

# Bilateral recordings and processing in hearing aids

Peter Blamey, Hayley Fiket, Daniel Pearce and Elaine Saunders Dynamic Hearing, Australia

## DUAL=PERCEPTION

### Bilateral probe tube microphone recorder

- Real ear measurements
- Real time acoustic monitoring & recording
- Binaural time, intensity & spectral analysis
- Aided and unaided listening comparisons

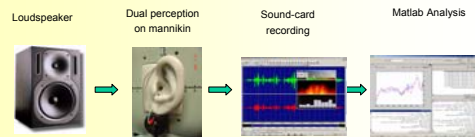
**Real ear measurements** have been a feature of hearing aid fittings since the 1980s. Traditionally, audiologists have used probe tube microphone measurements to validate the prescription goals for each ear separately. With the advent of advanced digital signal processing hearing aids, it has become increasingly important to understand how bilaterally fitted hearing aids interact with each other in a variety of acoustic environments and ensure that the hearing aid characteristics are complementary when acting in unison. A good way to do this is by making real-ear measurements and recordings from a pair of hearing aids simultaneously.

**DUAL=PERCEPTION** is a bilateral probe tube microphone recorder that can be mounted on an acoustic research manikin for measurement and recording under controlled conditions, or worn by a subject in everyday acoustic situations.

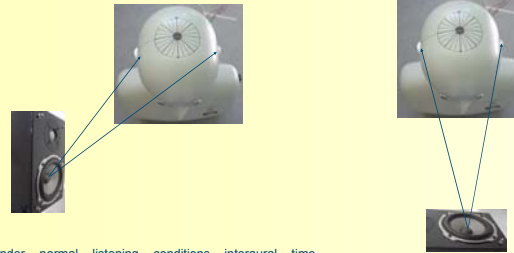
The DUAL=PERCEPTION system is designed for research into bilateral processing for hearing aids and demonstrations of the effects of hearing aids on binaural hearing in real situations. The system was calibrated in a sound field, to obtain the frequency response of each microphone. A "compensation" filter was designed, and applied to the recorded signal prior to measurements.

A further filter was designed to compensate for the transfer function of a Sennheiser headphone and ear canal resonance so that recordings could be played back through the headphones to produce the same signal intensity at the ear drum of the listener as was present at the eardrum when the recording was made.

The diagram below shows the set-up for the DUAL=PERCEPTION recordings and playback. A loudspeaker presented sound from the front or from 90 degrees to the left or the right. Recording were taken from the two probe tube microphones simultaneously with an ARX Microphone pre-amplifier which provided 30dB of gain. The line signals from pre-amplifier were fed into an Extigy Sound Card and sampled in stereo at 16 kHz.



**Binaural cues for sound localization and audio streaming** depend on time, intensity, and spectral differences between the signals reaching the two ears. These differences can be modified by hearing aids in ways that might enhance or corrupt these cues. Theoretically we hypothesize that equal time delays and consistent processing of sound levels are required for bilateral hearing aids. Stereo recording through hearing aids have been analysed to illustrate the effects of mismatching parameters

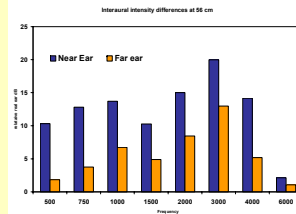


Under normal listening conditions interaural time differences can vary by up to 0.66 milliseconds. Interaural intensity differences increase with frequency. They vary with distance for sound sources closer than one meter but are constant beyond one meter.

Sounds from in front of the listener arrive at both ears at the same time with equal intensity under normal listening conditions.

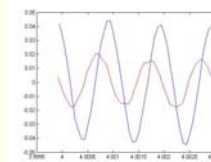
### Real ear measurements of interaural time and intensity differences

DUAL=PERCEPTION measurements were taken from both ears when sound was presented on the left.



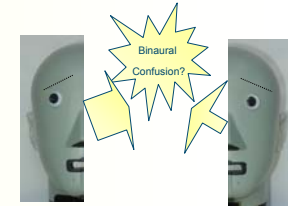
This measurement (bar chart) of the intensity of narrow band noise presented at 90 degrees at a distance of 56 cm shows that the head shadow effect is of the order of 5 to 10 dB across frequencies up to 4 kHz.

The recording to the right shows time in milliseconds and relative amplitude of a 1000 Hz pure tone presented at 90 degrees to the left ear. Phase and amplitude differences can be clearly seen indicating that the interaural time difference can be measured with the DUAL=PERCEPTION device.



**Mismatched amplification** can increase interaural time differences due to the processing delay in the hearing aid. Natural interaural intensity differences in the signal may be changed by fitting differences in the hearing aids.

Instead of a smooth binaural fusion the discrepancies in the signals received from each ear may lead to perceptual confusion if the hearing aids are not carefully matched.

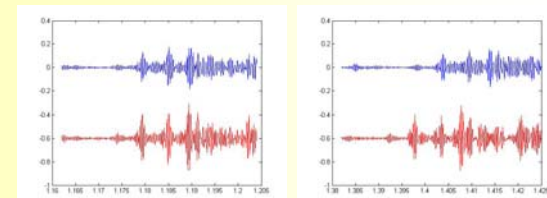


Binaural cues are important for perceiving speech in noise as well as for localization. Masking level differences between the ears can help the listener to perceive and focus on an individual speaker in background noise.



### Real ear recordings with hearing aids having matched and mismatched delays

DUAL=PERCEPTION recordings were made of a sentence using two BTE hearing aids programmed with a linear fitting suitable for a flat 50 dB hearing loss. The processing delay in the hearing aid could be chosen to be either 13 ms or 6 ms. Nine recordings were made altogether. The sentence was presented from the front, from the left, or from the right for each of three conditions: Two hearing aids with 13 ms delay; Two hearing aids with 6 ms delay; and Two hearing aids with 13 ms and 6 ms delay in the left and right ears respectively.



The figure above shows two of the recordings from the front. The left panel is for two hearing aids with matched delay of 13 ms. The right panel shows the mismatched condition.

The recordings are available for you to listen and draw your own conclusions. To us, the recordings from the unmatched fittings sound less natural than those with the matched fittings, but they still convey the localization information, probably because of intensity differences.

We plan to use dual perception for further demonstrations and new developments, especially studies involving the listener's own voice.

