Hearing Spatial Detail in Stereo Recordings

From the perspective of a Loudspeaker Designer & Audiophile
Recording the Eardrum Signal

Multiple Sound Streams in Time & Space

Ear signal = Sum of:
- Instruments
- Voices
- Noises
- Hall reflections
Playback of the Recording

The response to the stimulus
• The Auditory Scene
Issues with Binaural

**Eardrum signals**
- Individual anatomy dependent
- No movement tracking

**Auditory Scene**
- Foreshortened distances
- In-head localization
A single Loudspeaker in a Room

ACOUSTICS
- Direct sound
- Reflected sound
- Reverberation

Dipole loudspeaker near a room corner
A single Loudspeaker in a Room

**HEARING**
- Direction
- Distance
- Room
- Tonality versus head movement
- Pattern recognition
- Intelligibility
- Gestalt
- Horizon

**Spatial Hearing**
**Sound Streams**

Dipole loudspeaker near a room corner
Frequency Response for a single Loudspeaker in a Room

**On-axis**
Flat

**Off-axis**
Frequency independent at every angle
-> acoustically small source

**Room response**
Anechoic <-> Reverberant
Frequency independent?
Monaural Phantom Source between two Loudspeakers

- Unnatural phenomenon
- Localization versus head movement
- Distance
- Size
- Tonality versus head movement
Optimizing the Phantom Source between two Loudspeakers

Cross-talk cancellation
- 30 degree HRTF
- Sweet Spot size
- Reverberant sound
- Naturalness
Level at eardrum relative to frontal incidence at $0^0$

Level at a point on a rigid sphere relative to the level without the sphere

Duda & Martens, 1998
Optimizing the Phantom Source without XTC & in a Room

Off-axis Response
- As on-axis
- Lower level

Reflections
- Symmetry
- Delay

Source types
- Omni
- Dipole
- Cardioid
- Other?
On-axis Frequency Response?

Level at a point on a rigid sphere relative to the level at the center without the sphere
Shaw, 1974

Level at 22.5\(^{0}\) & 45\(^{0}\) incidence relative to 0\(^{0}\) incidence

Inverse of empirical EQ

17.5 cm diameter

0 dB

3.3 dB

22.5\(^{0}\)

45\(^{0}\)
Optimizing the Room Setup

- Loudspeaker-Listener triangle
- Symmetry to reflective surfaces
- Loudspeakers out in the room
- Lively room
- Diffuse End
- Dead End

Perceptually hiding Loudspeakers & Room
Phantom Source Placement horizontally by channel differences

Duplex Theory of Directional Hearing:
Inter-aural Time Differences (ITD) at low frequencies
Inter-aural Level Differences (ILD) at high frequencies
(Ignoring HRTF changes)
Recording as Creation of Art

The **Mix** of microphone signals

*Timbre*  
*Localization*  
*Spaciousness*
Scaling the Auditory Scene

Distance - Perspective - Loudness - Size

Distance
Perspective
Loudness
Size
An appropriate radiation pattern and setup of loudspeakers are essential to Phantom Source Creation and to experience Stereo optimally in a room.

STEREO System = ILLUSION Engine
LINKWITZ LAB
Sensible Reproduction & Recording of Auditory Scenes
Thank you for your attention

There will be a Demonstration of ‘Hearing Spatial Detail’
Room A, CCL Level +2
Friday, 10:00 to 19:00
Saturday, 10:00 to 19:00

Pluto-2.1 Stereo Loudspeakers will be used
(Small, active 2-way loudspeaker with omni-directional radiation characteristics below 4 kHz)