Medical Neuroscience | Tutorial Notes

Auditory System—Central Processing

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC1. The brain is the body's most complex organ.

NCC3. Genetically determined circuits are the foundation of the nervous system.

NCC6. The brain makes it possible to communicate knowledge through language.

NCC7. The human brain endows us with a natural curiosity to understand how the world works.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Identify the neural mechanisms for localizing sounds in space.
2. Discuss the organization of the auditory cortex.

TUTORIAL OUTLINE

I. Central processing of auditory information

- A. subcortical pathways (see **Figure 13.12**[2])
  - 1. first order neurons: spiral ganglion cells
    - a. peripheral process innervates inner hair cells
    - b. central process enters the pontine-medullary junction and bifurcates to innervate the **cochlear nucleus**
  - 2. second order neurons: cells in the cochlear nucleus that project to multiple targets on both sides of the brainstem
    - a. (contralateral) **nucleus of the lateral lemniscus** in the upper pons: involved in detecting presence and temporal properties of sound from one ear (a monaural pathway)
    - a. (bilateral) **superior olivary complex** in the mid-pons: different divisions of this complex are involved in localizing the sources of sounds in auditory space
      - (i) **medial superior olive** (MSO) (see **Figure 13.13**): localizes low frequency sounds based on interaural timing differences

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

(ii) **lateral superior olive** (LSO) (see **Figure 13.14**): localizes sound based on interaural intensity differences

3. inferior colliculus
   a. all lower auditory projections converge on the **inferior colliculus**
   b. here, for the first time in the auditory system, a complete map of auditory space is computed in the inferior colliculus
4. auditory thalamus
   a. inferior colliculus projects to the **medial geniculate complex**
   b. cells in the MGC are sensitive to particular combinations of sounds with distinct spectral and temporal characteristics

B. auditory cortex
   a. target of the MGC located on the superior aspect of the temporal lobe
   b. contains several subdivisions (see **Figure 13.15**)
      i. **"core"** area or **primary auditory cortex** that receives highly tonotopic input from the MGC; also maps binaural interactions
      ii. **"belt"** of additional, higher-order auditory areas
   c. asymmetry in structure and function
      i. the posterior portion of the auditory belt contains **Wernicke's area**, a division of the auditory cortex that is specialized (in humans) for comprehending speech
      ii. for most people (>99% of right-handers and >90% left-handers), functional Wernicke's area is in the left hemisphere
      iii. there is a structural asymmetry associated with this functional asymmetry: the *planum temporale* (the superior plane of the temporal lobe)
         - the left planum temporale is larger in most humans than the right
         - the degree of asymmetry is associated with perfect pitch abilities (greater asymmetry in people with perfect pitch)
      iv. activation of the right hemisphere is typically greater in the left when listening to music, compared to listening to speech and environmental sounds (see **Box 13E**)

STUDY QUESTIONS

Q1. Which of the following most depends upon the utilization of bilateral auditory information?

A. frequency discrimination
B. sound localization
C. distinguishing pitch from timbre
D. encoding of speech sounds
E. detection of very faint sounds

Q2. Which auditory structure first displays pronounced selectivity for specific combinations of sound frequencies in the auditory pathway?

A. cochlear nucleus
B. lateral superior olive
C. medial superior olive
D. nuclei of the lateral lemniscus
E. inferior colliculus
F. medial geniculate complex
G. auditory cortex