Binaural cues for Localising Sounds in Space

Interaural Time Differences (ITDs)
Interaural Level Differences (ILDs)

Binaural Mechanisms of Sound Localization
• Interaural time (or phase) differences at low frequency are initially analyzed in the MSO by coincidence detectors connected by a delay line system.
• Interaural level differences at high frequency are initially analyzed in the LSO by input that is inhibitory from one ear and excitatory from the other.

Advantages of Two Ears
• Improved detection / increased loudness
• Removing interference from echoes
• Improved detection of sounds in interfering backgrounds
• Spatial localization
• Detection of auditory motion

Interaural level differences
(high frequency)

Binaural Hearing
The ability to extract specific forms of auditory information using two ears, that would not be possible using one ear only.
To medial superior olive: information about sound localisation using timing (and possibly time coding of speech)

To inferior colliculus: information about pinna sound transformations

To lateral superior olive: information about PARALLEL PROCESSING OF INFORMATION IN THE COCHLEAR NUCLEUS

Either commisural or to inferior colliculus information about sound level and voice pitch

To inferior colliculus: information about complex sounds (possibly place coding of speech)

Input from cochlear nerve

To lateral superior olive: information about sound localisation using interaural intensity

To medial nucleus of the trapezoid body: information about sound localisation using interaural intensity

Interaural Level Difference Pathway

Excitatory

Inhibitory

Interaural time differences (low frequency)

Evans (1975)

The discharges of cochlear nerve fibres to low-frequency sounds are not random; they occur at particular times (phase locking).
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To inferior colliculus: information about pinna sound transformations

To lateral superior olive: information about sound level and voice pitch

To inferior colliculus: information about complex sounds (possibly place coding of speech)

Input from cochlear nerve

To lateral superior olive: information about sound localisation using interaural intensity

To medial nucleus of the trapezoid body: information about sound localisation using interaural intensity

Interaural Time Difference Pathway

The coincidence detection model of Jeffress (1948) is the widely accepted model for low-frequency sound localisation

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Matches between the inputs from the two ears in the Barn Owl Nucleus Laminaris

Pathways for analysing interaural time differences
Interaural Phase Sensitivity in the MSO

Yin and Chan (1988)

Smith et al 1993

Bekius et al 1999

BF tones

Noise

Cat

Guinea Pig

Palmer et al., 1990

McAlpine, Jiang, and Palmer 2001

Distribution of peaks of ITD functions in response to interaurally-delayed noise

Yin et al., 1986

Palmer et al 1990

Distribution of peaks of ITD functions in response to interaurally-delayed noise
ITD processing is RF-dependent.

ITD functions are steepest around midline.

The consequence of this is that:

As ITD increases across the physiological range the activity at any frequency increases.
Descending pathways

Function of the descending or centrifugal innervation

- Protection from acoustic trauma
- Control of the mechanical state of the cochlea
- Involvement in selective attention
- Detection of complex signal in noise