Áudio Computacional

Áudio 3D

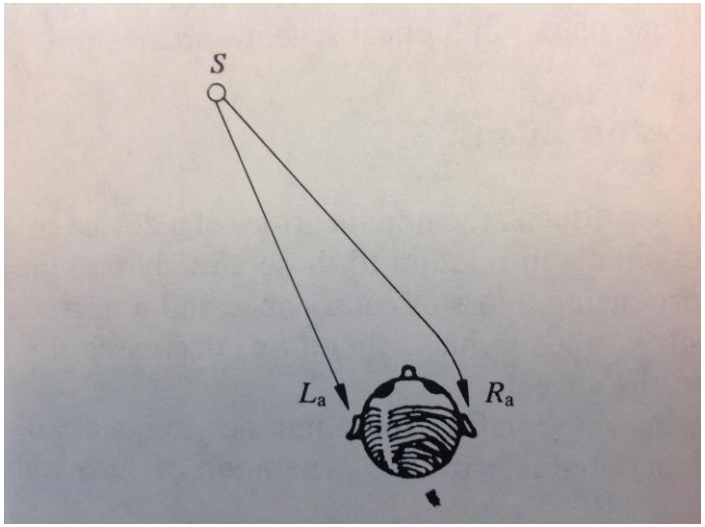
Mestrado em Engenharia Electrotécnica e Computadores

Faculdade de Engenharia da Universidade do Porto

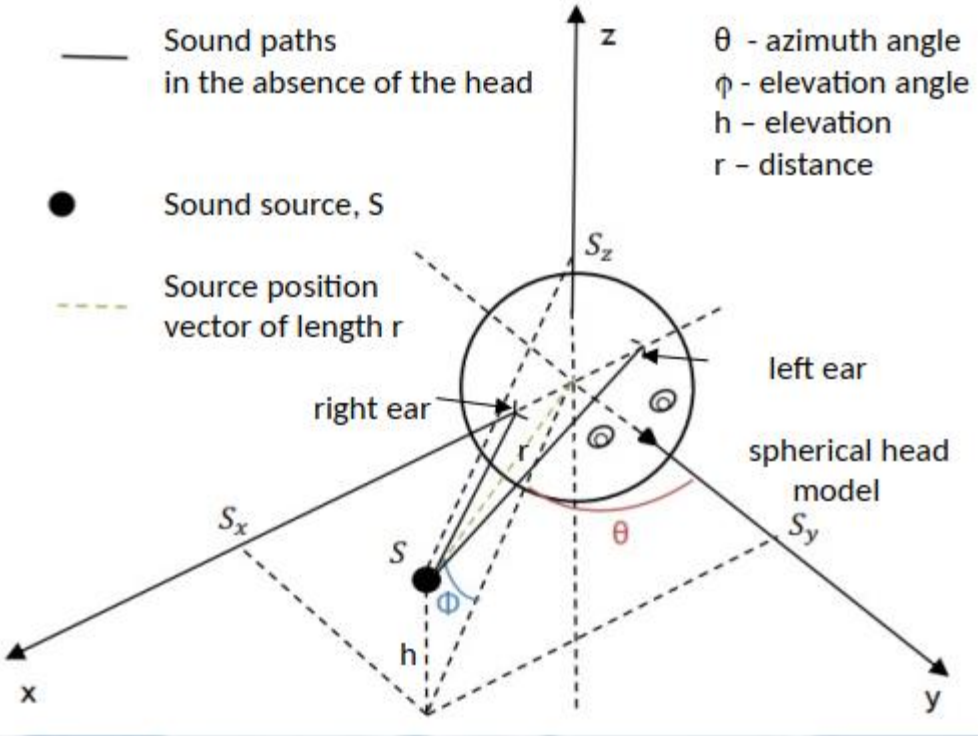
Introdução

Introdução ao áudio espacial

- Localização auditiva (binaural)



- Posição da fonte sonora – referência e coordenadas:



Introdução ao áudio espacial

- Inter-aural time difference (ITD)

Modelo teórico (qualquer frequência)

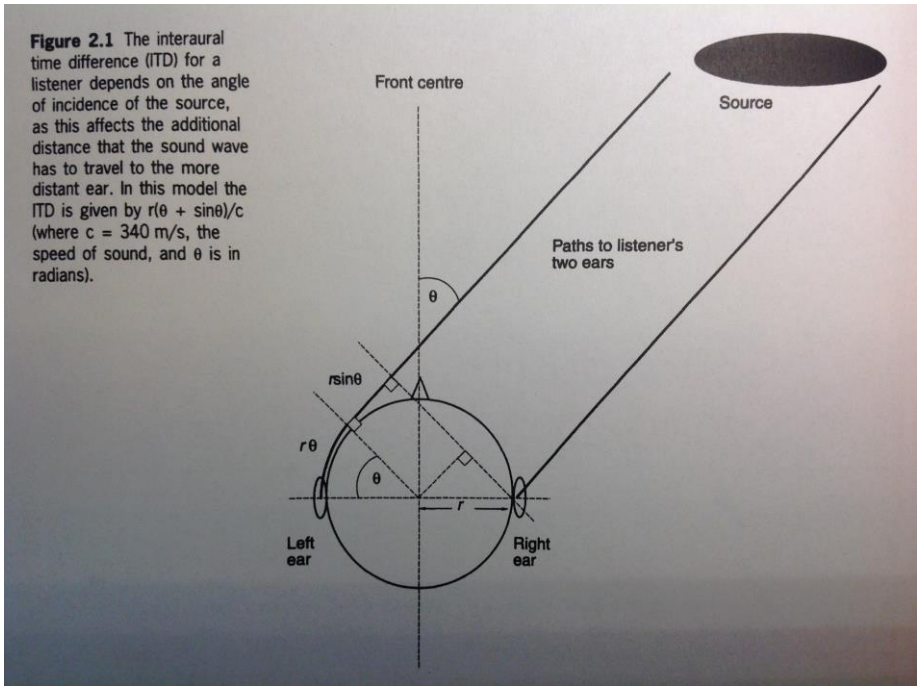


Figure 2.1 The interaural time difference (ITD) for a listener depends on the angle of incidence of the source, as this affects the additional distance that the sound wave has to travel to the more distant ear. In this model the ITD is given by $r(\theta + \sin\theta)/c$ (where c = 340 m/s, the speed of sound, and θ is in radians).

- Posição aparente da fonte sonora
- Com várias fontes (precedência):

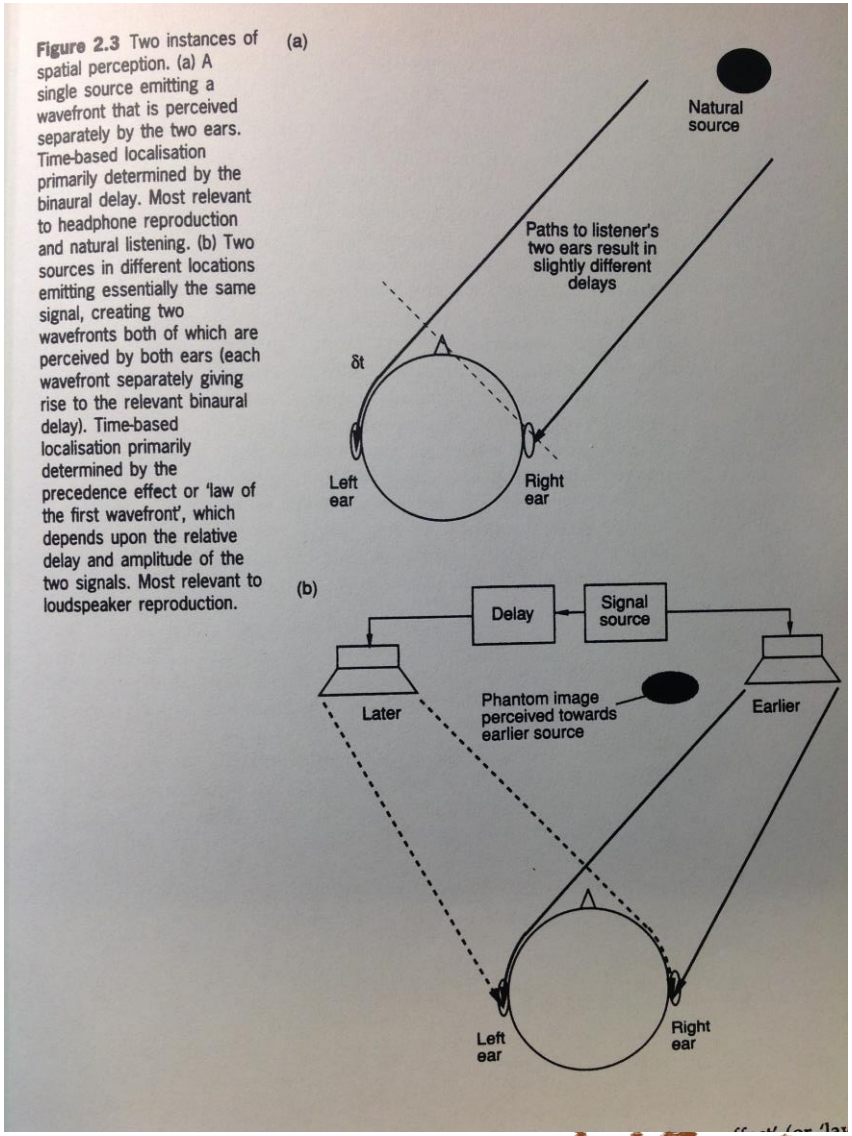


Figure 2.3 Two instances of spatial perception. (a) A single source emitting a wavefront that is perceived separately by the two ears. Time-based localisation primarily determined by the binaural delay. Most relevant to headphone reproduction and natural listening. (b) Two sources in different locations emitting essentially the same signal, creating two wavefronts both of which are perceived by both ears (each wavefront separately giving rise to the relevant binaural delay). Time-based localisation primarily determined by the precedence effect or 'law of the first wavefront', which depends upon the relative delay and amplitude of the two signals. Most relevant to loudspeaker reproduction.

Introdução ao áudio espacial

- Inter-aural time difference (ITD) e inter-aural level difference (ILD)
- Compromisso e uso combinado para controlar
  - Posição aparente da fonte sonora
  - Com várias fontes (precedência):

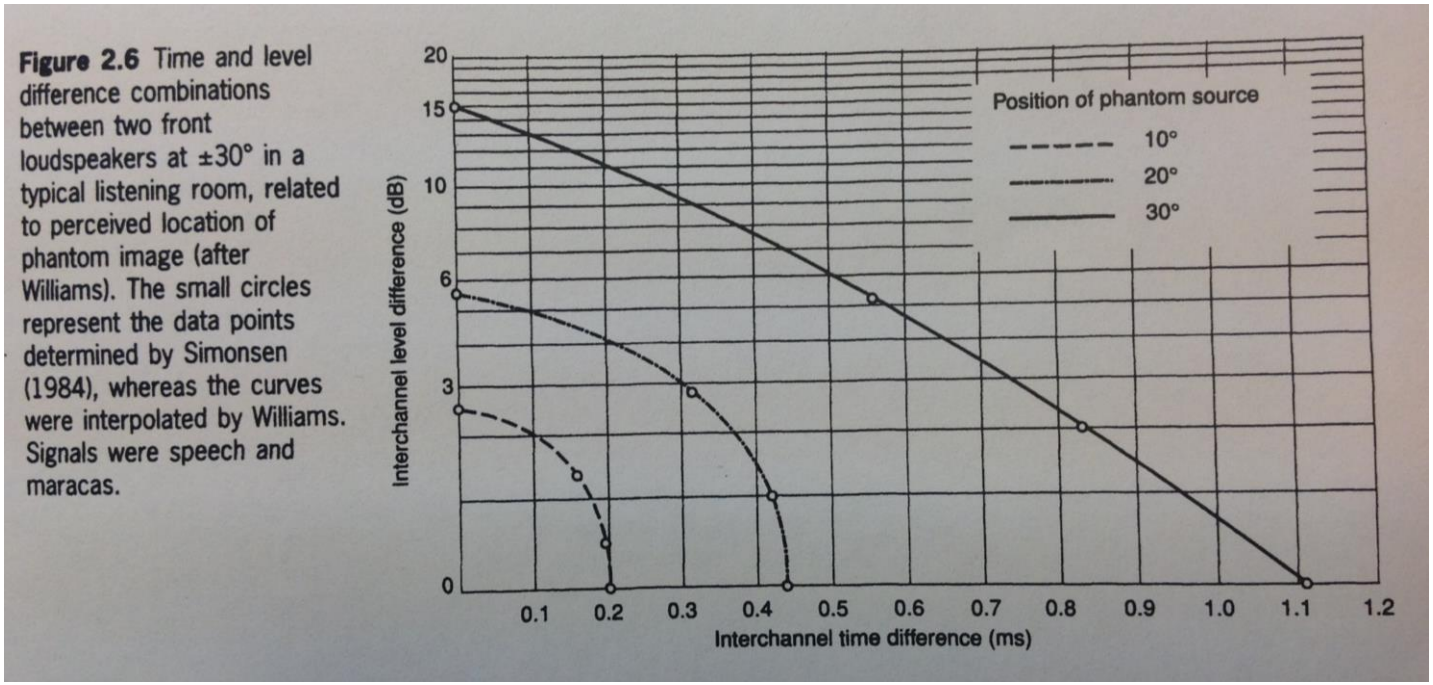


Figure 2.6 Time and level difference combinations between two front loudspeakers at ±30° in a typical listening room, related to perceived location of phantom image (after Williams). The small circles represent the data points determined by Simonsen (1984), whereas the curves were interpolated by Williams. Signals were speech and maracas.

Introdução ao áudio espacial

- Funções de transferência relacionadas com a cabeça (HRTF) :

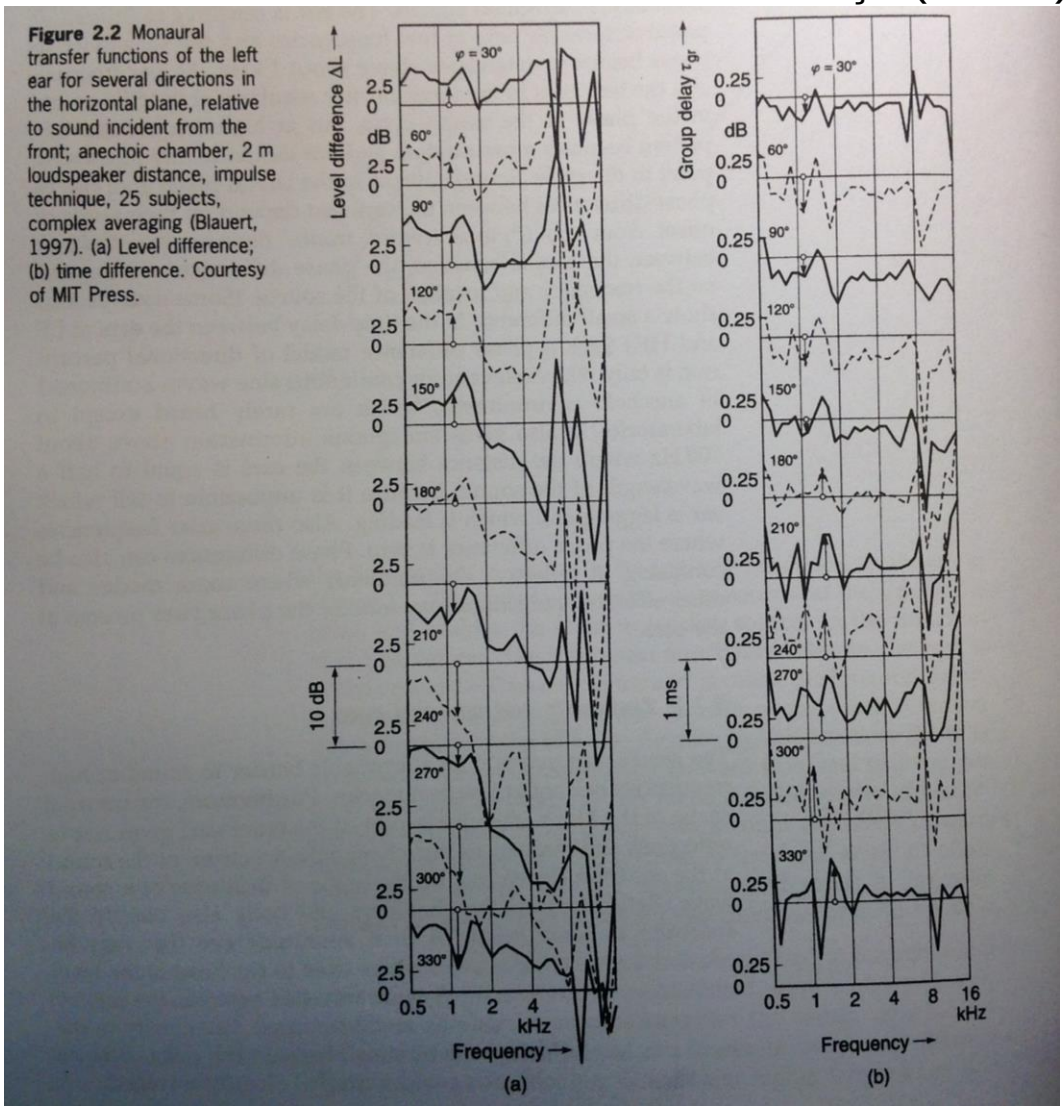


Figure 2.2 Monaural transfer functions of the left ear for several directions in the horizontal plane, relative to sound incident from the front; anechoic chamber, 2 m loudspeaker distance, impulse technique, 25 subjects, complex averaging (Blauert, 1997). (a) Level difference; (b) time difference. Courtesy of MIT Press.

Sistemas de áudio espacial

- Sistema estéreo (Blumlein):
  - Configuração padrão:

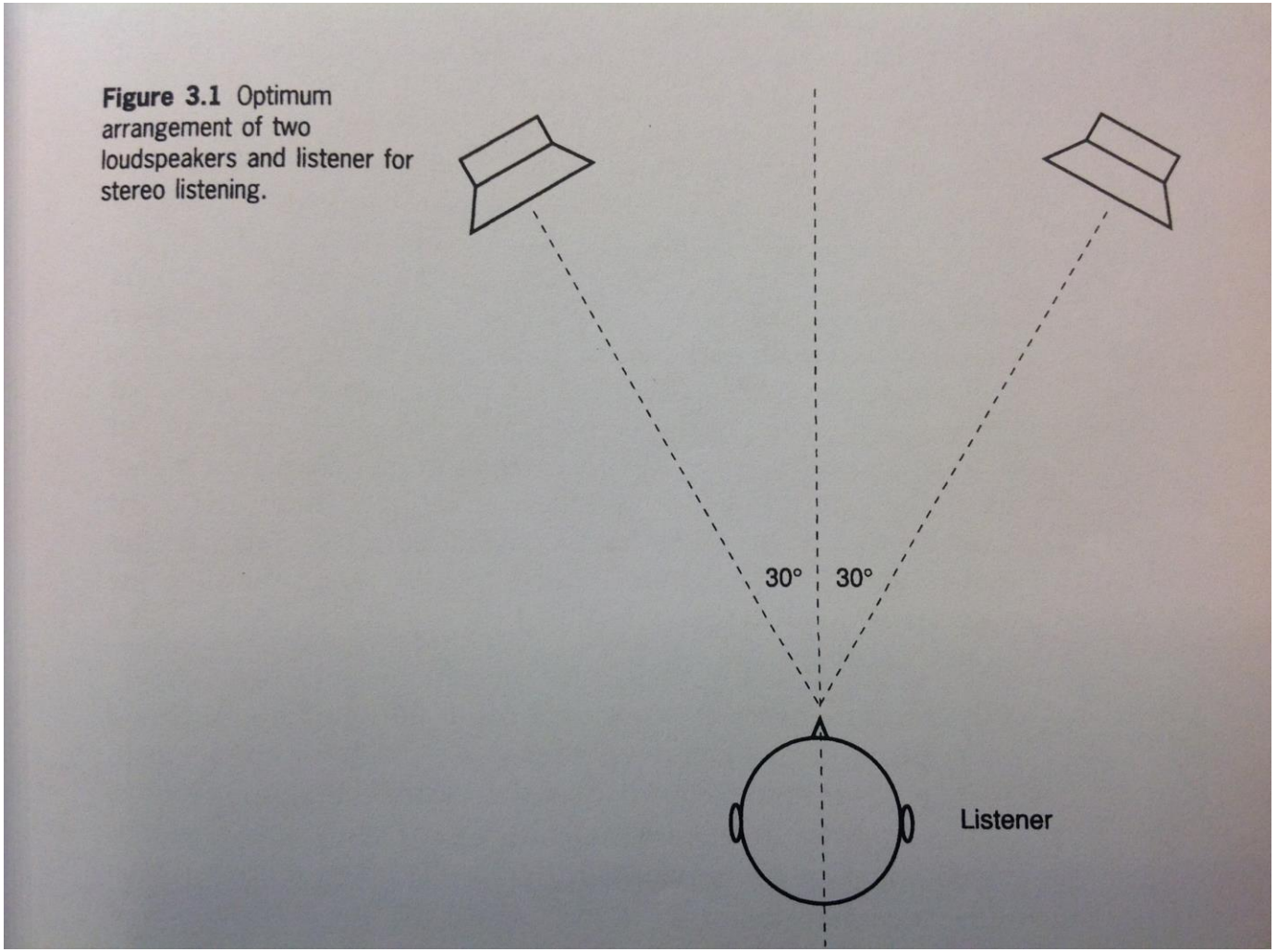


Figure 3.1 Optimum arrangement of two loudspeakers and listener for stereo listening.

Sistemas de áudio espacial

- Sistema estéreo (Blumlein):
  - Fonte real e fonte virtual

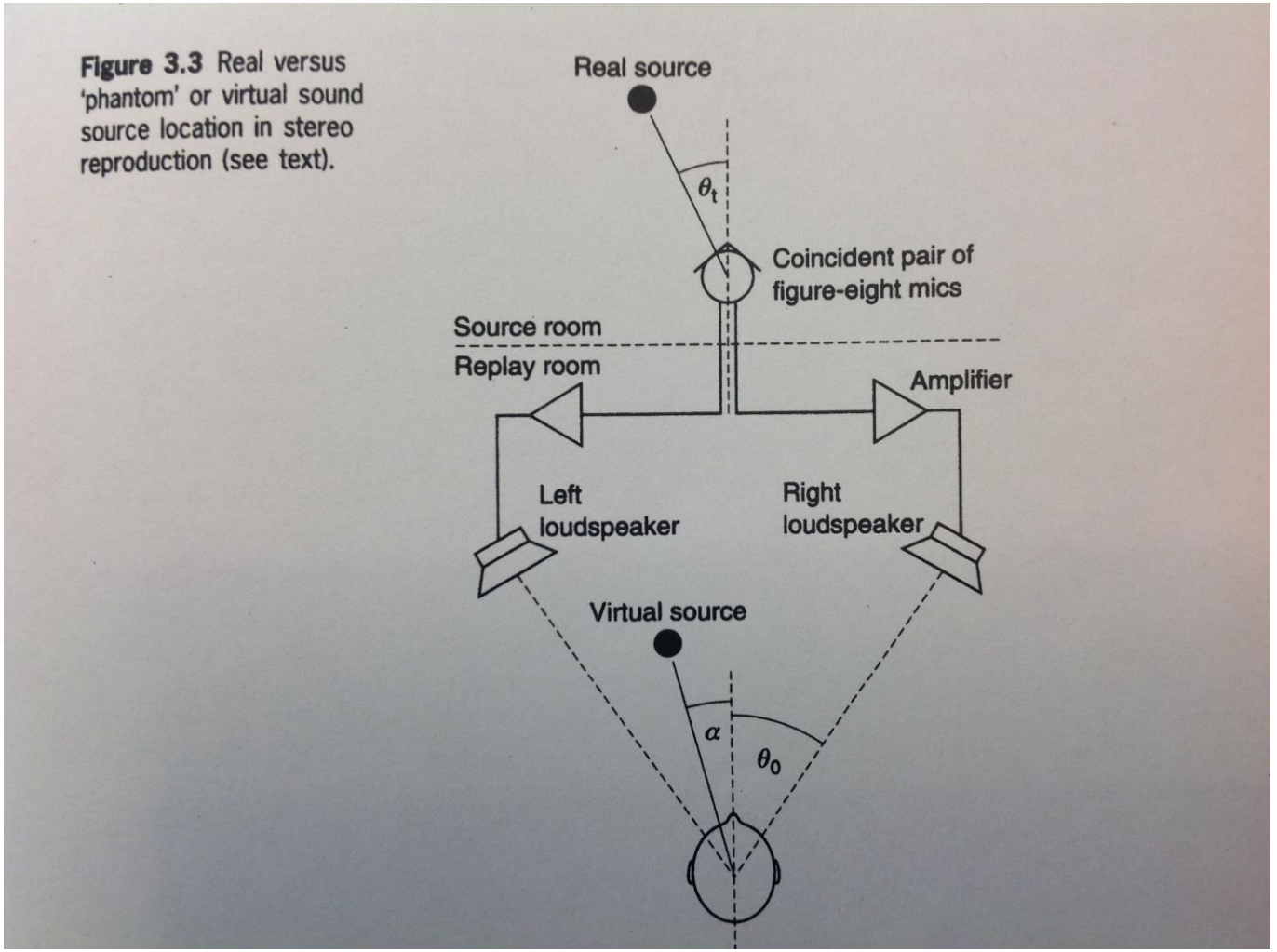


Figure 3.3 Real versus 'phantom' or virtual sound source location in stereo reproduction (see text).

Sistemas de áudio espacial

- Sistema estéreo (Blumlein):
  - Desempenho experimental relativamente diferença de TEMPO entre altifalantes:

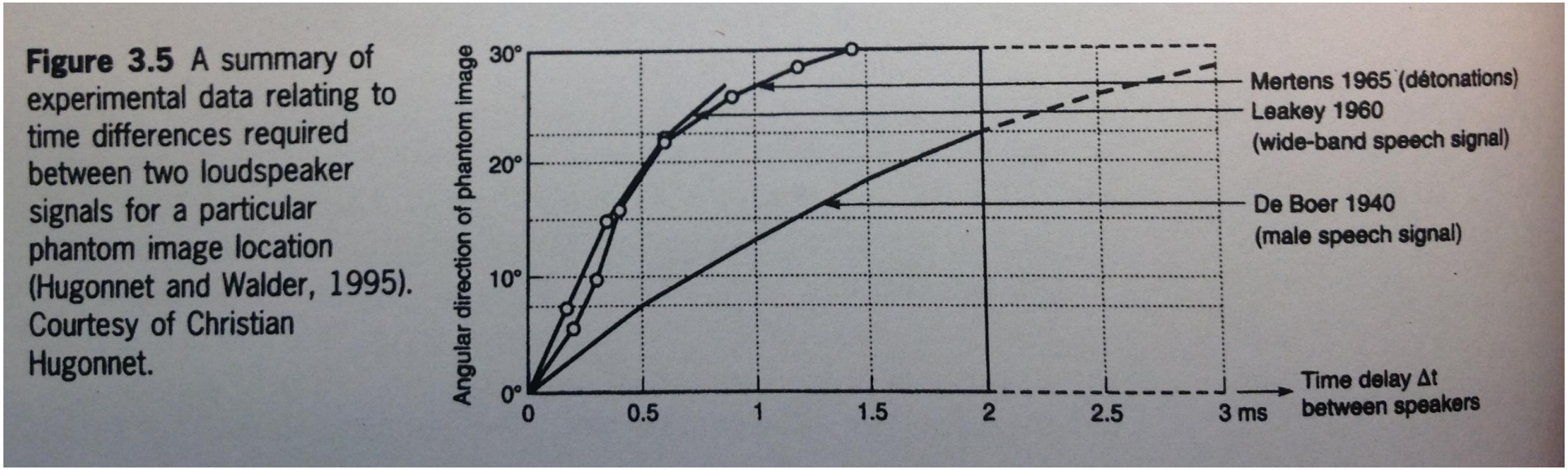


Figure 3.5 A summary of experimental data relating to time differences required between two loudspeaker signals for a particular phantom image location (Hugonnet and Walder, 1995). Courtesy of Christian Hugonnet.

Sistemas de áudio espacial

- Sistema estéreo (Blumlein):
  - Desempenho experimental relativamente diferença de AMPLITUDE entre altifalantes:

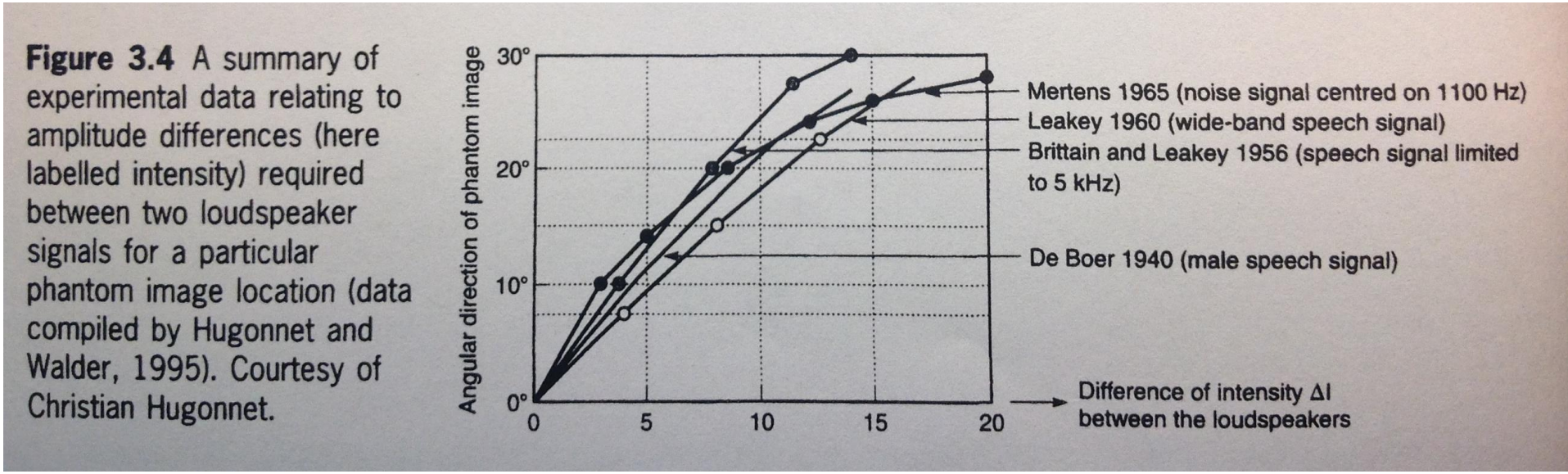


Figure 3.4 A summary of experimental data relating to amplitude differences (here labelled intensity) required between two loudspeaker signals for a particular phantom image location (data compiled by Hugonnet and Walder, 1995). Courtesy of Christian Hugonnet.

Sistemas de áudio espacial

- Sistema estéreo (Blumlein):
  - Auscultadores em vez de altifalantes

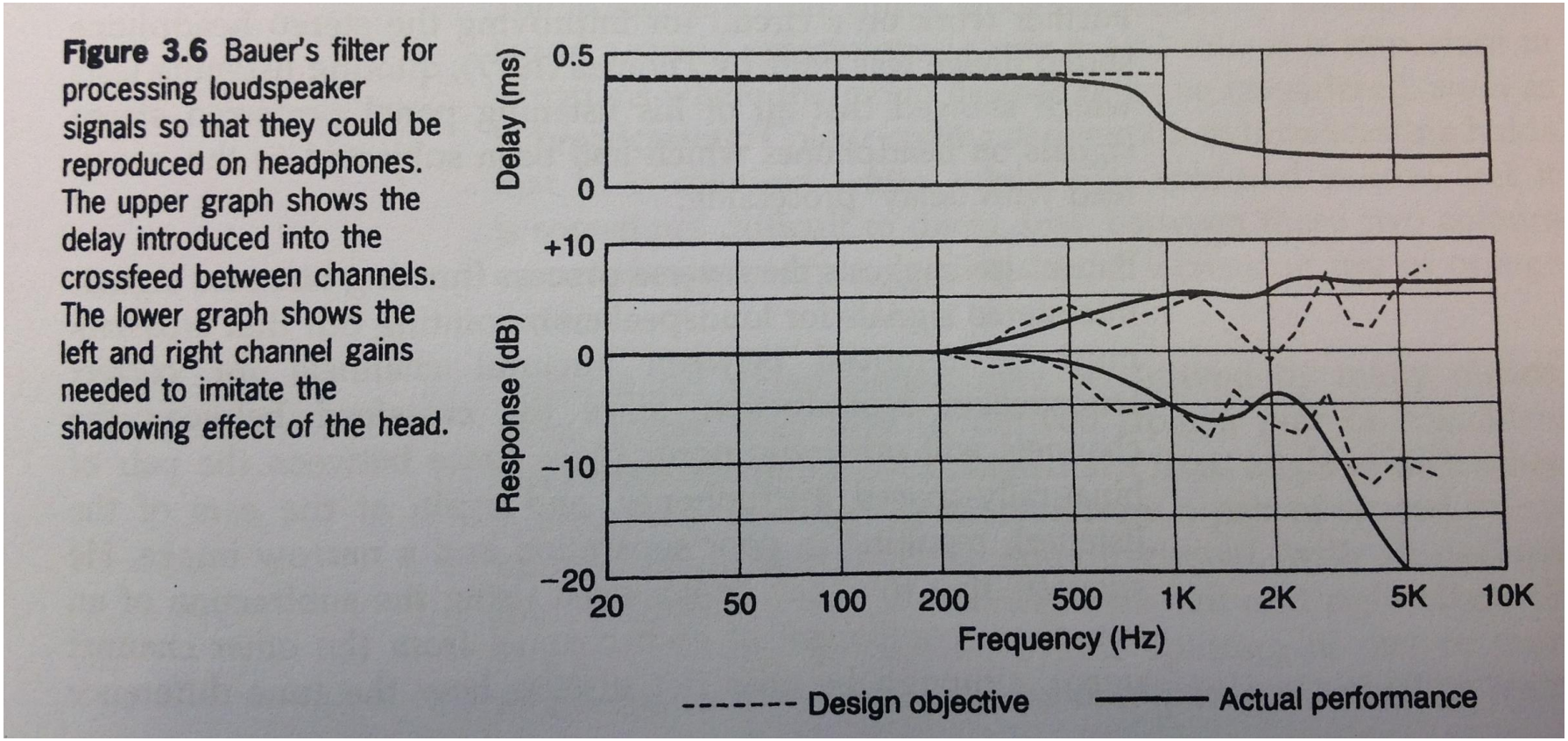


Figure 3.6 Bauer's filter for processing loudspeaker signals so that they could be reproduced on headphones. The upper graph shows the delay introduced into the crossfeed between channels. The lower graph shows the left and right channel gains needed to imitate the shadowing effect of the head.

Sistemas de áudio espacial

- Sistema binaural: captação, gravação e reprodução:

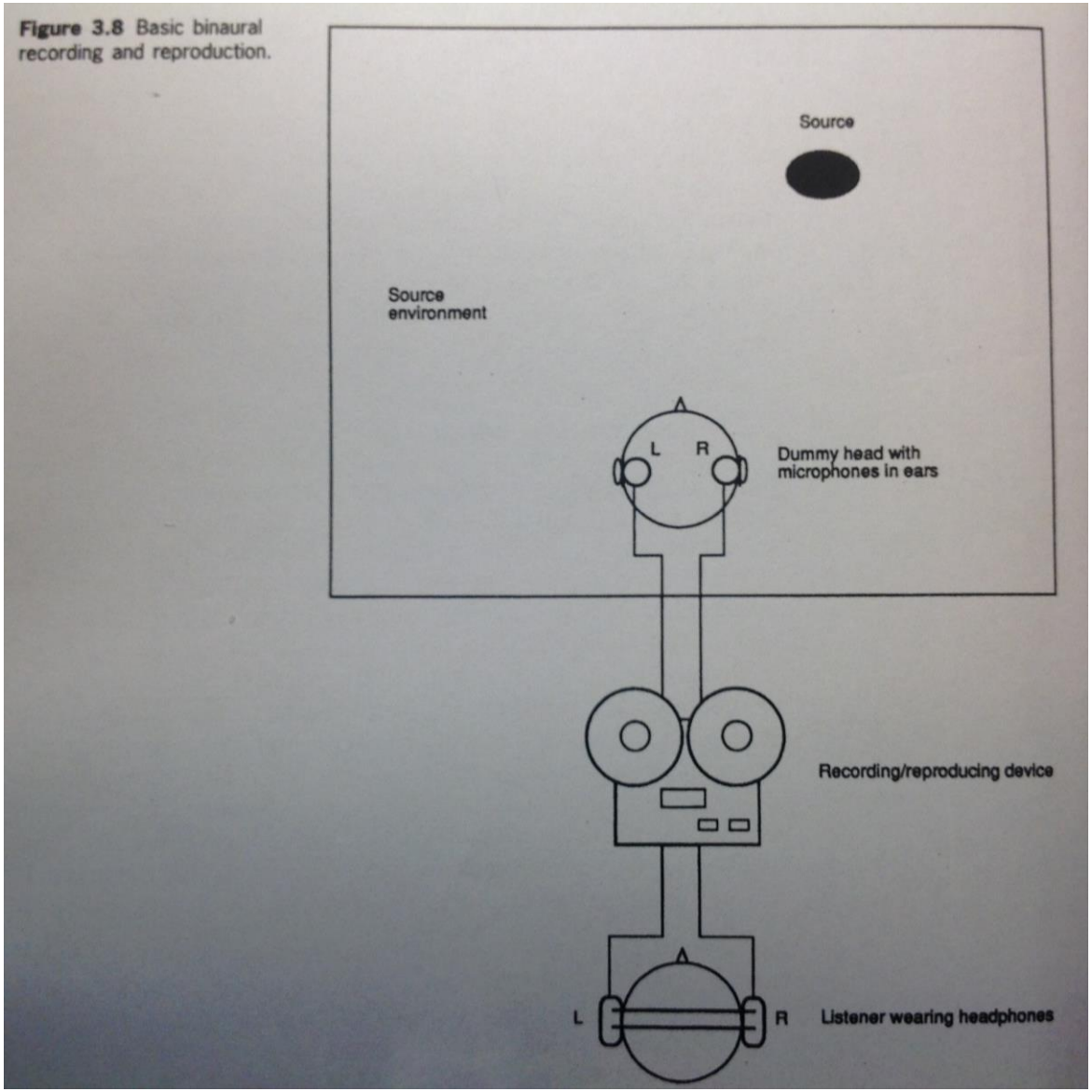


Figure 3.8 Basic binaural recording and reproduction.

Sistemas de áudio espacial

- Sistema binaural:

problema: diferenças entre indivíduos nas HRTF

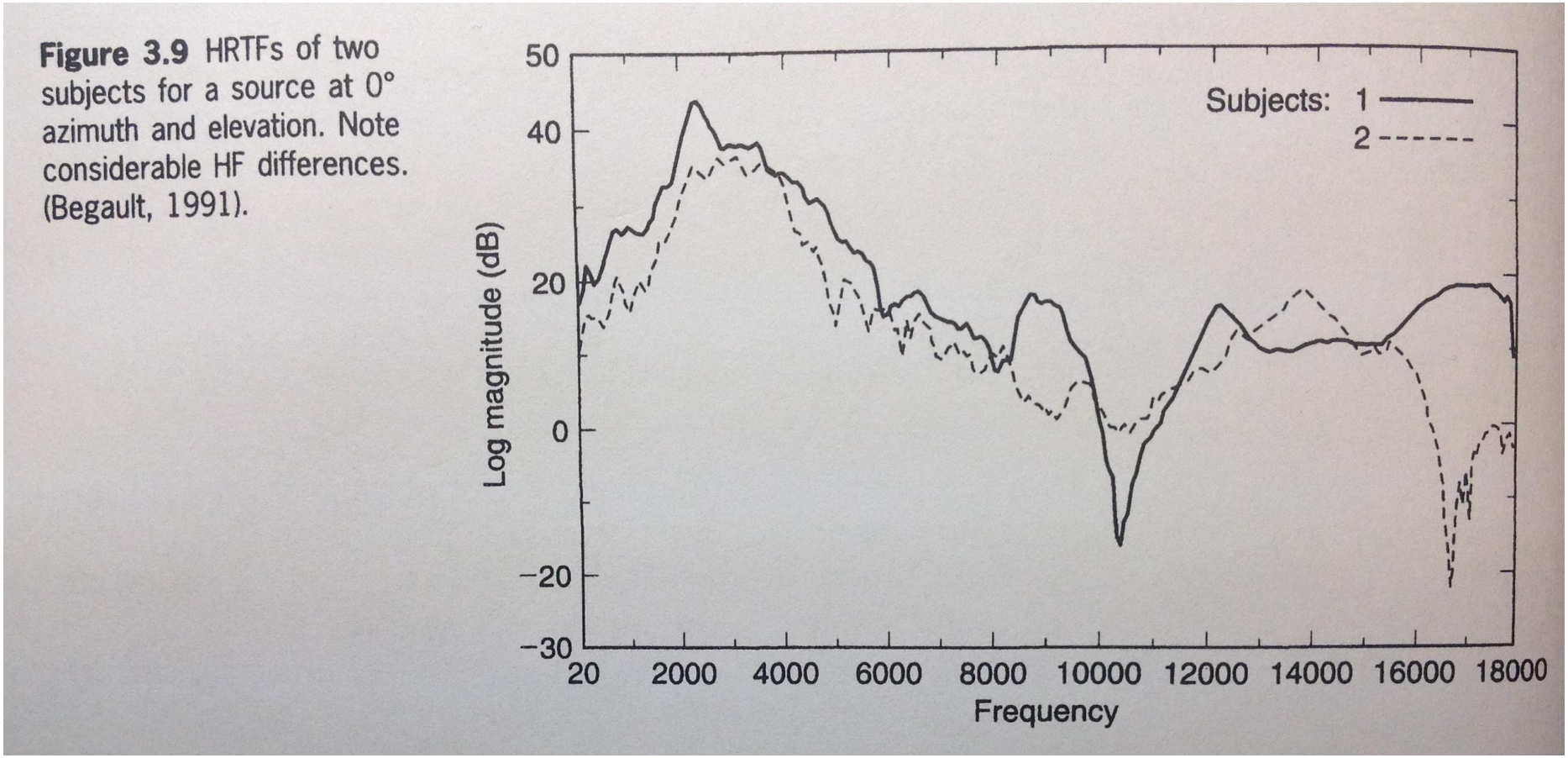


Figure 3.9 HRTFs of two subjects for a source at 0° azimuth and elevation. Note considerable HF differences. (Begault, 1991).

Sistemas de áudio espacial

- Sistema binaural:

Captação com manequim:

Sistemas de áudio espacial

- Sistema binaural:

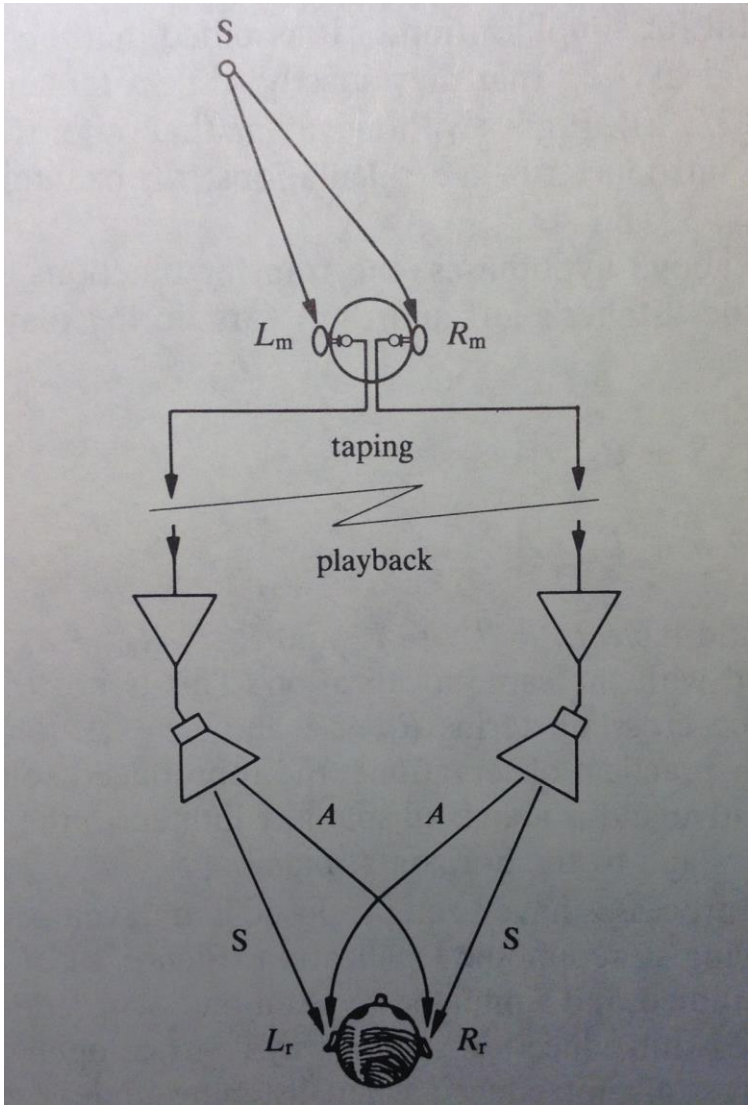
ou utilizar microfones de colocar nos canais auditivos (in-ear-channel mics):

Sistemas de áudio espacial

- Sistema binaural:

Reproduzir em altifalantes

Problema: interferência cruzada (cross-talk)



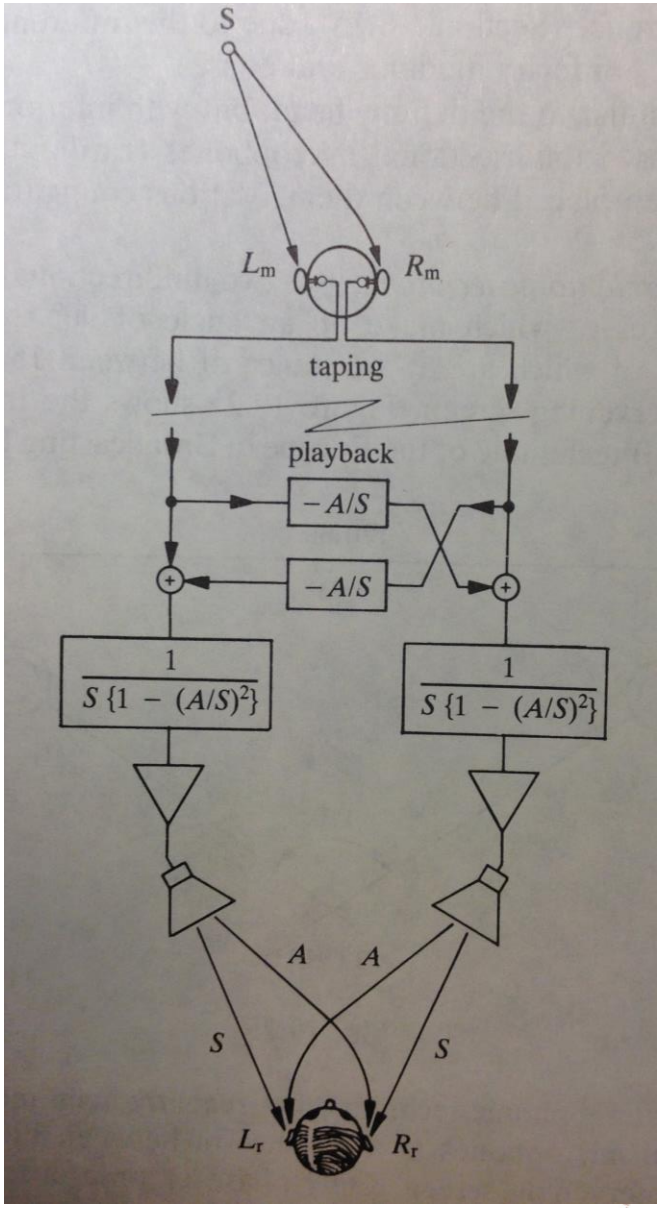
Sistemas de áudio espacial

- Sistema binaural:

Reproduzir em altifalantes

Problema: interferência cruzada (cross-talk)

Solução: processar e cancelar A interferência cruzada



Sistemas de áudio espacial

- Sistema binaural:

Som envolvente virtual ou teatro-em-casa

Produzir um CENTRO virtual e envolventes virtuais

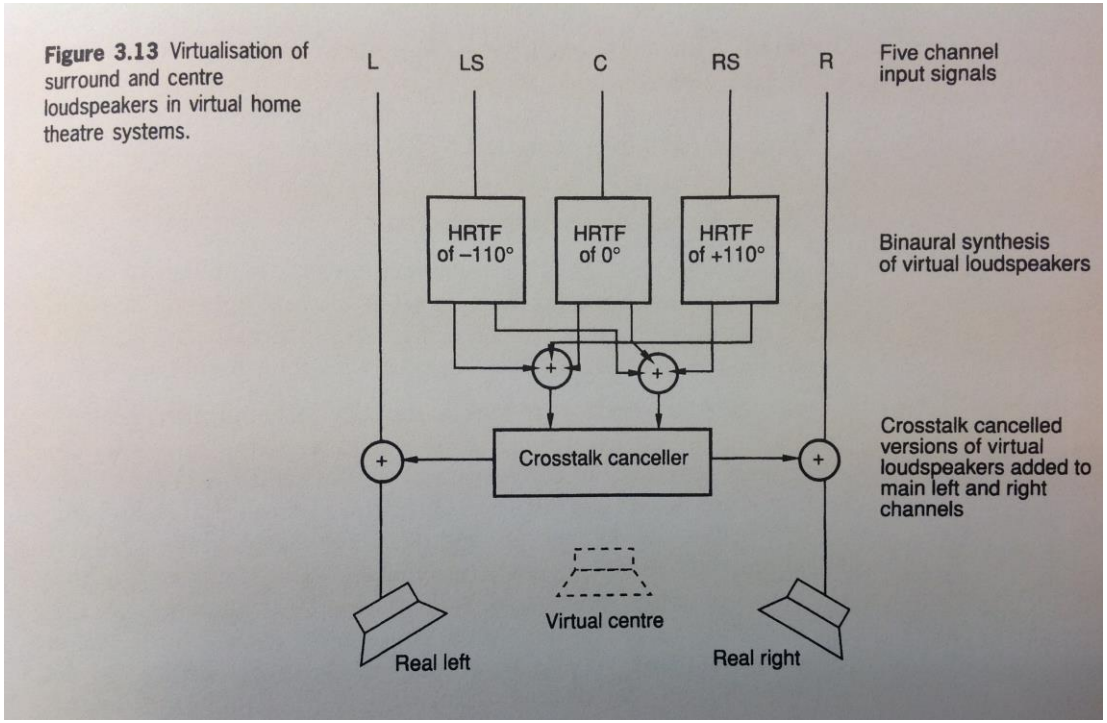
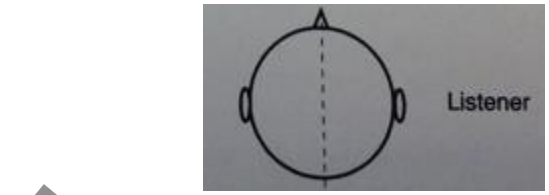


Figure 3.13 Virtualisation of surround and centre loudspeakers in virtual home theatre systems.



Sistemas de áudio espacial

- Sistema binaural:

Ambientes acústicos virtuais (auralização)

Em duas fases:

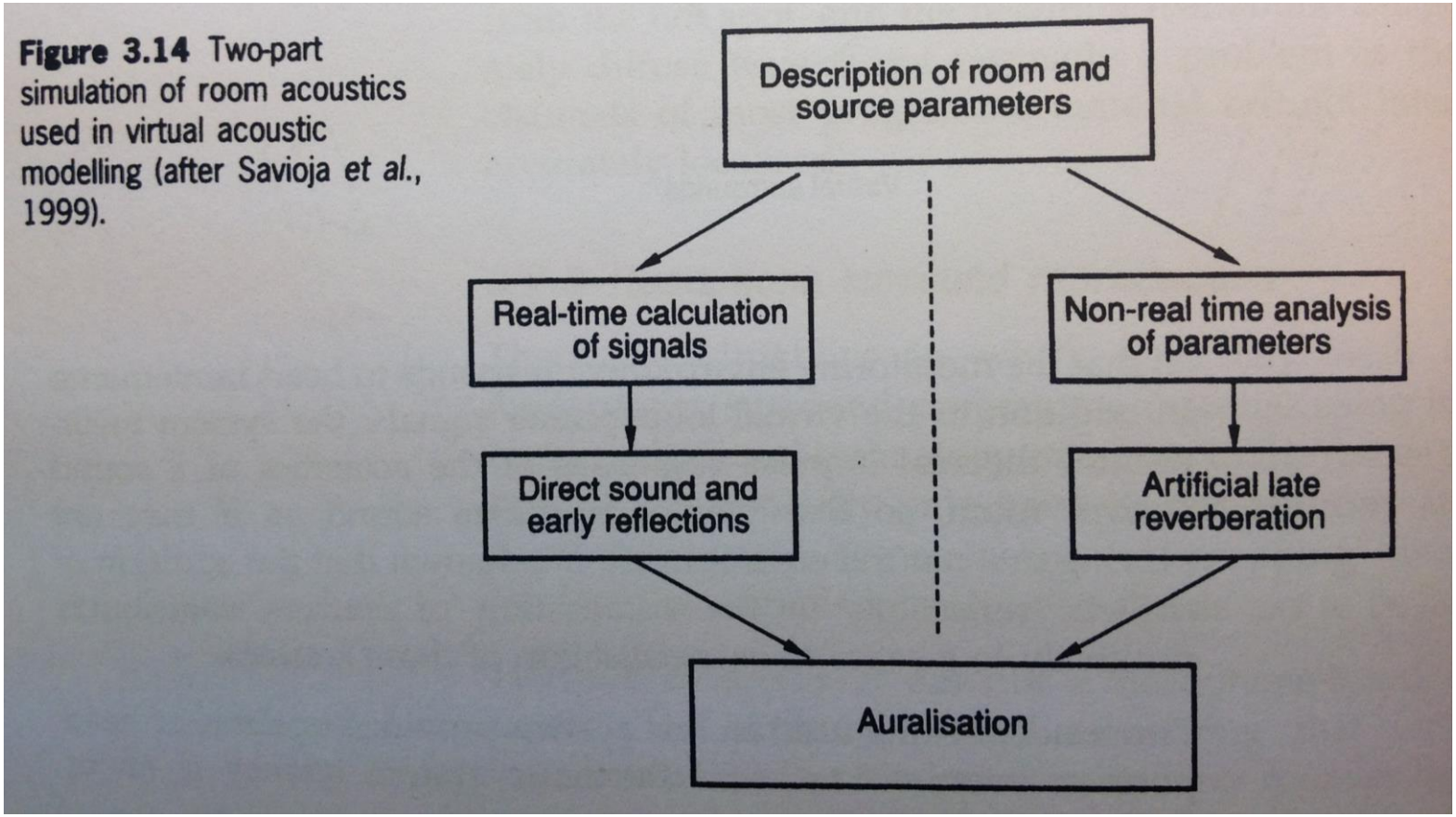
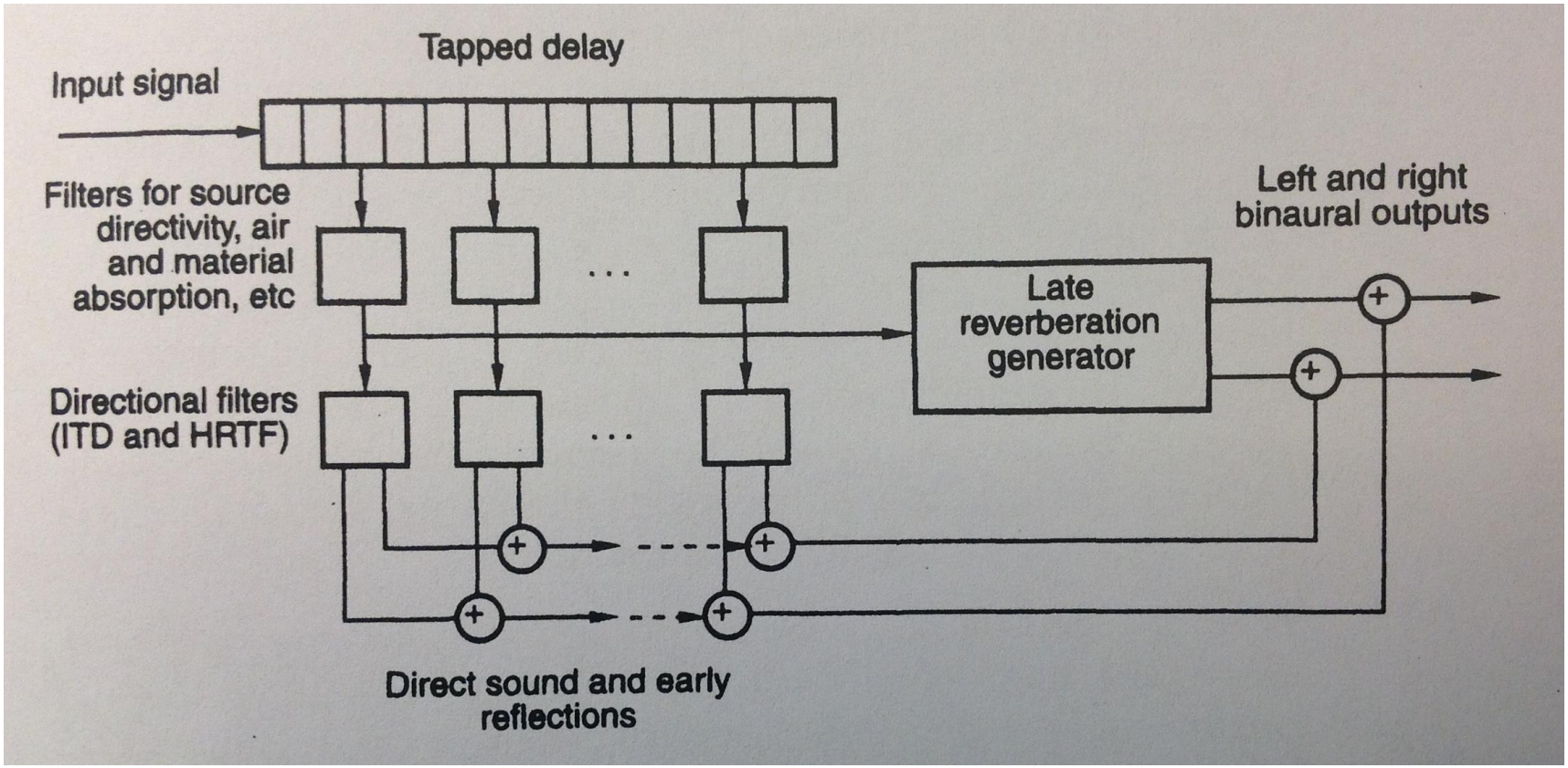


Figure 3.14 Two-part simulation of room acoustics used in virtual acoustic modelling (after Savioja *et al.*, 1999).

Sistemas de áudio espacial

- Sistema binaural:

Ambientes acústicos virtuais (auralização) processamento de sinais:



Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Sistema 5.1

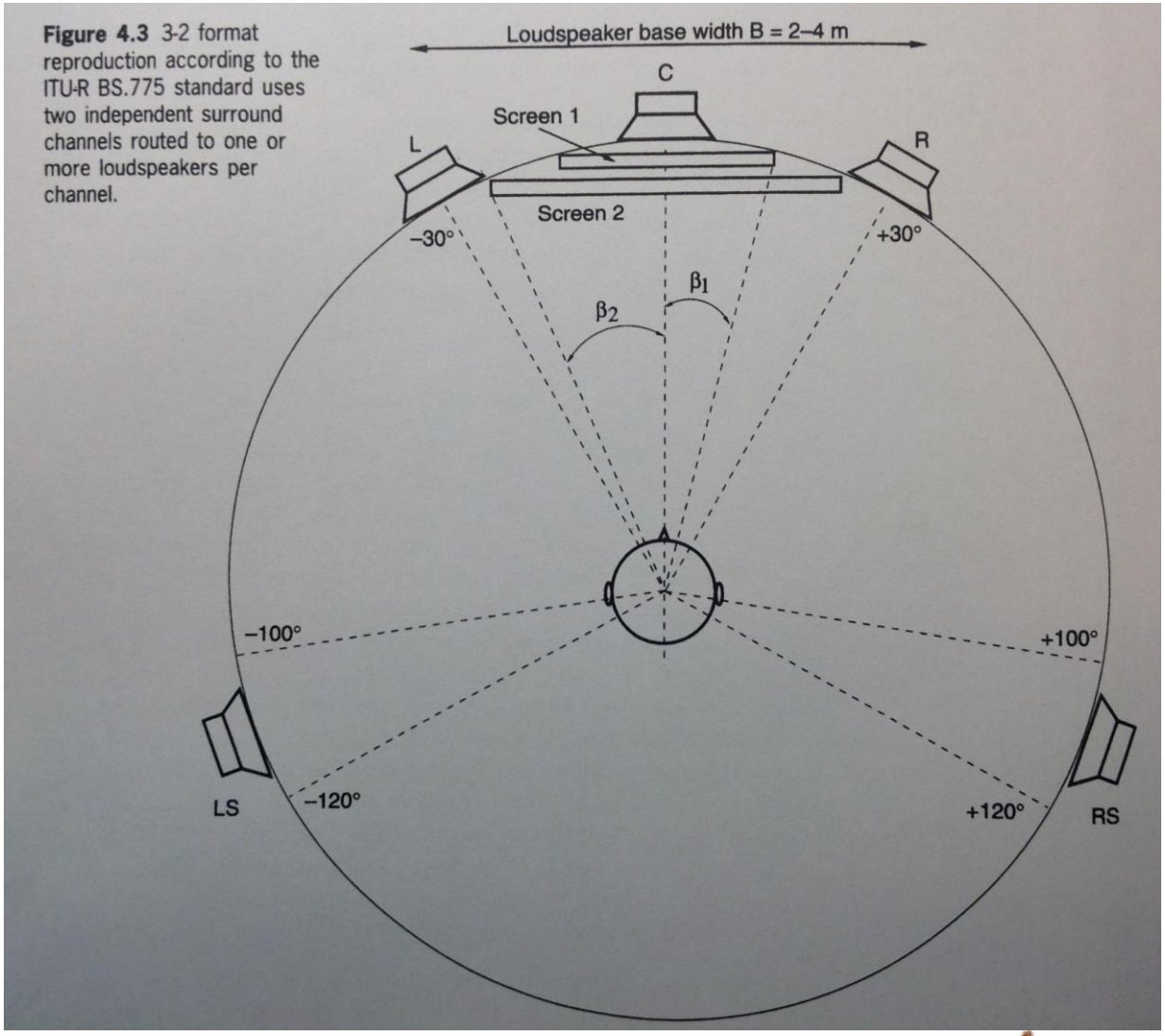


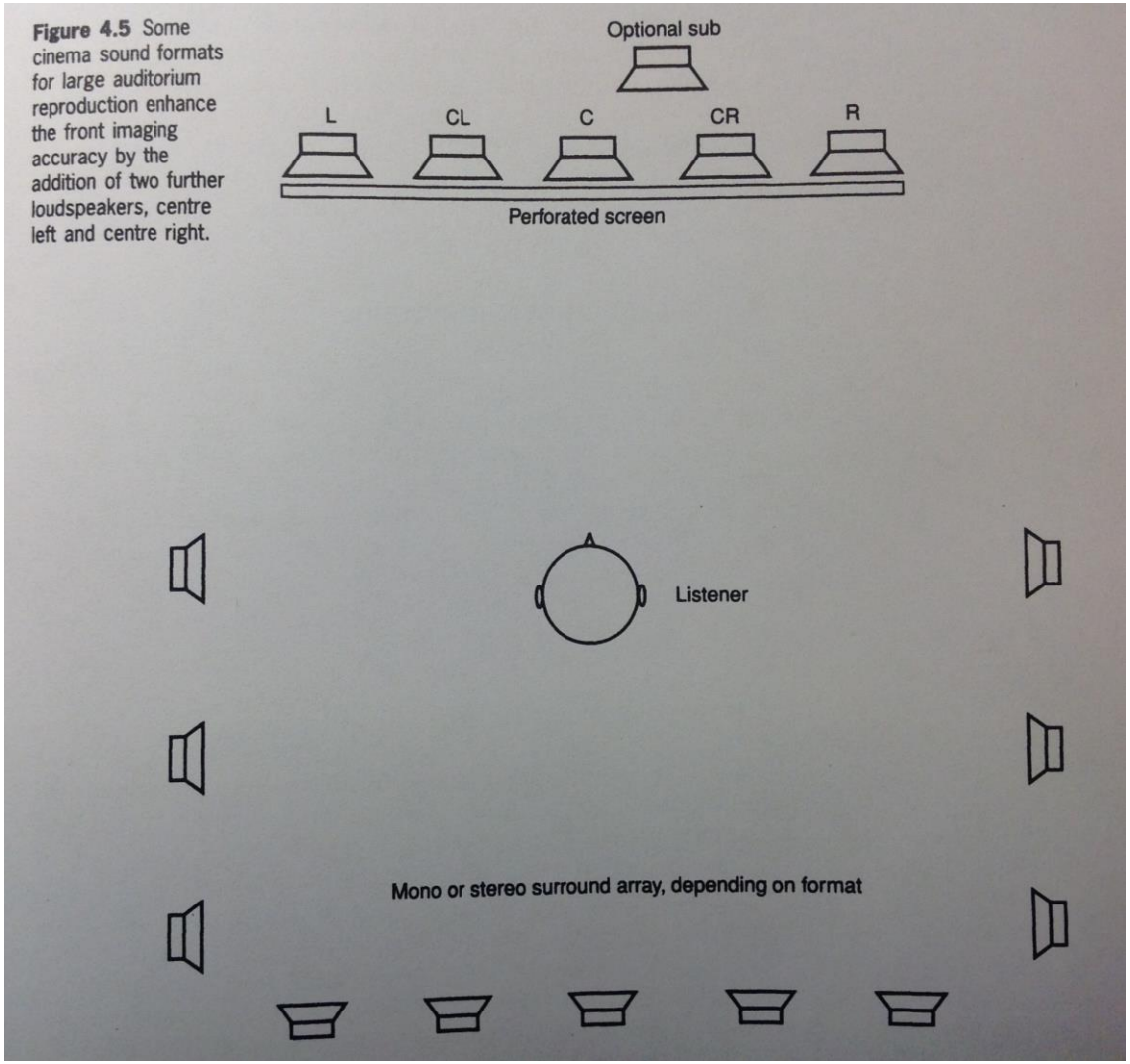
Figure 4.3 3-2 format reproduction according to the ITU-R BS.775 standard uses two independent surround channels routed to one or more loudspeakers per channel.

Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Sistema 7.1
em cinema

Dolby, Lexicon,
Dolby EX,
Dolby digital,
DTS



Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Ambisonics:

Configuração da cápsula microfónica base
(4 mics em disposição tetraédrica)

Formato A dos sinais

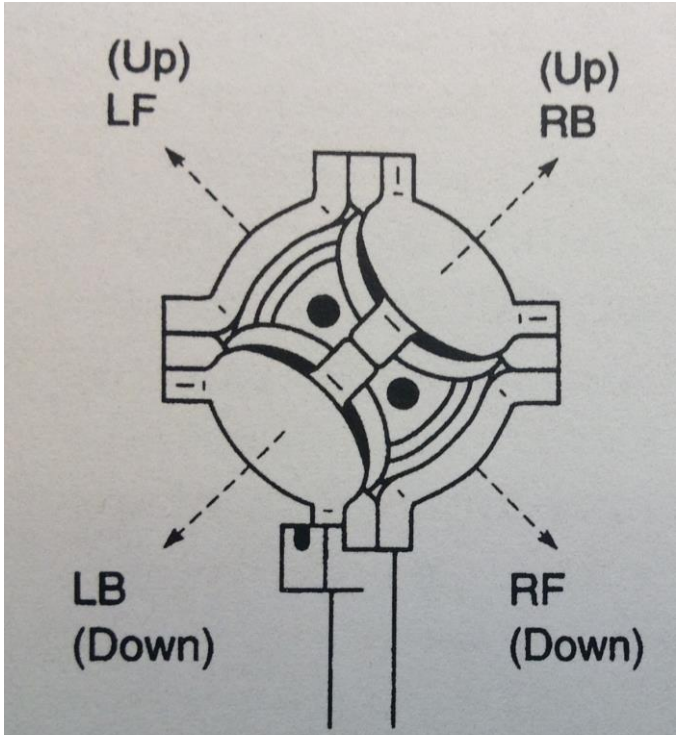


Figure 4.14 A-format capsule directions in an Ambisonic microphone.

Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Ambisonics:

Formato B dos sinais

4 sinais do formato B:
3 velocidades volumétricas direccionais
+ 1 pressão omni

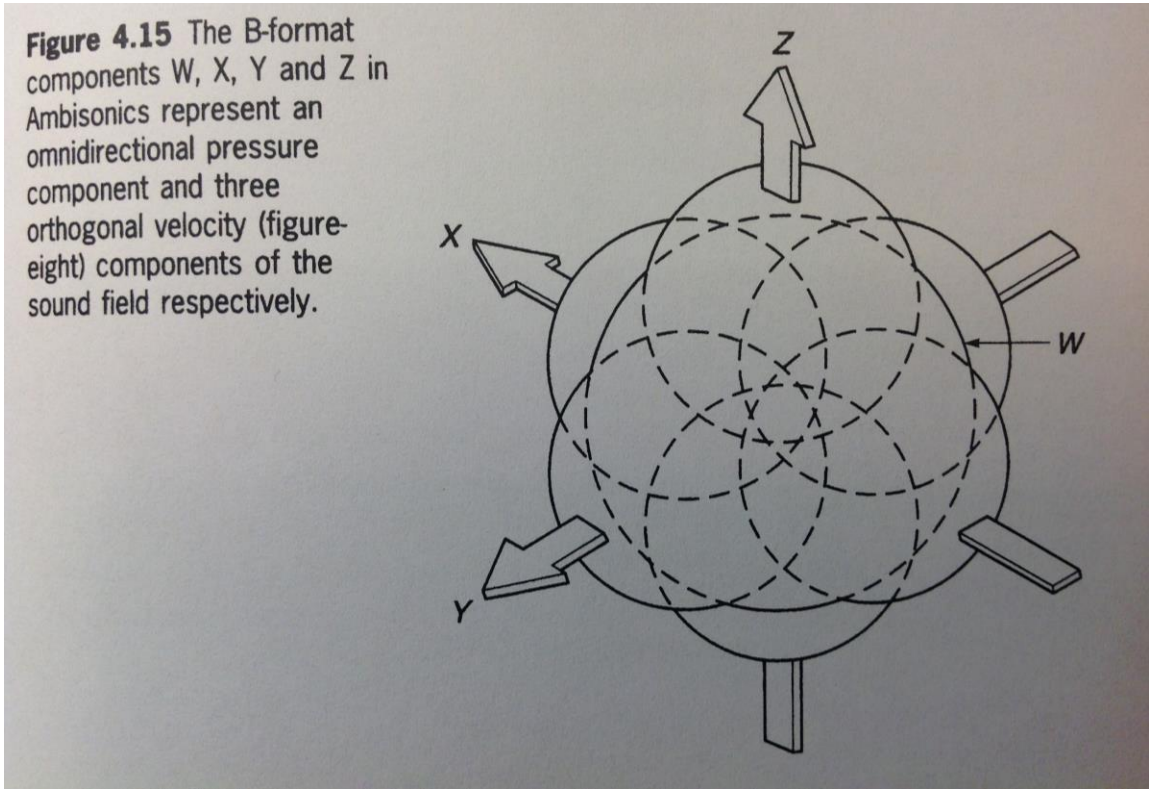


Figure 4.15 The B-format components W, X, Y and Z in Ambisonics represent an omnidirectional pressure component and three orthogonal velocity (figure-eight) components of the sound field respectively.

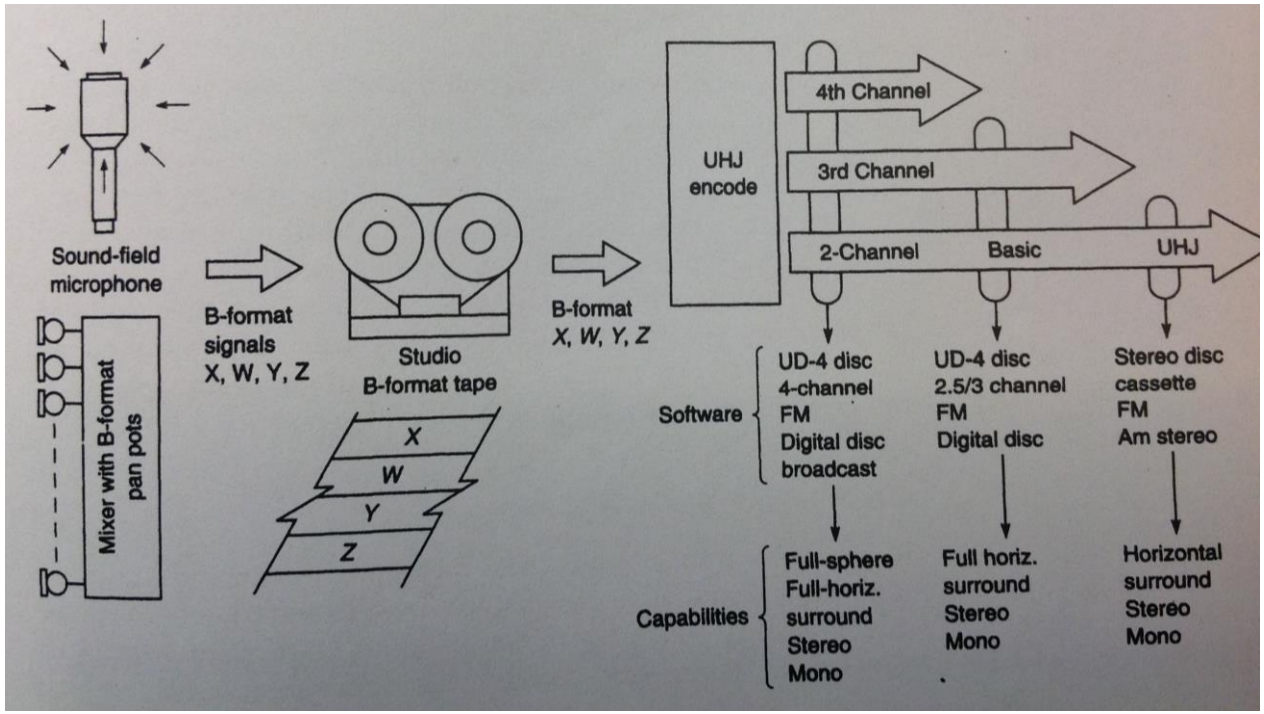
Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Ambisonics:

Formato C dos sinais

4 sinais do formato C:
2 canais compatíveis estéreo (L, R, ou Σ e Δ)
+
Canal T para melhoria da resolução horizontal
+
Canal Q contendo informação de elevação



Sistemas de áudio espacial

- Sistemas multi-canal e envolventes:

Ambisonics:

Formato D dos sinais
n sinais do formato D - Sinais para altifalantes, dependendo da configuração adoptada

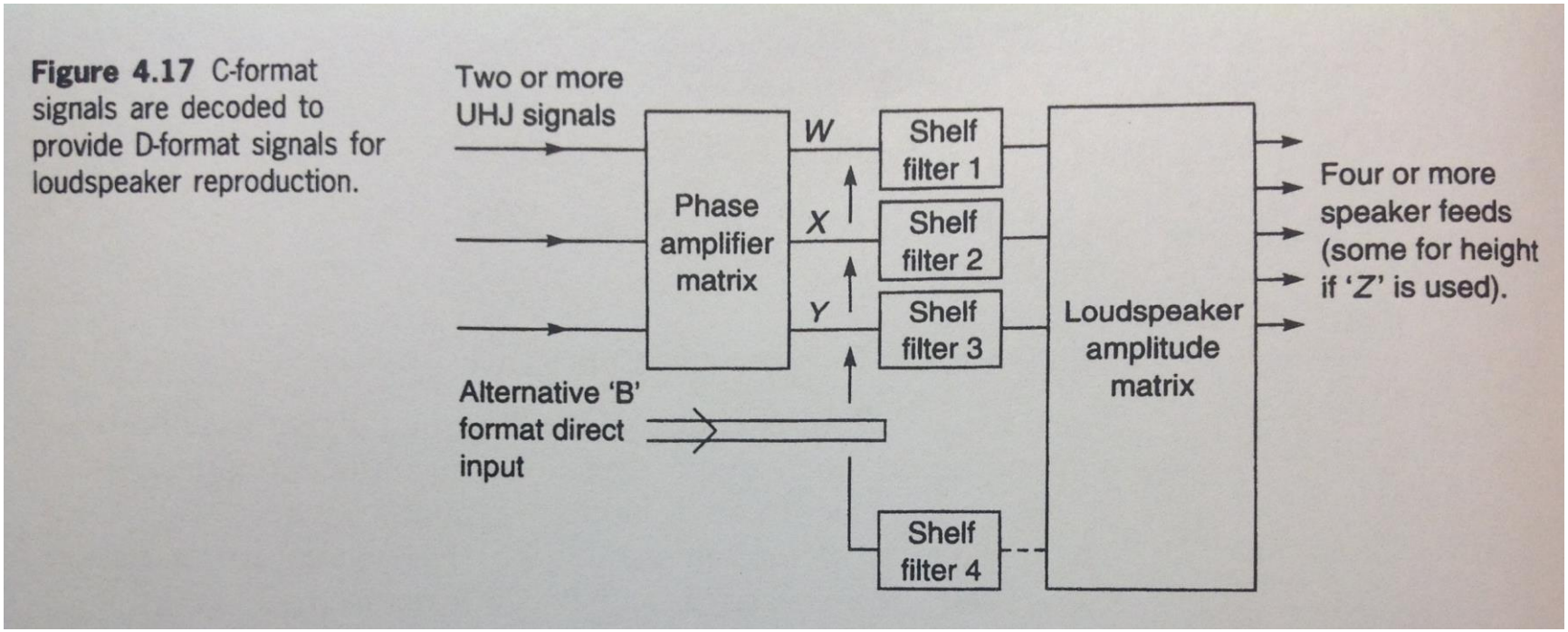


Figure 4.17 C-format signals are decoded to provide D-format signals for loudspeaker reproduction.

Aplicações

- Música
- Música 3D virtual binaural
- Cinema
- Cinema virtual binaural
- Captação microfónica 3D

Referências principais

Spatial Hearing, J. Blauert, MIT Press, 1997
Acoustics and Electroacoustics, Mario Rossi, Artech House, 1988
Spatial Audio, Francis Rumsey, Focal Press, 2001