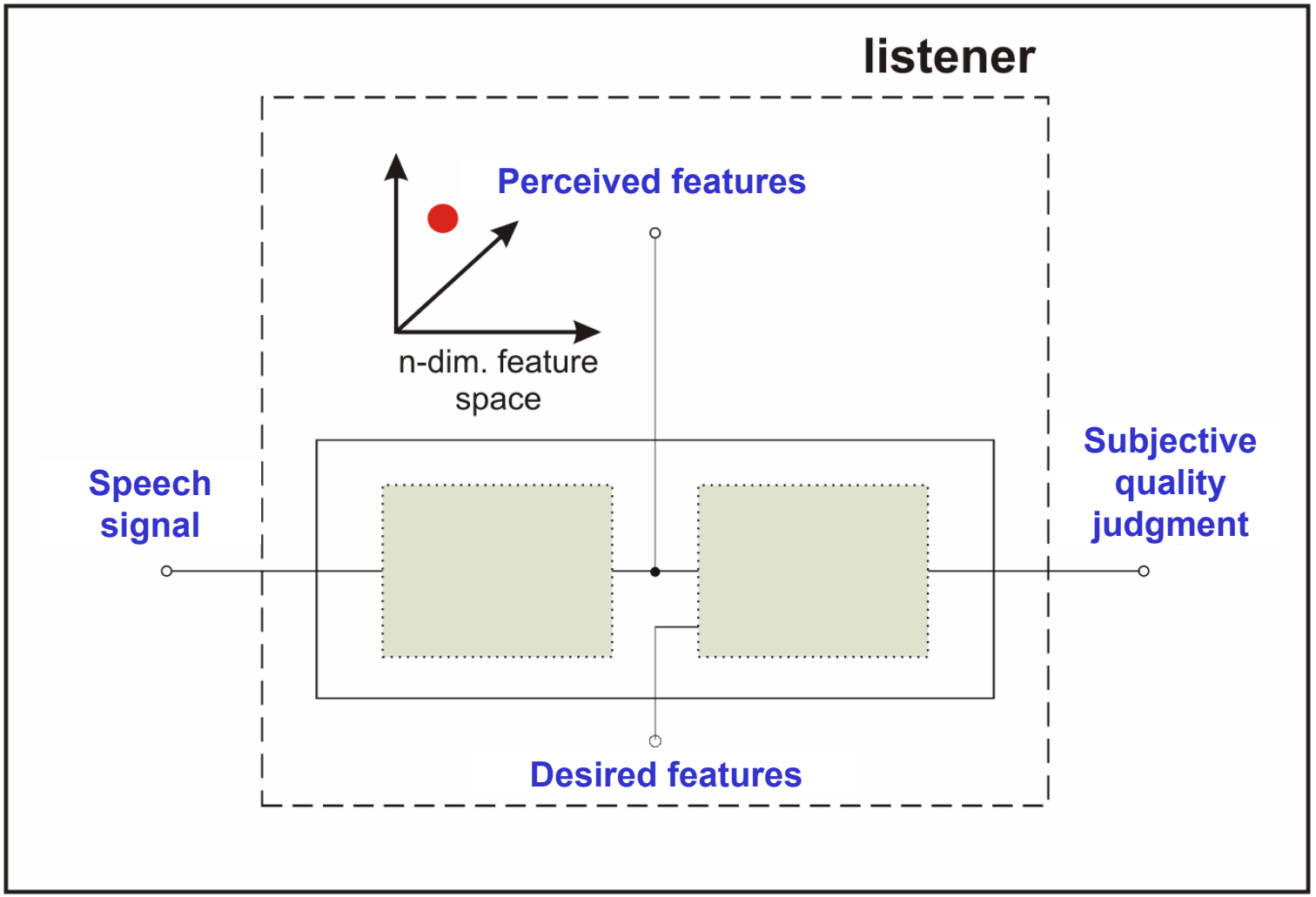
Quality Dimensions of Narrowband and Wideband Telephone Connections

Marcel Wältermann [1]
Alexander Raake [2]
Sebastian Möller [3]

[1] IKA, Ruhr-University Bochum, Germany
[2] LIMSI-CNRS, University de Paris-Sud, Orsay, France
[3] Deutsche Telekom Laboratories, Berlin, Germany

Definition: Speech Quality



[adapted from Blauert, 1994; Jekosch, 2000; Raake, 2005]

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- Extraction of perceptual dimensions:

  Multidimensional scaling experiment
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- Overall quality
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Motivation

- Long-term goal:
  - Instrumental estimation of overall quality
    - valid for both *NB* and *WB* networks
    - valid also for *future* transmission technologies and user interfaces
- Awareness of perceptual dimensions:
  - New, attribute-based approach
- Applications:
  - Speech transmission
  - Speech enhancement
  - Network planning
  - Network monitoring

Extraction of Perceptual Dimensions

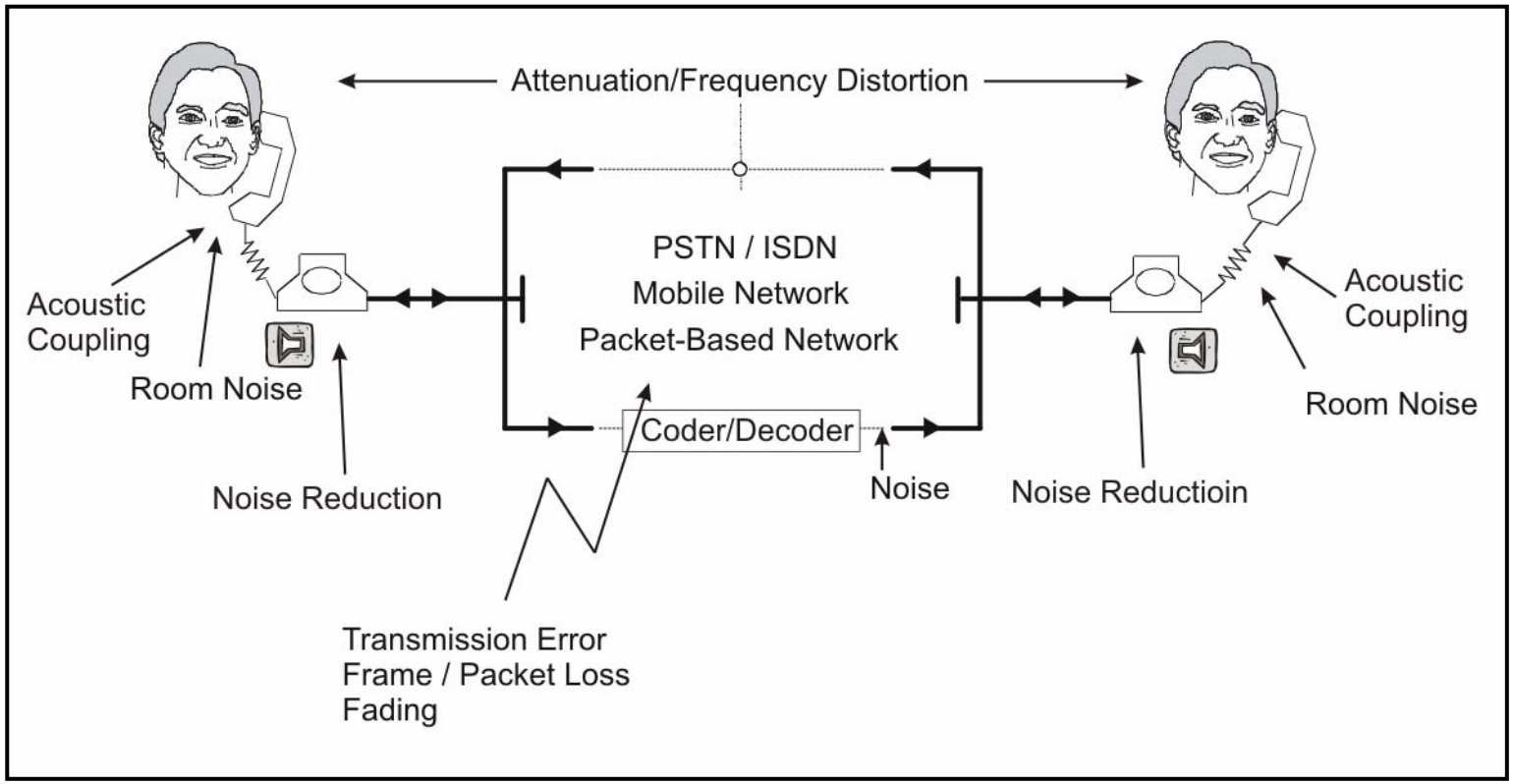
- Multidimensional scaling experiment
- Similarity of pairwise-presented stimuli judged by 14 test subjects

Mapping:
n-dim. Feature space → *n*-dim. Stimulus space

- Revelation of dimensionality *n*
- Subsequent labelling of the dimensions

Considered Speech Samples (1/2)

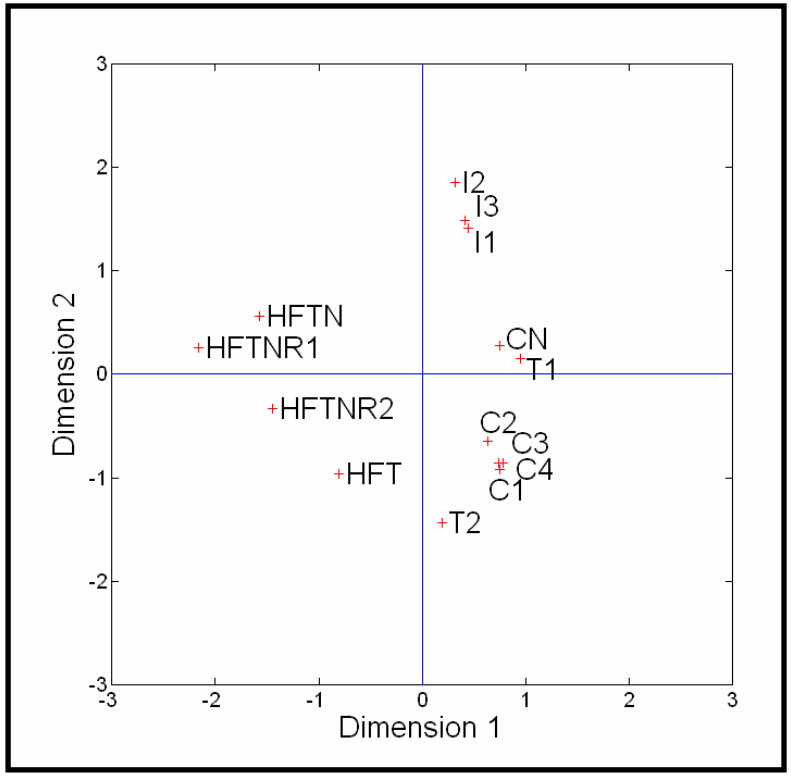
- 14 stimuli, 2 speakers (f/m) → 364 judgments

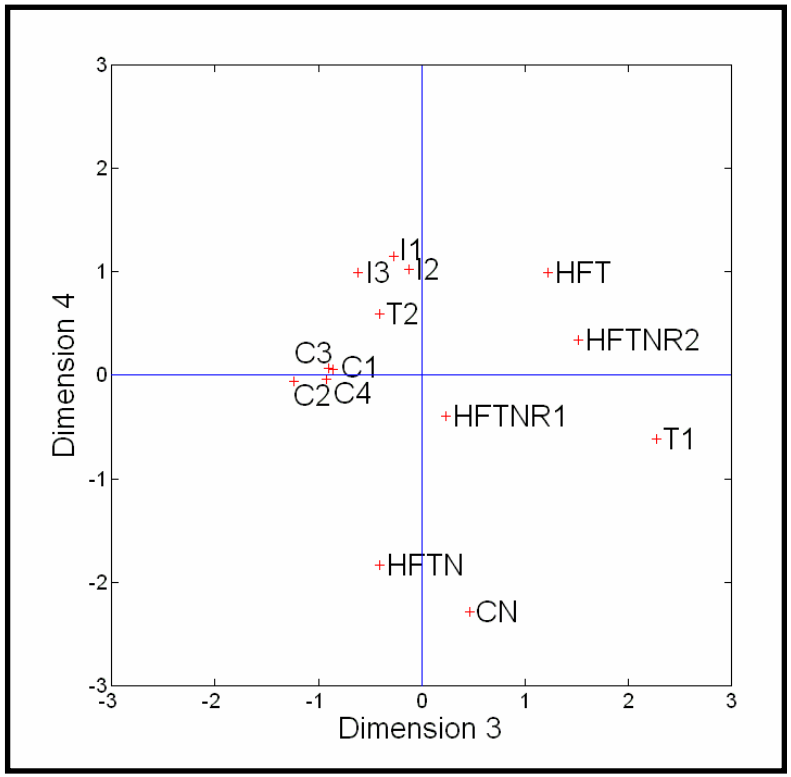


Considered Speech Samples (2/2)

Abbreviation	Codec	Send filter	Additional impairment
C1	G.711	IRSmod	-
C2	G.726	IRSmod	-
C3	G.729A	IRSmod	-
C4	AMR	IRSmod	-
CN	G.711	IRSmod	Nfor = -50 dBmp
T1	G.711	IRSmod	Bandpass 0.5 – 2 kHz
T2	G.711	Flat	-
I1	G.729A	IRSmod	10% packet loss
I2	G.729A	IRSmod	20% packet loss
I3	G.711	IRSmod	10% interruptions ($\cos^2$-ramps)
HFT	G.711	Flat	HFT
HFTN	G.711	Flat	HFT, Hoth Noise
HFTNR1	G.711	Flat	HFT, Hoth Noise, Boll N.R.
HFTNR2	G.711	Flat	HFT, Hoth Noise, Ephraim/Malah N.R.

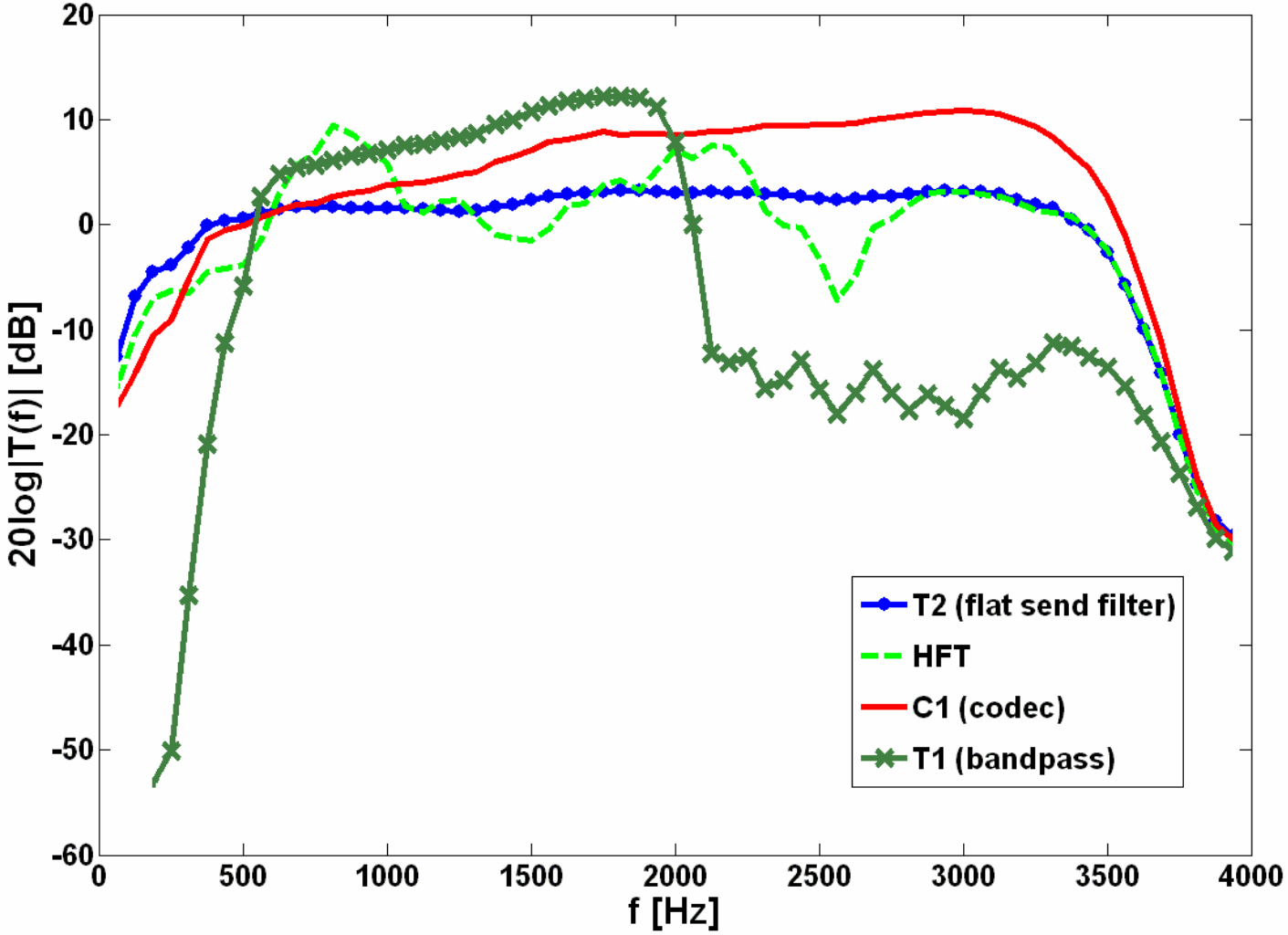
Interpretation of the Stimulus Space





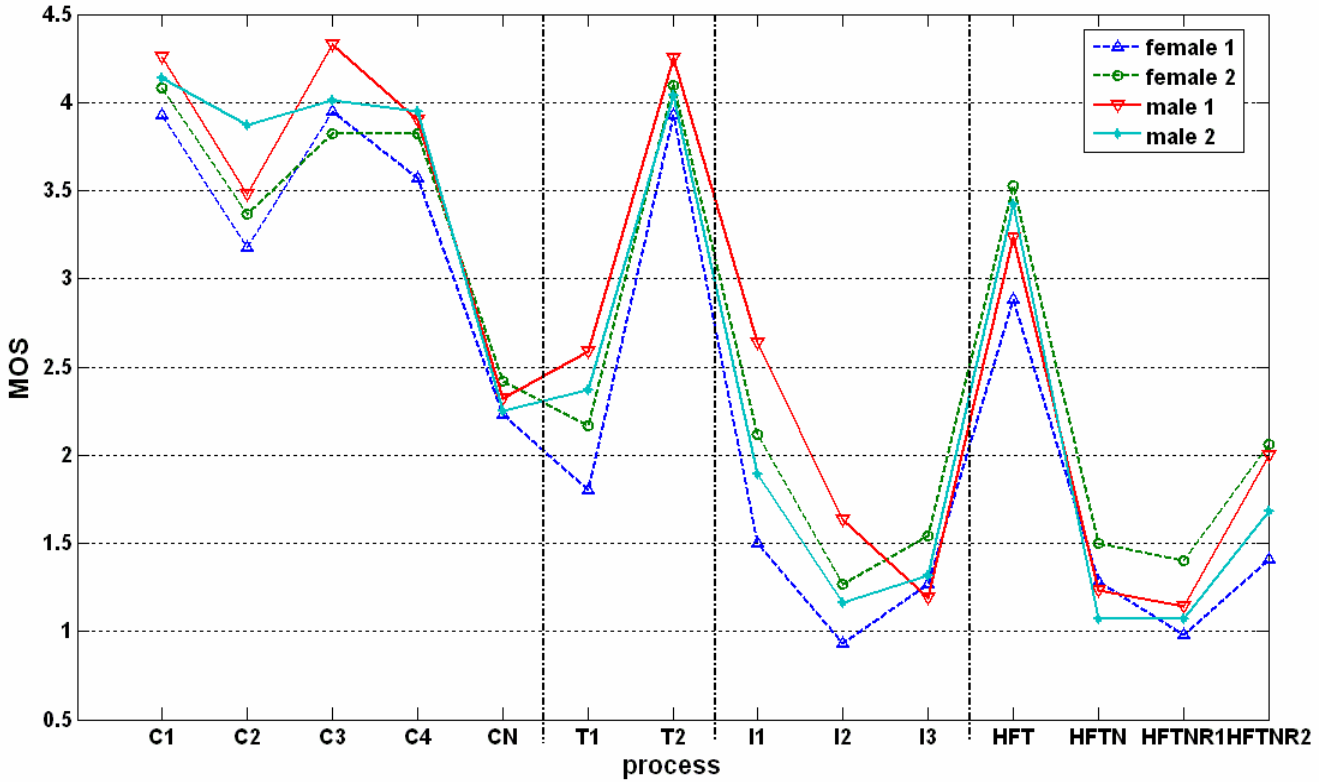
- Dim. 1: Directness / Clearness
- Dim. 2: Interruptedness
- Dim. 3: Frequency Content
- Dim. 4: Noisiness

Estimated Transfer Functions



Judgment of Overall Quality

- 16 subjects, two additional speakers, 56 judgments
- Mean Opinion Scores (MOS):



Regression Analysis

- Prediction of the overall quality by means of the derived stimulus space
- Assumption: linear relation
- $R^2 > 90\%$

Dimension	b_k ♀	b_k ♂
Directness / Clearness	0.380	0.379
Interruptedness	-0.812	-0.740
Frequency Content	-0.247	-0.168
Noisiness	-0.057	-0.379

Conclusions and Outlook (1/2)

- 4 identified dimensions
  - Interruptedness
  - Directness / Clearness
  - Frequency Content
  - Noisiness

Interruptedness, Directness / Clearness: about 70% of overall quality

Directness / Clearness, Frequency Content: frequency-dependent

- Most significant dimension is frequency-independent
- Directness / Clearness: HFT vs. non-HFT
  - Possible correspondence with Brüggen (2001):
    - ≤ 2kHz: “sound coloration“ due to early reflections (comb filter)
    - “diffusity“ due to late reflections (spatial and temporal fuzziness)
- Perceptual differentiation of codecs is negligible

Conclusions and Outlook (2/2)

- **Consequences regarding WB speech:**
  - Most impotant perceptual dimension should be *independent* from NB / WB, but…
  - *Weightings* may change for WB conditions, therewith…
  - *Importance* of remaining dimensions may be different for WB

- **Next steps in regard to an universally valid model for speech quality estimation:**
  - Verification of the consistency of NB and WB feature spaces
  - Investigation of single dimensions, taking WB into account
  - In this way, relevance of perceptual dimensions for overall quality can be determined in relation to bandwidth

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Contacts

- **Marcel Wältermann**
  Institut für Kommunikationsakustik
  Ruhr-Universität Bochum
  D-44780 Bochum, Germany
  E-mail: marcel.waeltermann@ruhr-uni-bochum.de
- **Alexander Raake**
  LIMSI-CNRS
  Université de Paris-Sud
  F-91403 Orsay, France
  E-mail: alexander.raake@limsi.fr
- **Sebastian Möller**
  Deutsche Telekom Laboratories
  Ernst-Reuter-Platz 7
  D-10587 Berlin, Germany
  E-mail: sebastian.moeller@telekom.de