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► **To cite this version:**

Nicolas Misdariis, Alexandre Lang, Brian F. G. Katz, Patrick Susini. Perceptual effects of radiation control with a multi-louspeaker device. Acoustics08, Jun 2008, Paris, France. 2008. hal-01107055

**HAL Id: hal-01107055**

**<https://hal.science/hal-01107055v1>**

Submitted on 25 Jan 2024

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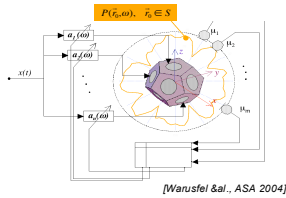
# Perceptual Effects of Radiation Control with a Multi-Louspeaker Device

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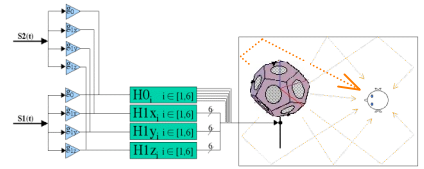
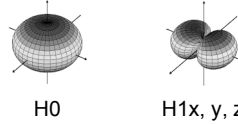
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## FRAMEWORK: Analysis, Synthesis and Control of the Acoustical Radiation of a Sound Source

Spherical Harmonics Decomposition Principle



$$\sum_{i=1}^N a_i(\omega) \cdot P_i(\vec{r}_0, \omega) = T(\vec{r}_0, \omega), \forall \vec{r}_0 \in S$$



Source S: {Pi} i=1,...,N      Target T: Spherical Harmonics (SH)      Application: Encoding / Decoding

## OBJECTIVES:

- Perceptual evaluation of the acoustical radiation control
- Identification of the principal components influencing the perception of the directivity

## EXPERIMENT:

- Question:** Does the acoustical radiation control allow to reduce the perceived gap between a real sound and a sound coming from an electro-acoustical device ?

### Corpus:

- 3 technological devices:

[1-D]



fig.1a: 1-D device

[2-D]



fig.1b: 2-D device

[3-D]

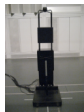


fig.1c: 3-D device

- 2 groups of stimuli:

### speaking/singing voice

- signal data : recorded in anechoic room for different phonemes
- spatial data : measured in anechoic room for different phonemes
- sequence : succession of phonemes (/a/-ch/-il/, ...)
- stimulus : each unit of the sequence associated to a directivity pattern

### simulated plate

- signal data : synthesized by physical modeling (modal approach)
- spatial data : theoretical model of radiation [Lauvagnet, JASA 1998]
- sequence : superposition of vibration modes
- stimulus : each mode associated to a directivity pattern [SAS : Warusfel &al., ASA 2004]

↳ 2 control factors for the directivity:

- degree of freedom of the diffusion device: **D1, D2, D3** (cf. fig.1)
- level of complexity of the controlled directivity:

**R1:** uncontrolled – **R2:** cardioid – **R3:** dipole – **R4:** monopole – **R5:** "real"

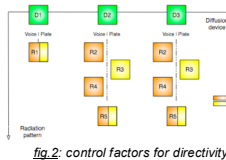


fig.2: control factors for directivity

- dummy head recording at Ircam auditorium (ESPRO)
- binaural rendering in a sound isolation booth

**Task:** Semantic differential judgements on 3 scales :

**E1:** « width » – **E2:** « distance » – **E3:** « realism »

## PERSPECTIVES:

- Further investigations involving:
  - a definition of a relevant set of semantic attributes
  - a single type of stimuli with the missing link to the reality (a human speaker/singer or a physically hit plate)
- Investigations on the links between perceptual attributes and objectives criteria (Directivity Index, Reverberation Time, etc. ...)

## RESULTS: (for voice stimuli only)

**Analysis #1:** MANOVA 1

- independent variables: **D2, D3, R2, R4, R5**
- dependent variables: **E1, E2, E3**

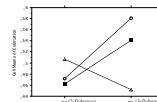


fig.3a: effect of D on E

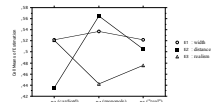


fig.3b: effect of R on E

↳ significant effect of **D** and **R** on **E**  
[Lambda de Wilks test, F=75,8 (resp. 20.1), p<0.0001]

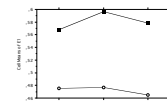


fig.4a: D/E interaction on E1

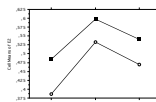


fig.4b: D/E interaction on E2

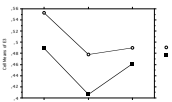


fig.4c: D/E interaction E3

↳ non significant interaction between **D** and **R**

**Analysis #2:** MANOVA 2

- independent var.: **D1, D2, D3, C1, C2, C4, C5, C6, C8, C9**  
(D1+R1) (D2+R2) (D2+R4) (D2+R5) (D3+R2) (D3+R4) (D3+R5)
- dependent var.: **E1, E2, E3**

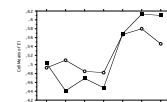


fig.5a: effect of C on E1

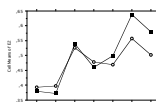


fig.5b: effect of C on E2

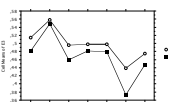


fig.5c: effect of C on E3

↳ significant effect of **C** on **E**  
[Lambda de Wilks test, F=21,06, p<0.0005]

- on **E1:** significant difference between {C1, C2, C4, C5} and {C6, C8, C9}
- on **E2:** significant difference between {C1, C2} and {C4, C5, C6, C8, C9}
- on **E3:** no significant difference

↳ interaction between **C** and **Stimulus** [Lambda de Wilks test, F=2,21, p<0,005]

## CONCLUSIONS:

- Radiation control has a significant effect on auditory perception
- This effect is significant for « width » and « distance » attributes
- Scale « realism » doesn't seem appropriate for evaluating this effect
- The gap between real source and diffusion device tends to be reduced