

Directional effects on young children In real life

Teresa YC Ching¹, Harvey Dillon¹, Anna O'Brien¹,
Lisa Hartley¹, Josef Chalupper², David Hartley¹,
George Raicevich¹, Catherine Morgan¹

¹National Acoustic Laboratories, ²Siemens Ltd, CRC

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Why directional microphone technology for young children?

- Auditory maturation (Werner, 2008)
 - sensitivity is adult-like by 6 months
 - Resolution and attention continue to develop over first decade
- Children have difficulty listening to speech in noisy situations (Crandell, 1993; Finitzo-Hieber & Tillman, 1978)

Why directional microphone technology for young children?

- Children have difficulty listening to speech in noisy situations (Crandell, 1993; Finitzo-Hieber & Tillman, 1978)
- Younger children have greater difficulty than older children (Ching et al, 2008)

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Improve SNR for children

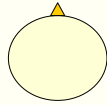
- Proximity-based technology (Lewis, 1991; Madell, 1992)
 - Multiple talkers
 - Incidental and directed learning
 - Cosmetic and social concerns
- Directivity-based technology
 - Listener-talker orientation
 - Listener-talker distance
 - reverberation

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Research on school-aged children in a laboratory,



- Directionality improved speech perception when target speech came from the front (Gravel et al, 1999; Ricketts et al, 2007)



- Directionality decreased speech perception when target speech originated from behind (Ricketts et al, 2007)

Do children look ahead at the talker?

Yes, school-aged children do so in classrooms (Ricketts & Galster, 2007).

Do young children look at the talker in real life?

Subjective rating of school-aged children

After 1-month trials,

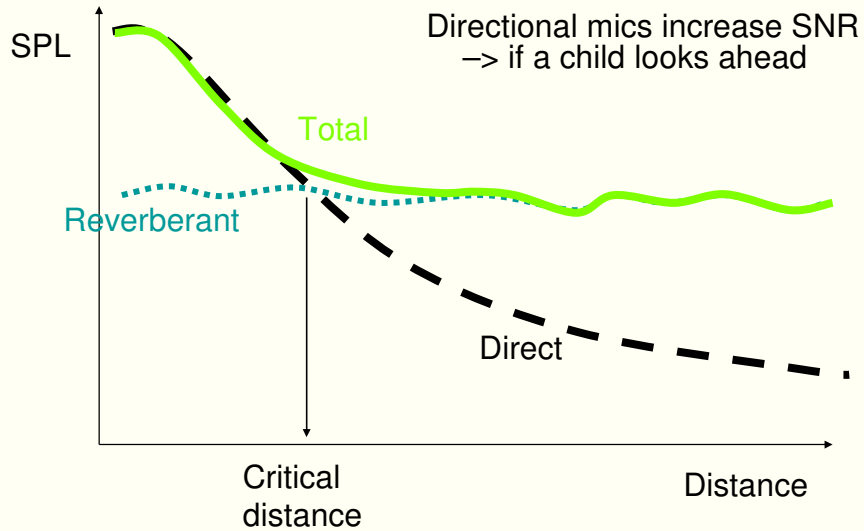


In real-life situations, effectiveness of directional microphones are affected by

- listener-talker distance
- reverberation

- when directionality was compared in same hearing aids, children (26) reported no significant difference (Ricketts et al, 2007)

When there is noise and reverberation,
A directional microphone lifts the speech in front,
but not the noise



Source: Dillon, NAL

Survey

When do you fit directional microphones to children?

- When they are infants ?
- Above 3 years of age ?
- When they are school age ?
- When they are adolescents ?
- When they are adults ?



Research questions

- How often do young children look at the talker in real-life situations?
- What proportion of a child's everyday life would he/she benefit from directional microphone technology?

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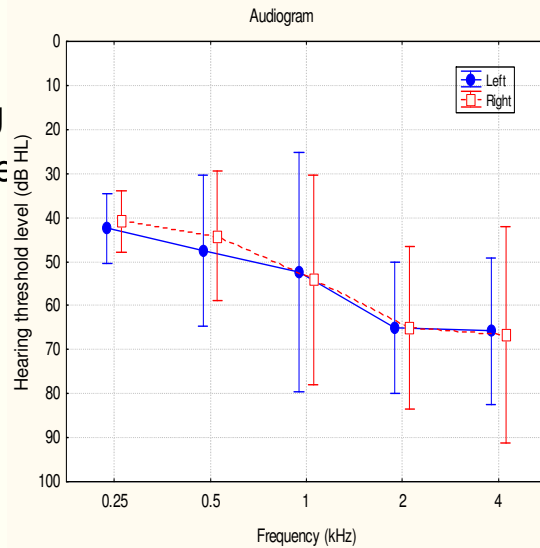
Aim

- To determine the extent to which directionality in hearing instruments is advantageous for young children in everyday natural environments

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Subjects

- 27 Children
 - 11 normal hearing
 - 16 hearing-impaired
- Age: 0;11 to 6;6



Method

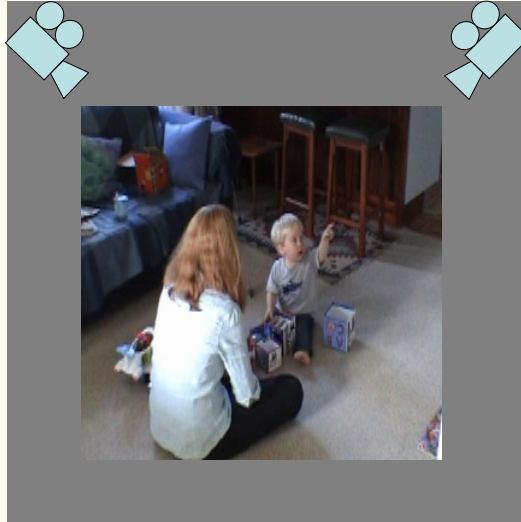
1. Video-record listening behaviour

Four scenarios :

- Child interacts with parent/caregiver in the child's home
- Child plays, with a parent elsewhere in the same room
- Child with a small number of children and adults around, and speech is not always directed to the child (e.g. mothers' group)
- Child plays outdoors with other children and adults

Video recording

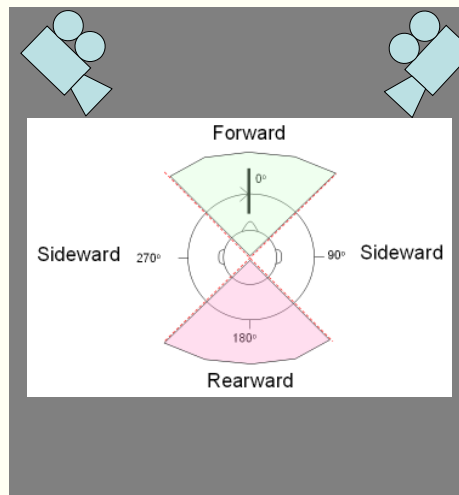
During recording, the closest (“best”) and furthest (“worst”) distances between child and talker were estimated, and speech levels were measured at these locations.



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Video analysis

- Videos “stitched” together and analyzed for:
 - Time “target speech” present
 - Proportion of time “target speech” is present that child is facing:
 - frontward
 - sideward
 - rearward



Listening behaviour - frontward



Listening behaviour: sideward



Method: 2. Directional benefits - Speech Transmission Index

- Dirac software for STI measurement
- Talker's head substituted by loudspeaker
- Child's head substituted by KEMAR's head
- Hearing aid dummy behind KEMAR's ear
- Stereo recordings of STI stimuli at 0, 90, 180 and 270° KEMAR azimuth
- Post-processing ->
 - omni and directional response
- Benefit = $STI_{\text{directional}} - STI_{\text{omni}}$



Method 3. Diary of everyday situations

- Parents described up to 10 situations in which their child spends most of their waking hours over a one-week period

Diary analyses

- Real-life situations categorized into:
 - One-to-one situations
 - Group situations
 - Solitary play

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Results

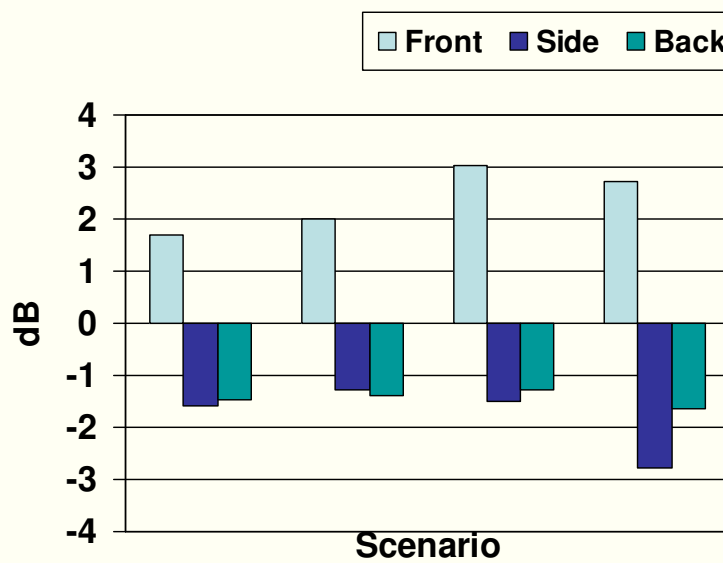
Averaged effect across “best” and “worst” estimates

	dB Advantage				
	Sc 1	Sc 2	Sc 3	Sc 4	Average
Front 0°	1.69	1.99	3.04	2.72	2.36
Side 90°/270°	-1.57	-1.28	-1.51	-2.78	-1.78
Back 180°	-1.48	-1.39	-1.27	-1.65	-1.44

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Directional advantage

(averaged across “best” and “worst” estimates)



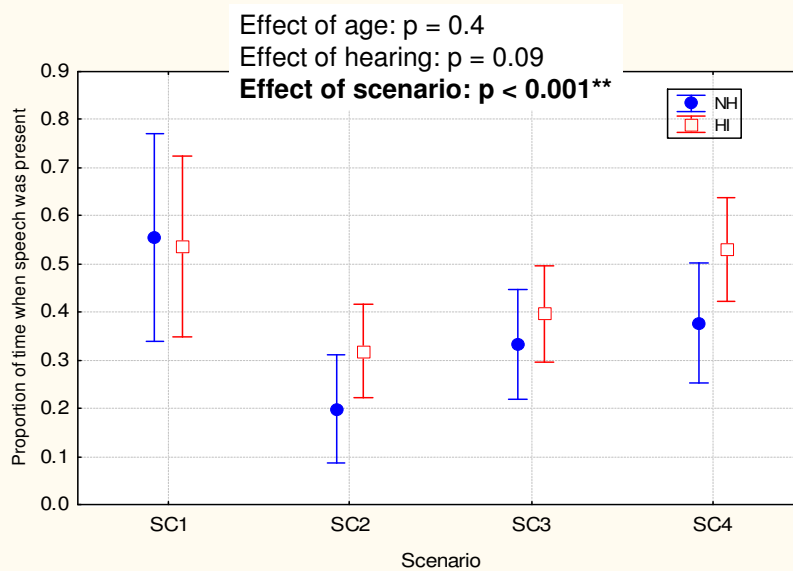
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If the child looks ahead

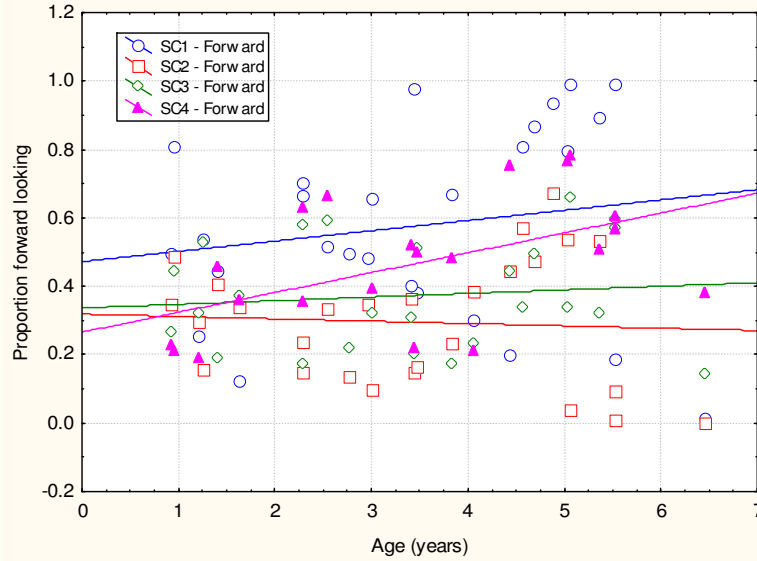
→ directional microphones increase SNR

.... But how often does the child look ahead?

How often do children look at the talker?

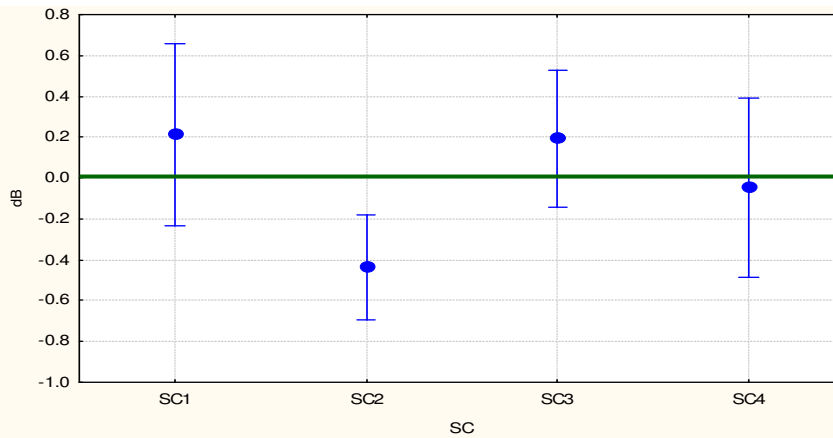


Proportion forward-looking vs age

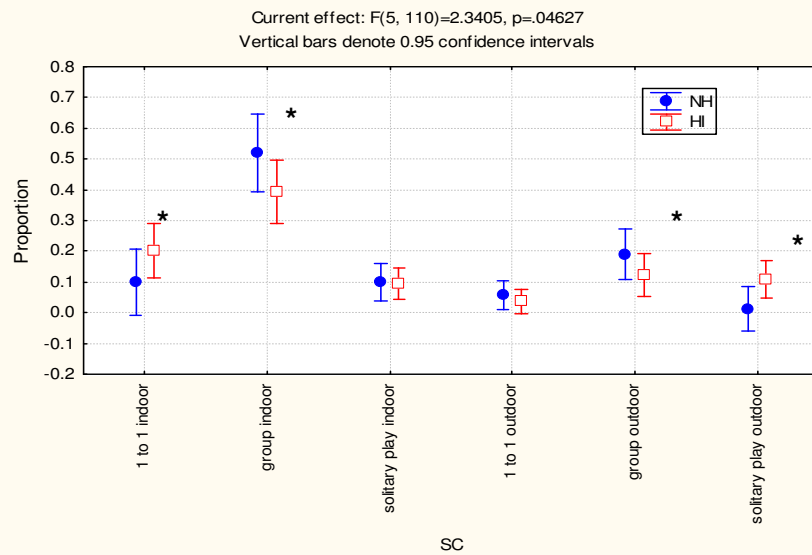


Overall advantage in real life

$$\text{Weighted adv} = \text{dBfront} * \% \text{front} + \text{dBside} * \% \text{side} + \text{dBback} * \% \text{back}$$



Daily activities as reported by parents



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Diary

- Indoors - HI children engaged in more one-to-one and less group situations than NH children ($p < 0.001$)
- Outdoors - HI children engaged in more solitary play and less group situations than NH children ($p < 0.001$)

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Summary

- Physical measurements of directional advantage up to 3 dB in different scenarios
- Age (11 m – 6.5 yrs) does not affect proportion of time children look at the talker.
- Both NH and HI children look at the talker >50% of the time during child-directed speech
- On average, weighted directional advantage varied between -0.4 dB to 0.2 dB across scenarios
- HI children engaged in more one-to-one and solitary play situations but less group situations than NH children

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Caveat

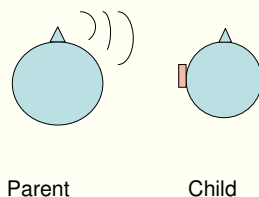
- HI children in this study had no experience in directional microphone technology
- Those with directional mics may look more at the talker
 - Talker attracts their attention
 - They are taught to look at the talker
 - They learn to look at the talker
- Hence, potential for greater weighted advantage than we found.

Interaction of compression and directional microphones

- Dominant speech signal from rear →
 - Directional mic decreases sensitivity →
 - Level decreased re an omni →
 - Compression in hearing aid increases gain
-
- Therefore net effect of directional mic and compression for rearwards wanted speech is a decrease in ratio of direct signal to (noise + reverberation) of around 3 dB, but a decrease in actual signal level of only around 1.5 dB.

Impact on side-by side interaction

- For side by side interaction, do **not** want a figure-eight pattern, so adaptive polar patterns would not be optimal.



Message for hearing aid companies

Auto-selection of directional microphones should be dependent on the direction of the dominant speech signal.

Message for clinicians

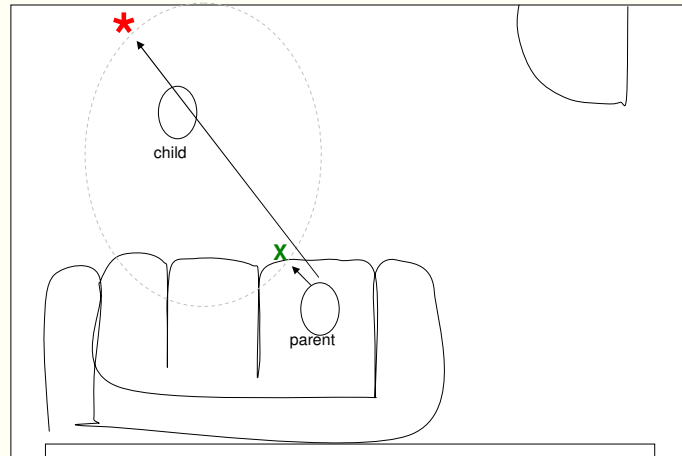
- Directional microphone technology does not significantly disadvantage children of any age
- Counsel caregivers and professionals on making the most of directional advantage
 - by facing the child when talking
 - by teaching the child to look at the talker

Ching TYC, O'Brien A, Dillon H, Chalupper J, Hartley L, Hartley D, Raicevich G and Hain J (2009). Directional effects on infants and young children in real life: implications for amplification. *Journal of Speech, Language and Hearing Research* 52:1241-1254.

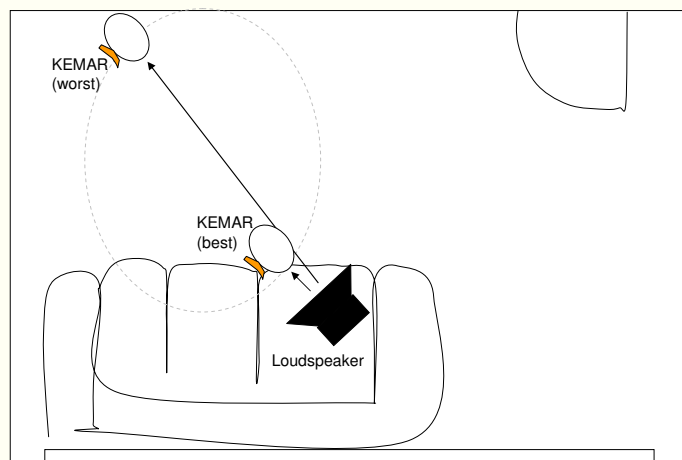
Thanks for listening

Teresa.ching@nal.gov.au

STI measurement positions

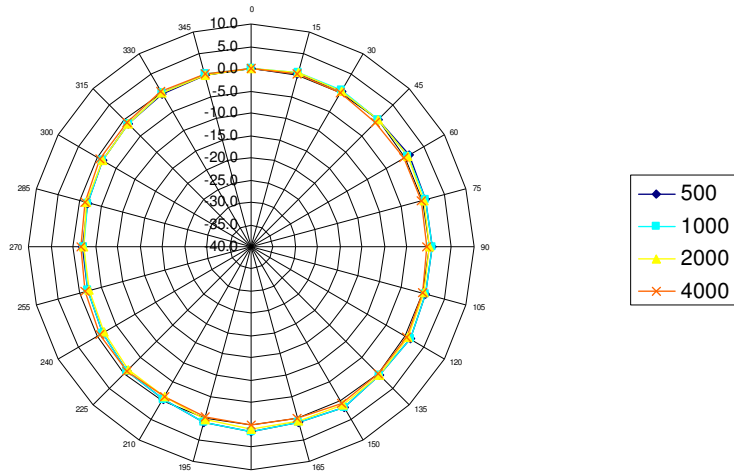


STI measurement position



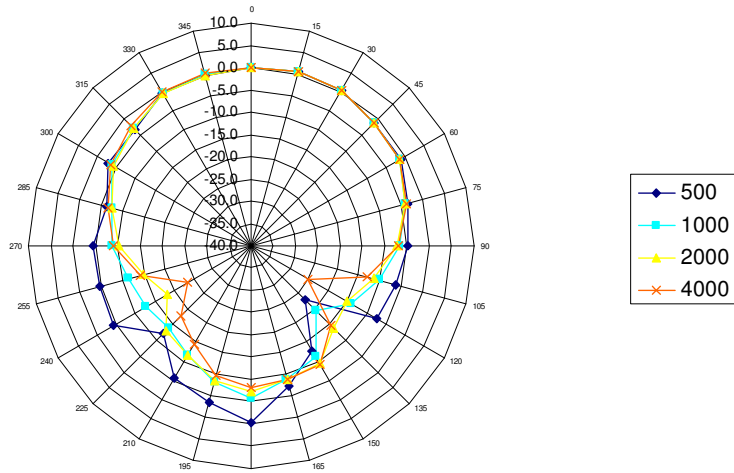
Free Field Omni directional (5.2 sec)

Free Field Results in dB V for processed Jens Script (Ch1)
1/3 Octave Analysis using IR time series data



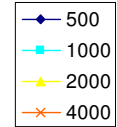
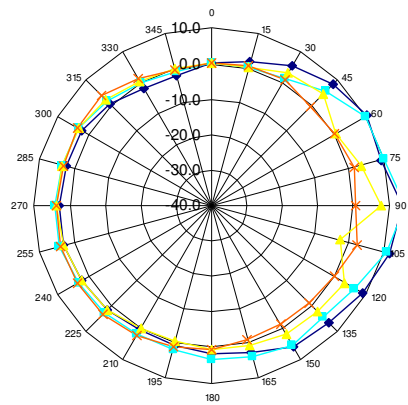
Free Field Directional (5.2 sec)

Free Field Results in dB V for processed Jens Script (Ch2)
1/3 Octave Analysis using IR time series data



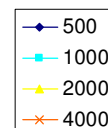
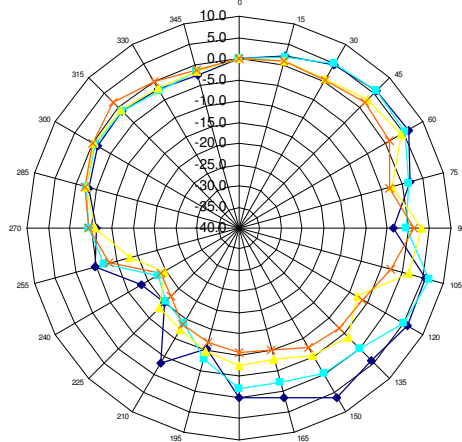
Kemar mounted Omni directional, Full 5.2 second data

Kemar Results in dB V for processed Jens Script (Ch1)
1/3 Octave Analysis using IR time series data



Kemar mounted Directional, Full 5.2 second data

Kemar processed results in dB V for processed Jens Script (Ch2)
Directional
1/3 Octave Analysis using IR time series data



Reverberation time

- Pure tone sweeps
- Stimulus peak at 40 dB above ambient noise
- Frequency specific values for T_{20} (time for stimulus intensity to fall by 60 dB, based on the first 20 msc of decay curve) calculated by Dirac software

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Reverberation time

