateral olive
Medial nucleus of the superior olive

and is thus a vital synaptic center in the auditory tract, playing an important role in acoustic reflexes (reflex eye movements towards the source of noise, fright movements).

Mesencephalon

Superior Parietal Lobule

Synonyms
- Lobulus parietalis sup.

Definition
In the direction of the occipital pole, the inferior and superior lobules unite at the postcentral gyrus. Analogous to the secondary motor cortex there is also a secondary sensory cortex for the somatosensory control; this is believed to stretch across both lobules and to be responsible for analysis, recognition and assessment of tactile information.

Telencephalon
- Visual Space Representation for Reaching

Superior Prefrontal Gyrus

Definition
Part of the frontal lobe; involved in orchestrating executive function.

Superior Rectus Muscle

Definition
Superior rectus is one of the six eye muscles.

Superior Semicircular Canal Dehiscence Syndrome

Definition
Disorder of the labyrinth caused by a dehiscence (opening) in the bone that covers the superior canal. Patients can develop vestibular and/or auditory symptoms and signs. The effect of the dehiscence is to create a third mobile window into the inner ear.

Disorders of the Vestibular Periphery

Superior Temporal Gyrus

Definition
The superior temporal gyrus is the cerebral cortical fold immediately ventral to the lateral fissure. Its posterior portion is part of the language cortex.

Superior Vestibular Nucleus

Synonyms
- Nucl vestibularis sup.
- Vestibular Nuclei
- Pons

Supernormal Stimulus

Definition
Stimulus with a releasing value that is higher than the releasing value of the natural key stimulus.

SuperSAGE

- Serial Analysis of Gene Expression