Neurobiology of Hearing (Salamanca, 2012)

Auditory Cortex (3)

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Outline

Lecture 1: Tonotopic organization and stimulus selectivity
   a) Anatomical structure of the mammalian auditory cortex
   b) Tonotopic organization of auditory cortex
   c) Firing patterns and tuning to preferred stimulus

Lecture 2: Temporal processing
   a) Coding of time-varying signals
   b) Temporal-to-rate transformation in A1
   c) Temporal-to-rate transformation outside A1

Lecture 3: Spectral and intensity processing
   a) Spectral processing
   b) Intensity processing

Lecture 4: Spatial and auditory-feedback processing
   a) Spatial processing
   b) Auditory-feedback processing
Auditory cortex is tonotopically organized

Suprasylvian sulcus

Merzenich et al. (1975)
Spectral processing:

- Frequency axis is expanded from one-dimension to two-dimension (*tonotopic & iso-frequency*)

- Iso-frequency axis allows additional processing of spectrally overlapping information from the periphery
Bandwidth of Excitatory RF

Analysis based on RF derived by pure tones: Frequency response area (FRA)

Schreiner and Mendelson (1990)
Neurons in the center of A1 are more sharply tuned

\[ Q_{10} = \frac{CF}{BW_{10}} \]
Neurons “O”-shaped FRA in A1 of awake marmoset

\[ SI = \frac{BW \text{ (loudest level)}}{BW \text{ (best level)}} \]

\[ MI = \frac{R \text{ (loudest level)}}{R \text{ (best level)}} \]

'S' (n = 175)
'I', 'V' (n = 100)

Sdagopan and Wang (2008)
Representations by “O”-shaped and “V”-shaped neurons
Auditory cortical RF derived by different stimuli

Schreiner et al. (2000)

Neurons with multi-peak RF in dorsal A1 of cat

Sutter and Schreiner (1991)
Neurons with multi-peak RF in A1 of marmoset
Two-tone Facilitation and Inhibition in single-peak Neurons

One-tone Responses

Discharge Rate (Spikes/Sec)

Frequency (kHz)

Two-tone Responses

% Change in Discharge Rate

S2 Frequency (kHz)

Facilitation

Inhibition

Harmonic structures in wide-range spectral integration

Single-peaked Neurons: inhibition

Multi-peaked Neurons: facilitation

Information processing in non-primary auditory cortex
Connections of Auditory Cortex

Morel and Kaas (1992)
Stronger responses to noises than to tones in non-primary auditory cortex of macaque monkey
“Combination sensitive” neurons in auditory cortex of echo-locating bats

Suga (1997)
Specialized auditory cortical area for processing sonar signals in echo-locating bats

Suga (1994)
Human speech production mechanisms

Vocal Tract Configuration

Formant Frequency Configuration

Vocal fold

“Pitch”
Pitch is a crucial linguistic cue in tonal languages

Four Chinese Tones (中文四声)

“Wang”

汪 (vast) 王 (King) 网 (net) 忘 (forget)

“Categorical Perception” (learned)
Pitch is a paralinguistic cue in English.
What is Pitch?

A sound’s periodicity or harmonic structure determines its pitch (unresolved or resolved pitch)

Pure tone (pitch: 100 Hz)

- **Same pitch** Different frequency range
- **Different pitch** Same frequency range

“Missing fundamental” harmonic complex (pitch: 100 Hz)
Pitch-neuron vs. Non-pitch Neuron

Example Non-Pitch Neuron

Example Pitch Neuron

Pure Tone Stimuli

Harmonic complex stimuli

Bendor and Wang (2005)
A “Pitch Region” in Auditory Cortex

Bendor and Wang (2005)
Similar locations of “Pitch region” in auditory cortex of humans and Monkey

A. Human

B. Marmoset

Bendor and Wang (2006)
What is the implication of this experiment?

The significance of the pitch-encoding neurons is that their function represents a transformation from acoustical to perceptual dimension, a crucial step in forming the neural basis of auditory perception.
Information Processing in Auditory System

Transformations

Sound → Isomorphically represented representations (auditory periphery, brainstem) → Non-isomorphically represented representations (midbrain, primary auditory cortex) → Perceptual representations (Non-primary auditory cortex)
Suggested readings:

Spectral Processing:


Information processing in non-primary auditory cortex:
