CCRMA/YAMAHA MASS Project
Masking Ambient Speech Sounds

Juan-Pablo Cáceres

MASS Project Background

Collaboration Summer 2006

CCRMA

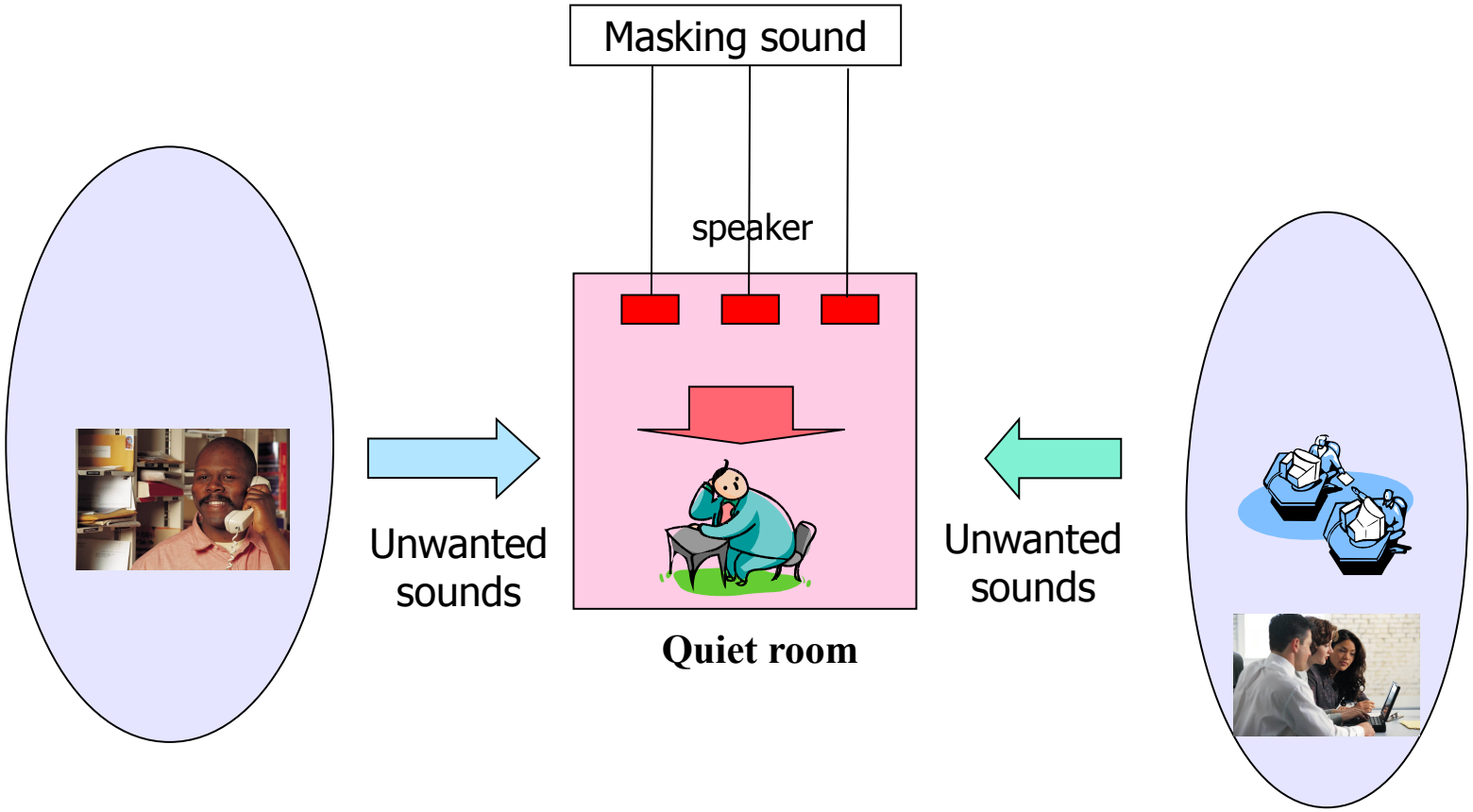
Chris Chafe
Jonathan Berger
Jonathan Abel
Juan-Pablo Cáceres
Hiroko Terasawa
Jason Sadural

Yamaha

Center for Advanced Sound Technologies
Innovative Technology Group

Yasushi Shimizu
Atsuko Ito

The Problem



Mask/Camouflage of Intruding Speech

Some Maskers

Pink Noise Types, spectrally matched

Efficiency lost for speech spectrally unmatched

female+speech.wav

Amplitude Modulated Noise

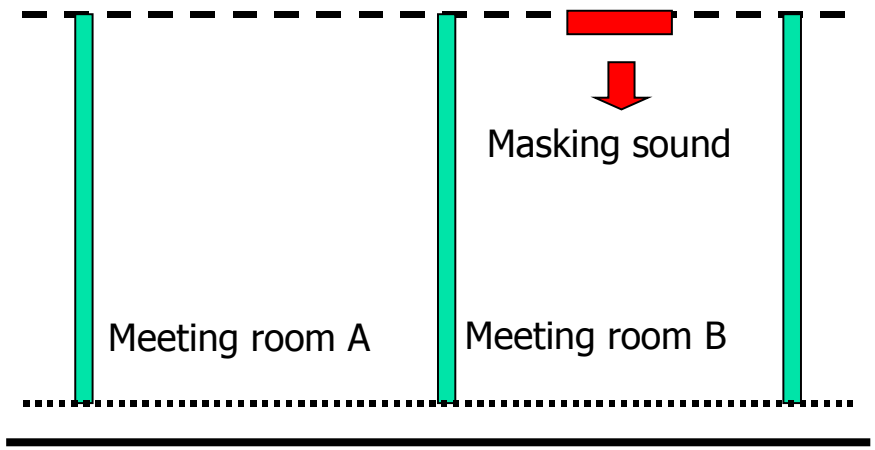
Too distracting

AM_max45dB.wav

Reversed Speech

Too distracting

reverse+2dB.wav



Mass Project Summary

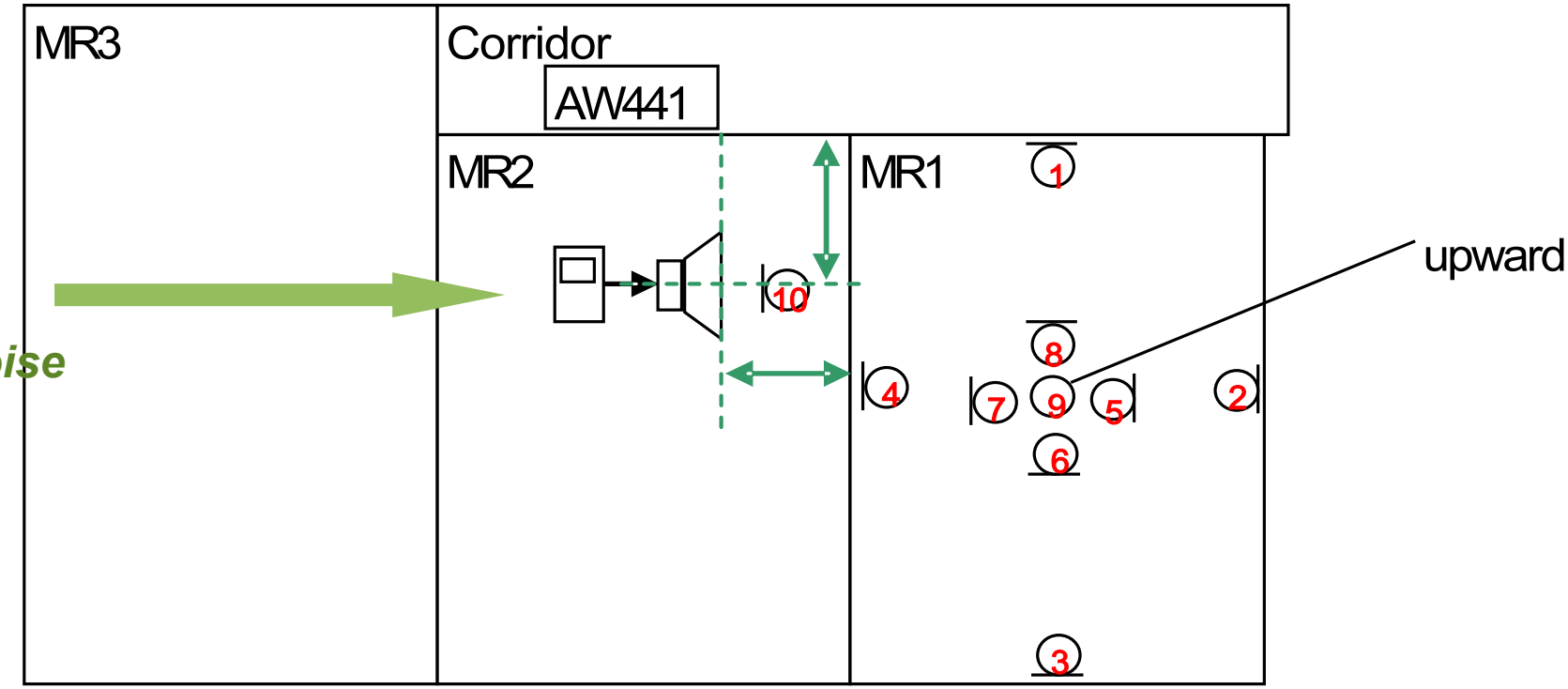
Tokyo Office Simulation for Experiment Setup

Masker Design: FM and Gurgle

Psychoacoustic Experiments

Recording for Room Modeling

- *Sine Sweeps*
- *Voices*
- *Calibration Noise*



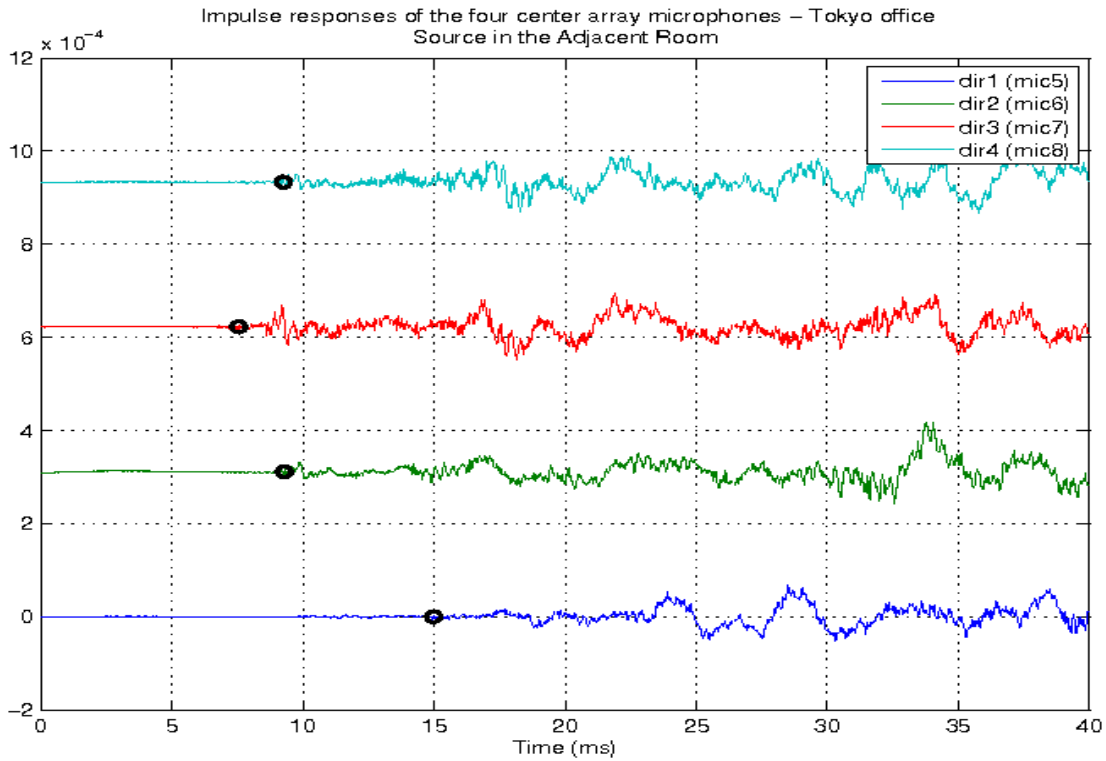
Tokyo Office

Recording for Room Modeling

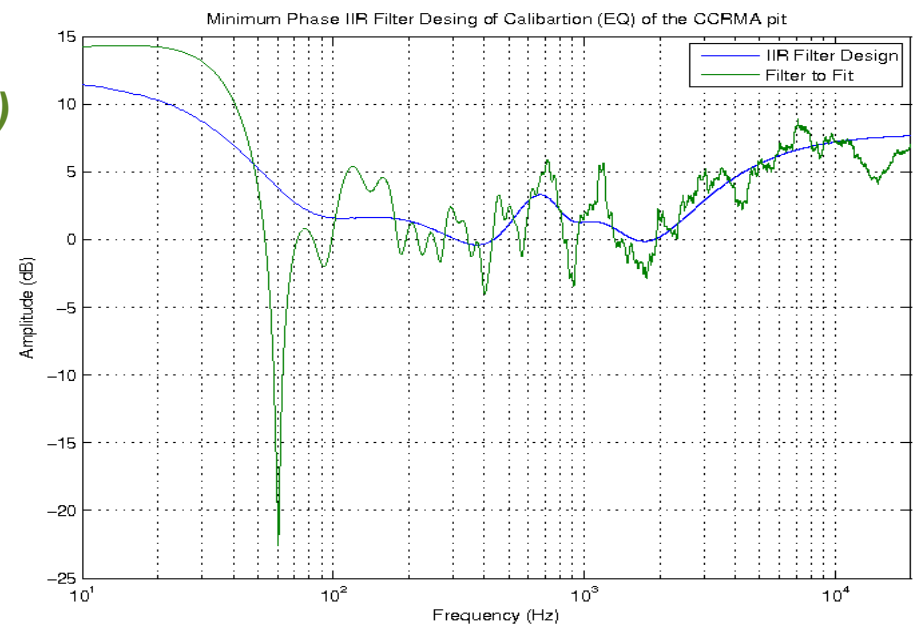
Tokyo Office

Recording

Impulse Response Generation

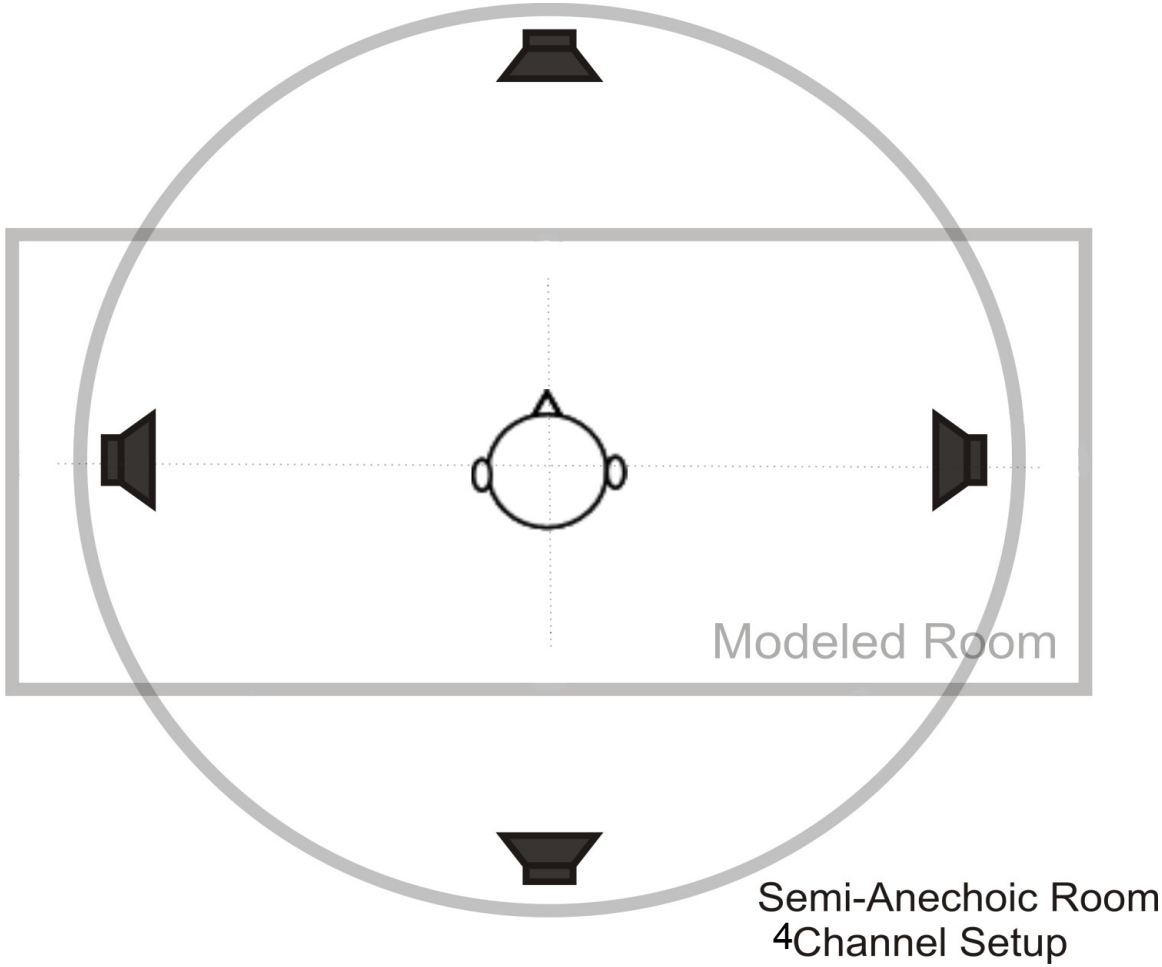


Calibration (EQ)

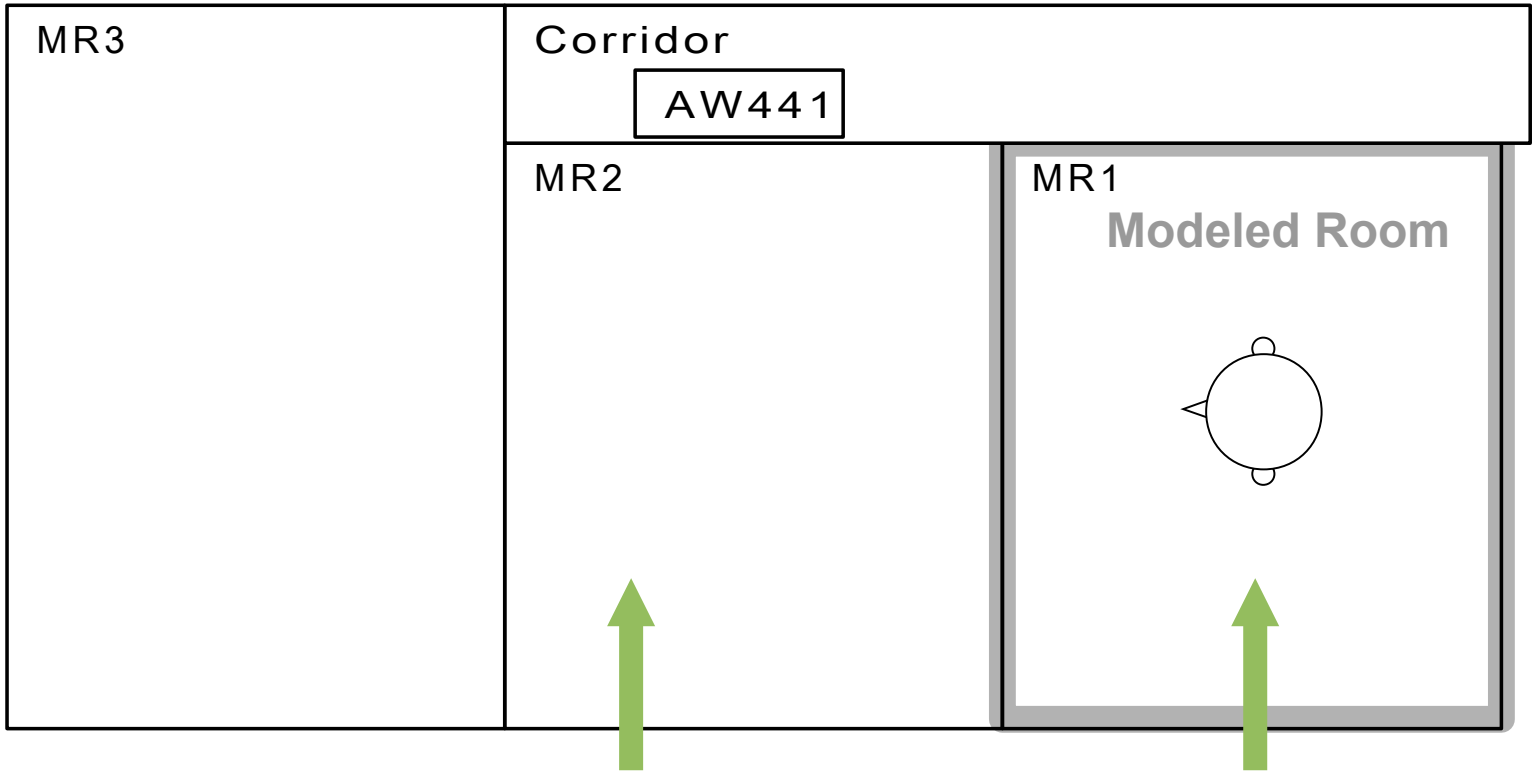


Room Modeling and Diffusion

Diffusion of Experiments



Speech Sounds in the Tokyo Office



Speech coming from the Adjacent Room

CONV_2people_e_adj_08dir1.wav

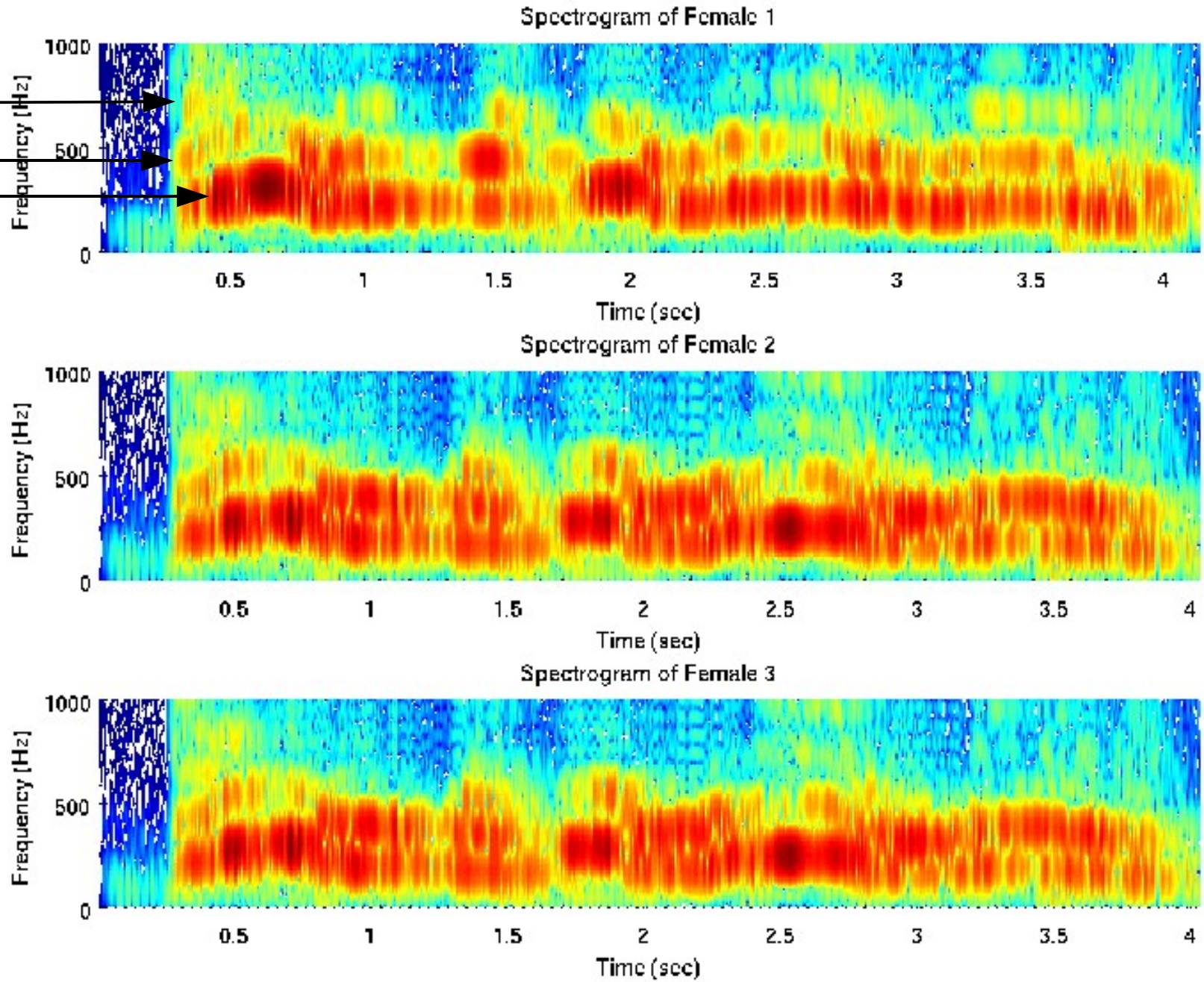
Speech Inside the Room

CONV_2people_e_ins_08dir1.wav

Need to be masked

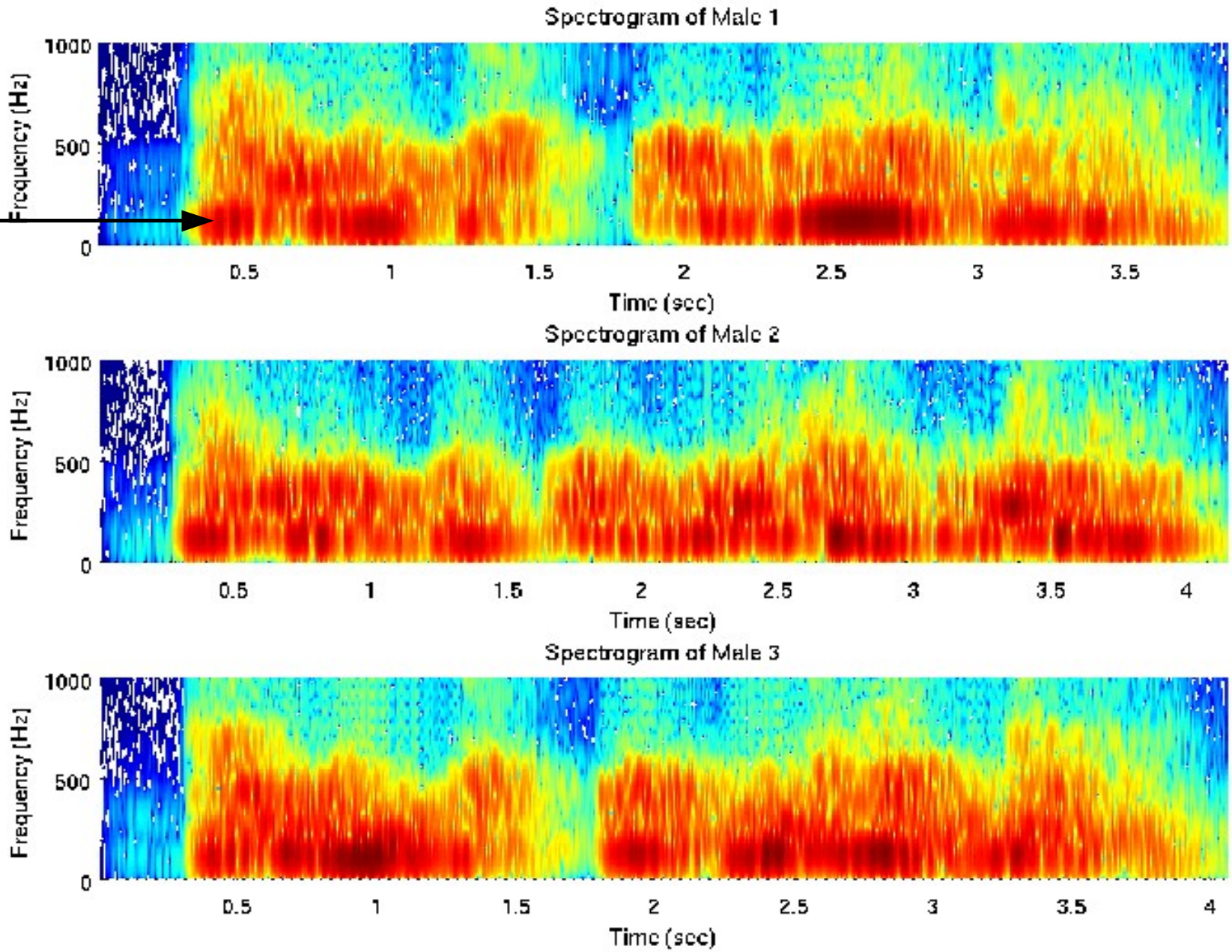
Female Speech Analysis (Tokyo Office)

Roughly 3 main peaks bands

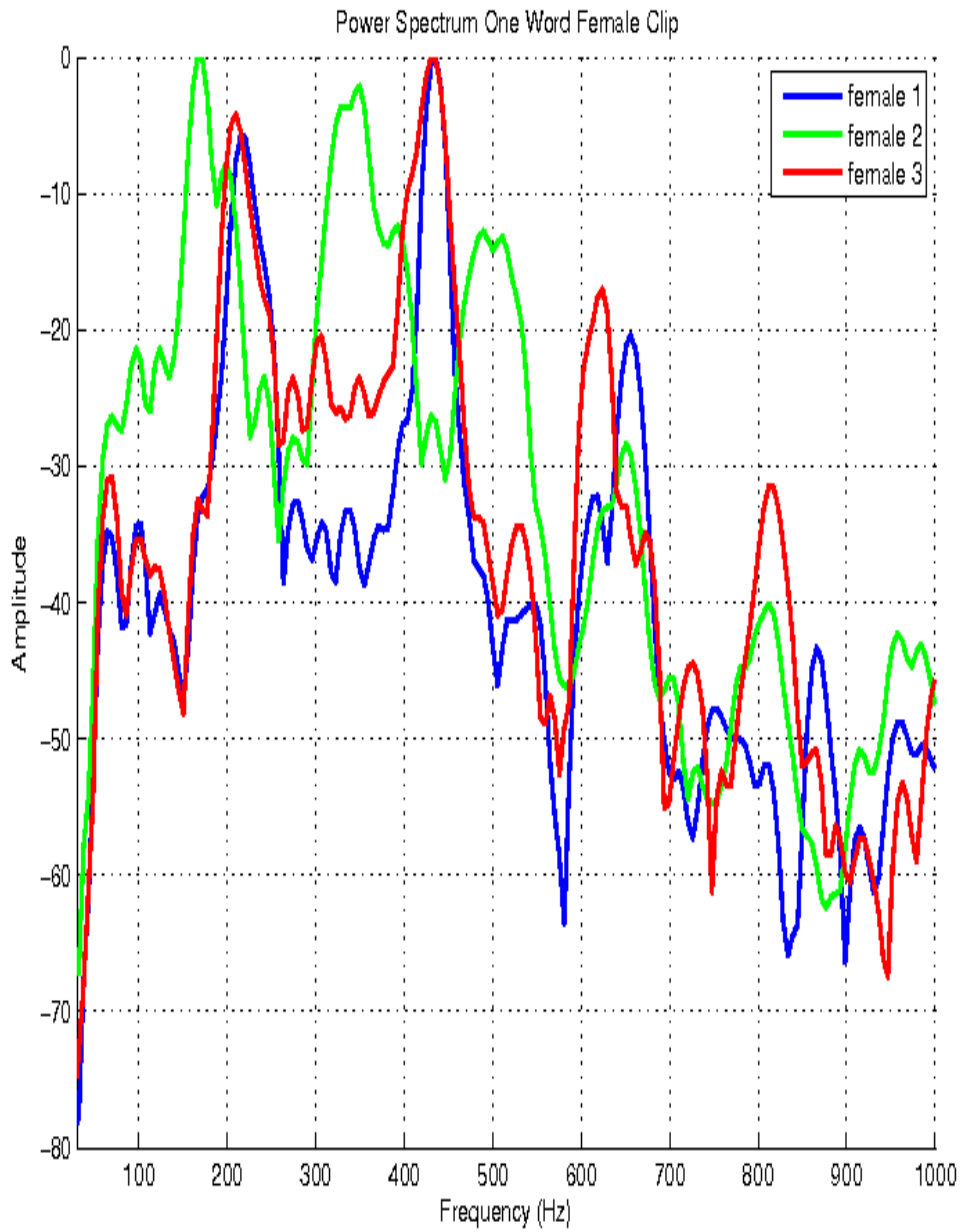


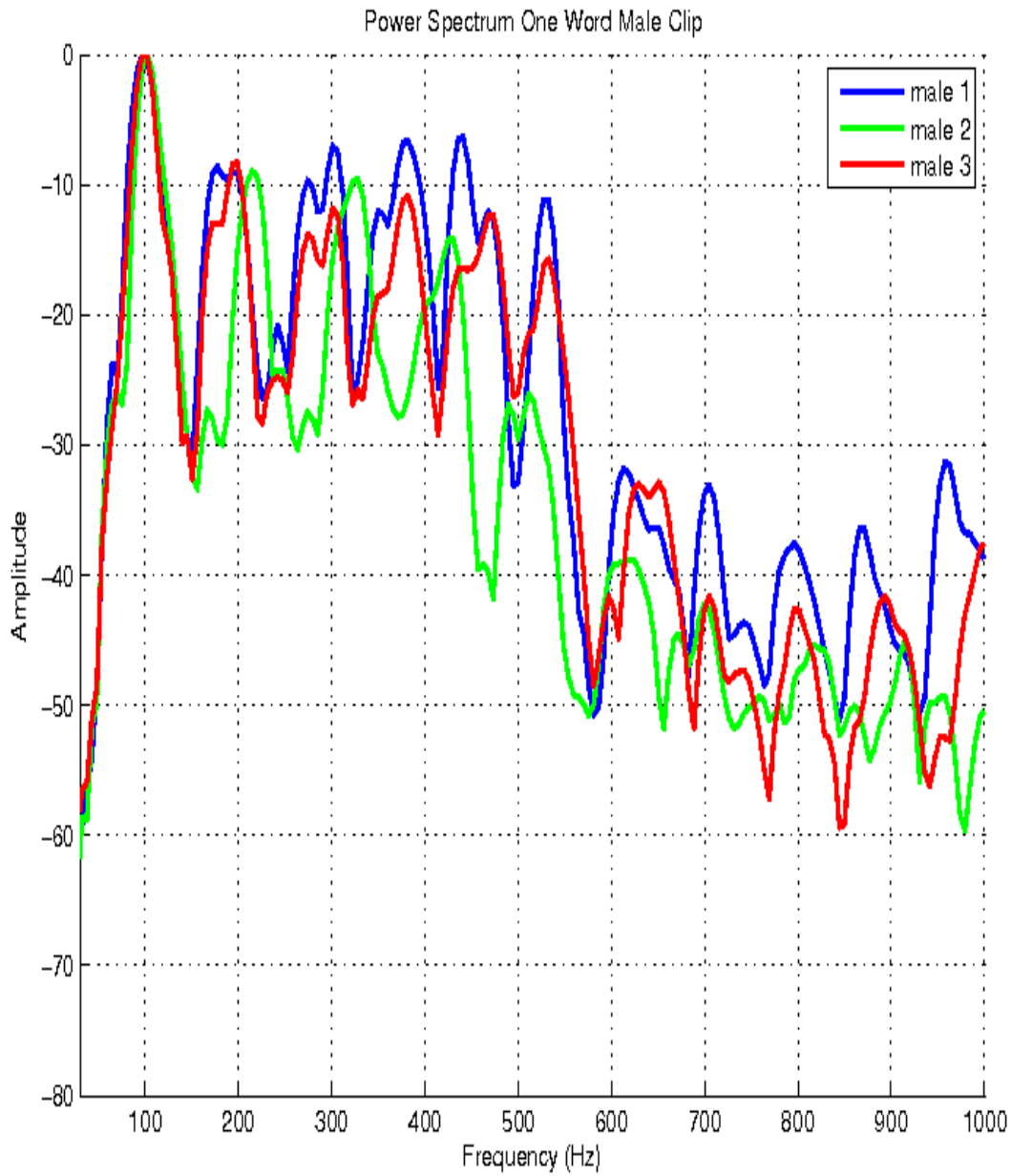
Male Speech Analysis (Tokyo Office)

Main Peak



Voice Comparison for One Word





Voice Analysis in the Tokyo Office

Wall: Low-Pass Filter
=> *Almost no energy above 1000 Hz*

Male voice: strong component around 100 Hz

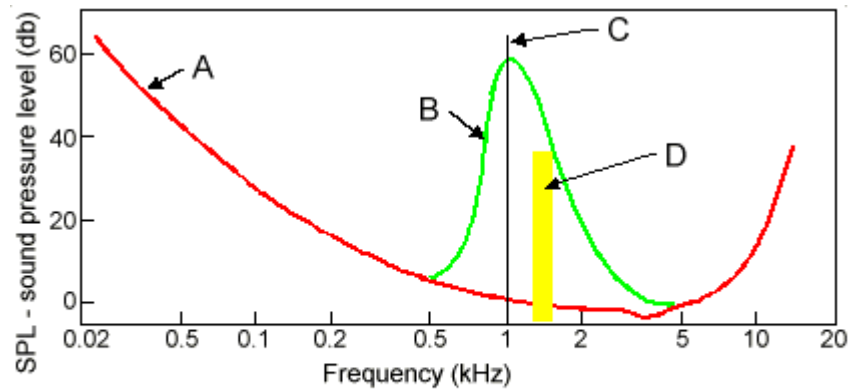
Female main band: ~200/300 Hz
Stronger second band: ~400/600 Hz

➡ ***This is the Energy that we need to mask***

Masking Phenomenon

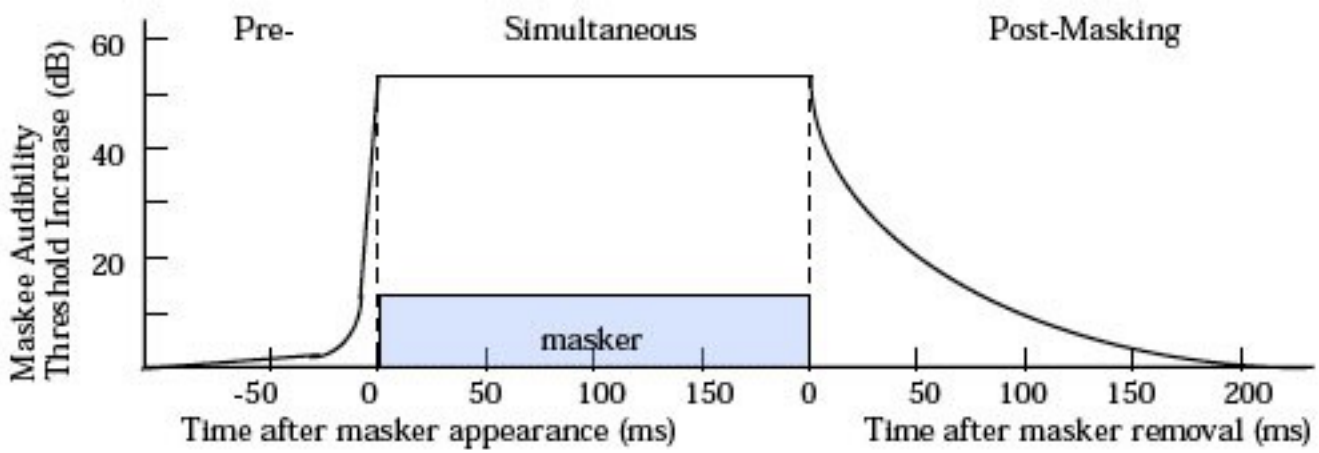
Loud sound & ~~soft sound~~

Frequency Masking



A Normal threshold of hearing
B Modified threshold due to tone C
D Band of noise rendered inaudible by the presence of tone C

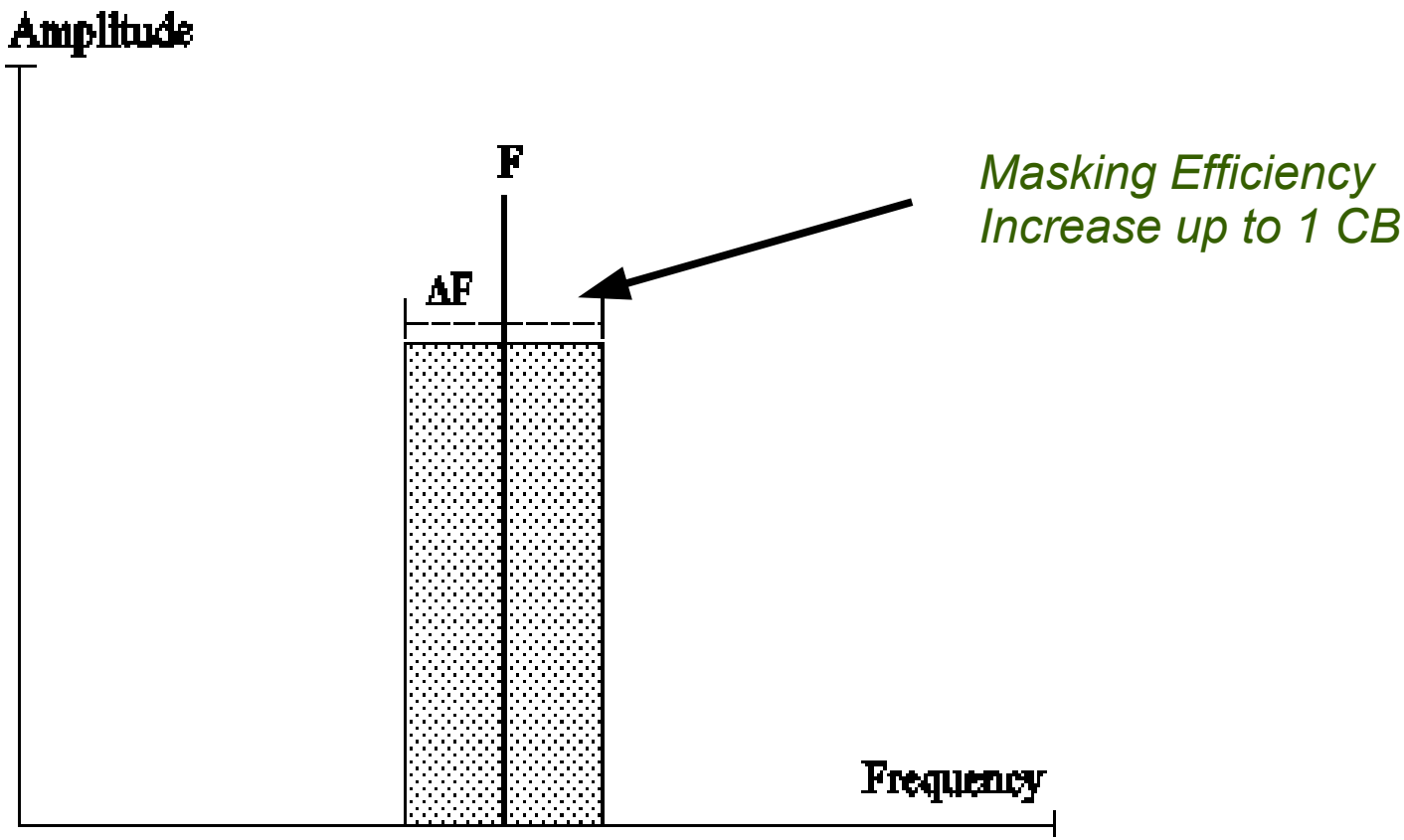
Temporal Masking



Critical Bands

Frequency difference at which 2 pure tones can be easily distinguished ("roughness" disappears).

Stimulate the same section of the basilar membrane



Perceptual Loudness
inside 1 CB

<

less

Perceptual Loudness
spanning more than 1 CB

Noise is better masker than tones

Why Using Noise as Masker?

Is LESS distracting

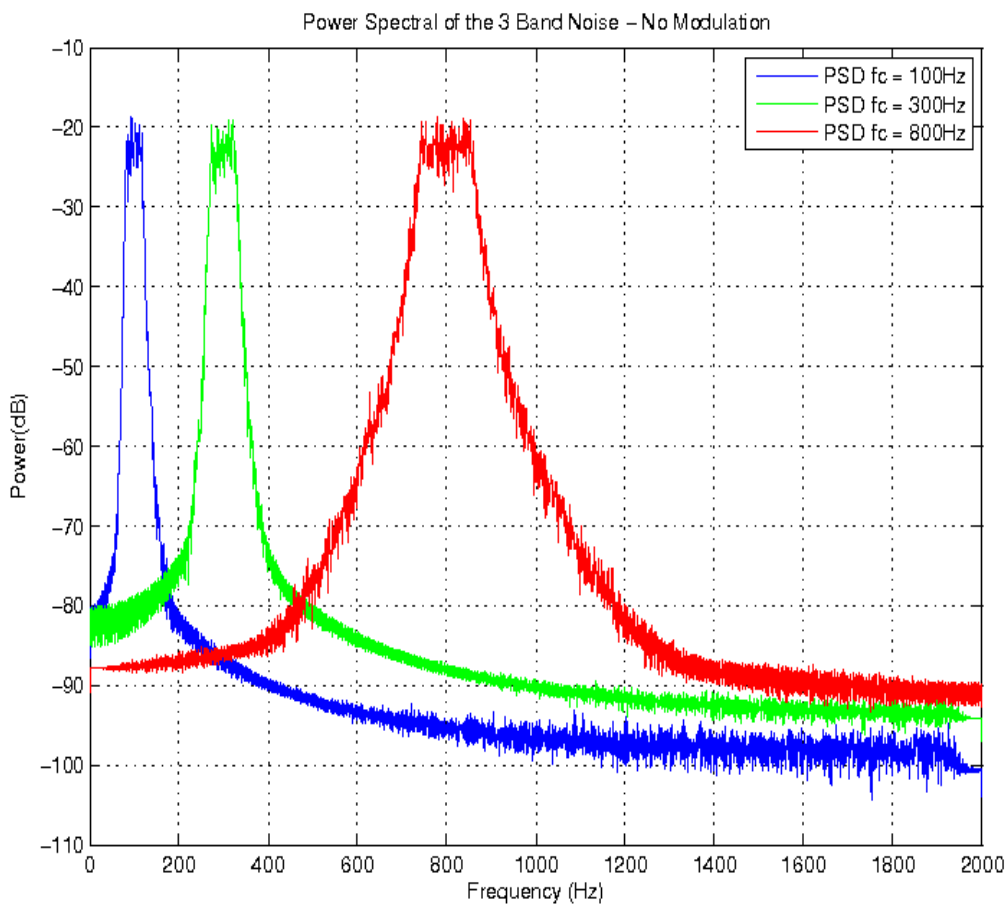
Is MORE efficient

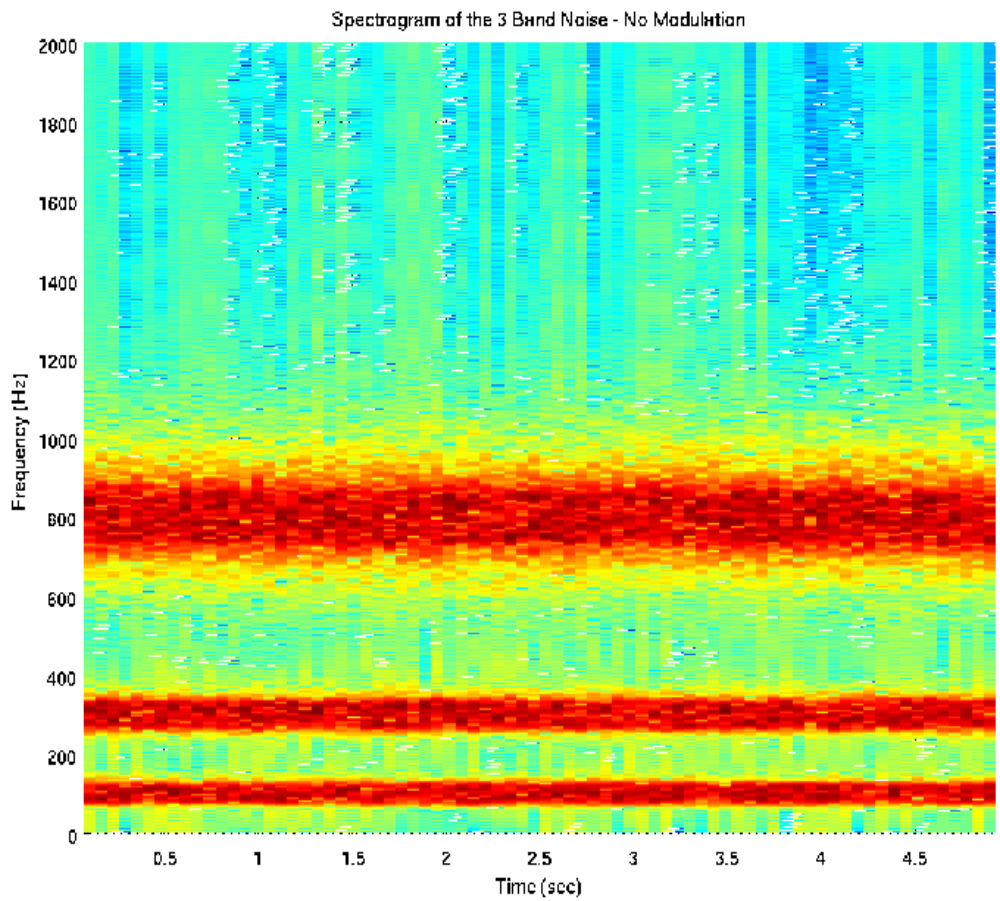
Use bands of noise of 1 Critical Bandwidth

Noise Bands as Masker

ERB (Equivalent Rectangular Bandwidth) for each band

$$ERB = 24.7\left(4.37\frac{f_c}{kHz}+1\right)$$





Cocktail Party Effect

Focus in *one* conversation in the midst of *other conversations* and *noise*

Simple and intuitive:
- **VASTLY** complex (physiological & technically)

Acoustic task:
- Separate out a single talker's speech from a complex spectrogram

Humans are extremely good at it

Factors that make the task easier

Directionality

Lip-Reading, gestures...

Voice quality (pitch, gender, ...)

Transition probabilities (i.e. MEANING)

Opposite problem

Jams a sound:

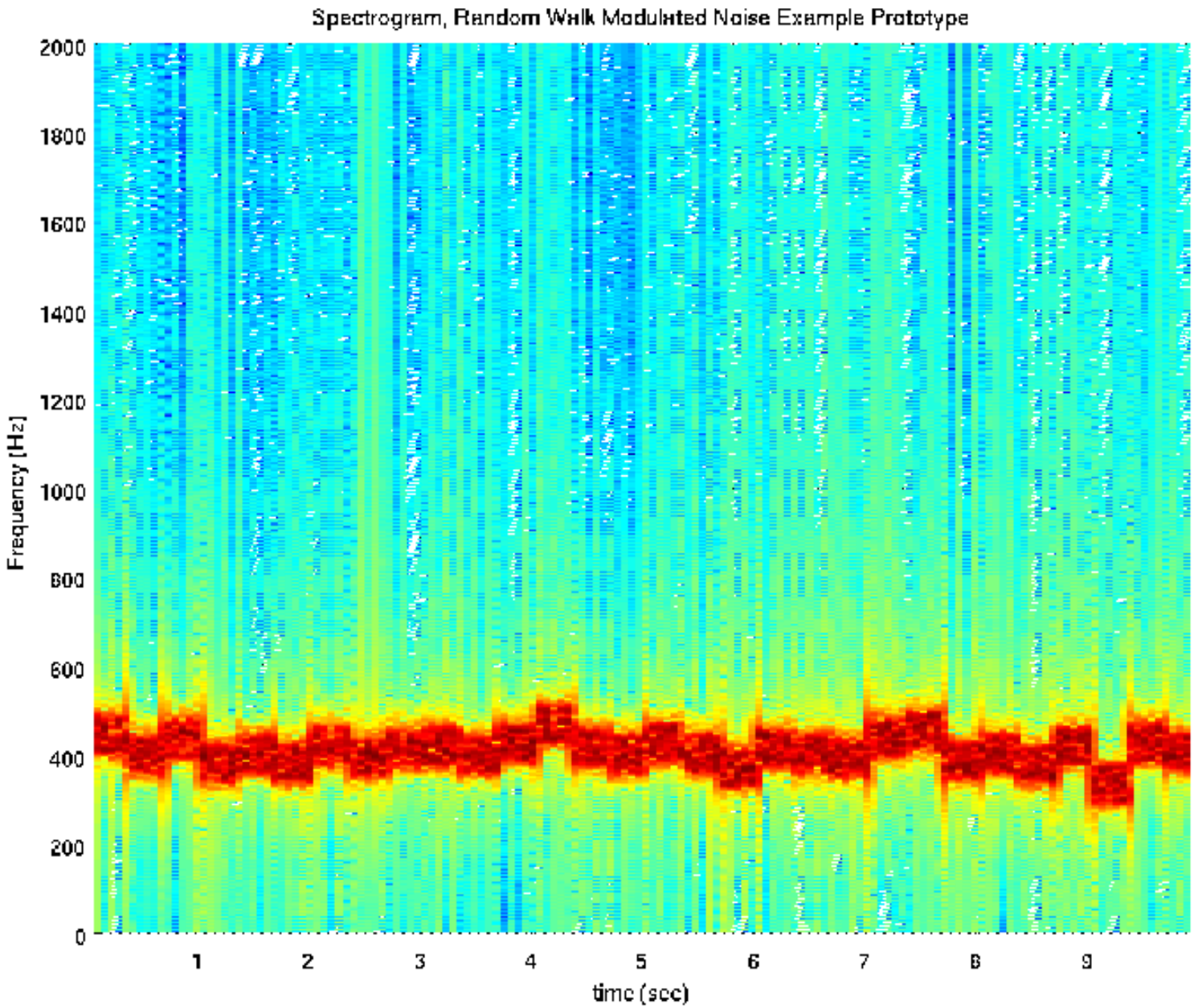
➡ ***Absorption into a cocktail party texture***

2 Approaches:

Energetic+Information Masker: FM Noise

Information Masker: “Gurgle”

Speech Like Modulation of Bands



“Gurgle” Masker

Developed entirely by ear.

Highly-modulated information masker using *FM-speech synthesis*

mask_gurgle.wav

Experiment 1: Masker Refinement

General protocol: best masker from a parametric masker

Genetic algorithm approach

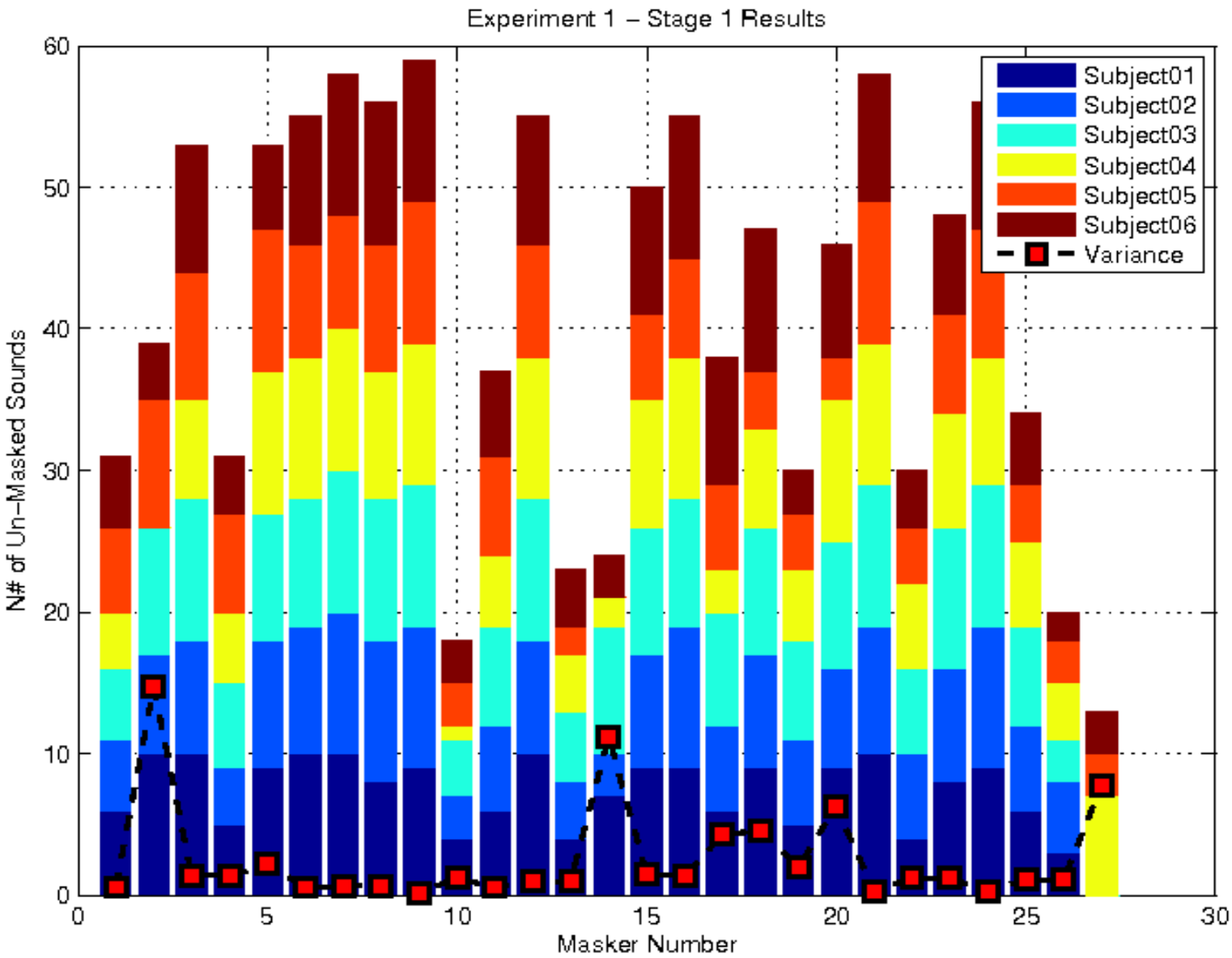
- Vary one parameter (all the others fixed)
- Find 1 or 2 “sweet spots”, fix that parameter
- Repeat the process for next parameter

Setup: Masker continuous stream, subject “reacts” when to intruding speech

Parameters for the 3 Noise Bands

- Center Frequency
- Relative Amplitude
- Modulation Rate
- Modulation Variance

Result examples after 1st Stage (fc)



FM Evolved Masker

	Band 1	Band 2	Band 3
fc1 (dB)	106.8	210	420
Amp (dB)	-10	0	0
fm (Hz)	2	5	9
fmAmpVar	*1fc*	*1fc*	*3fc*

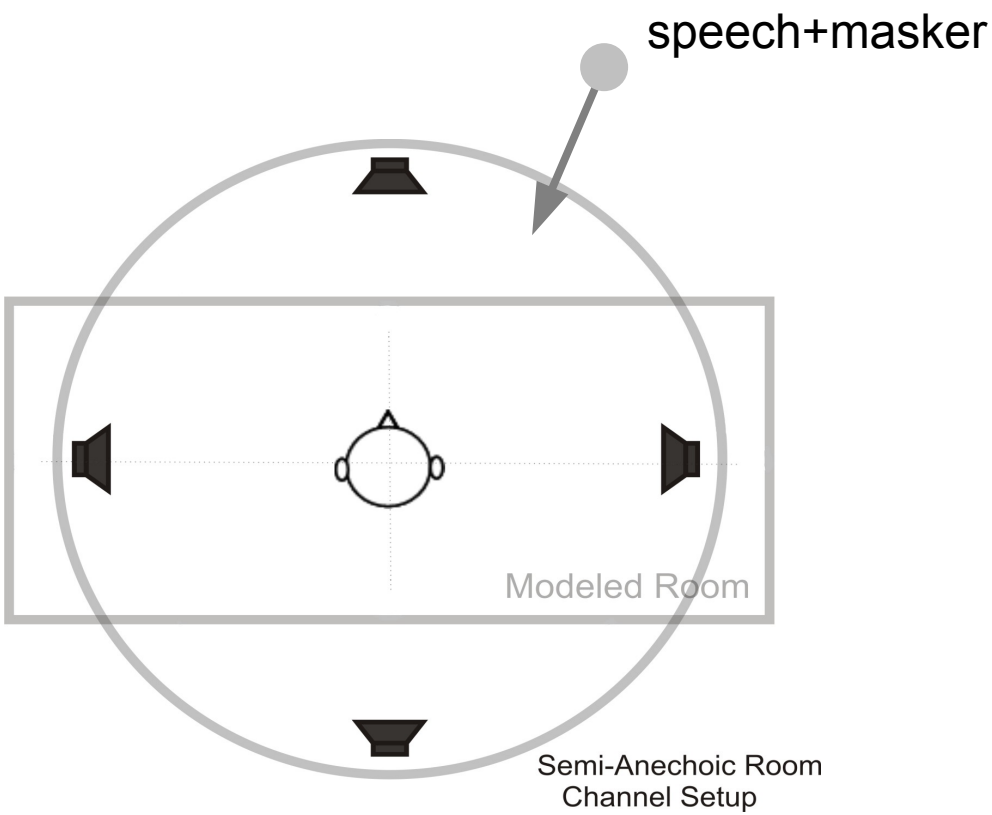
mask_fm.wav

Note Harmonic Relationship in fc

Experiment 2: Efficiency

Main Conclusions deal with directionality:

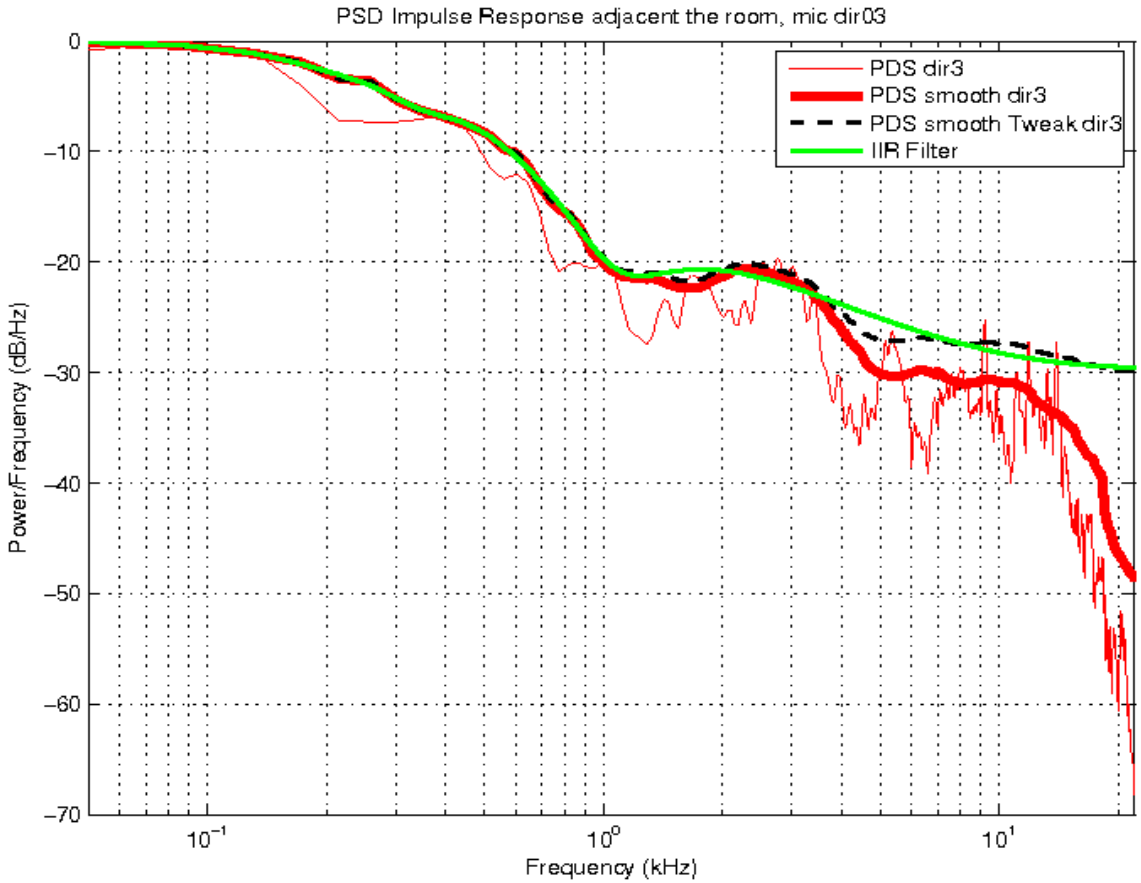
What if Intruding *Speech & Masker* come from the *same direction*?



Masking Noise Directionality

Keep source outside the room, remove wall effect.

Identify direct path, inverse filter it.



CONV_2people_e_adj_08dir1.wav

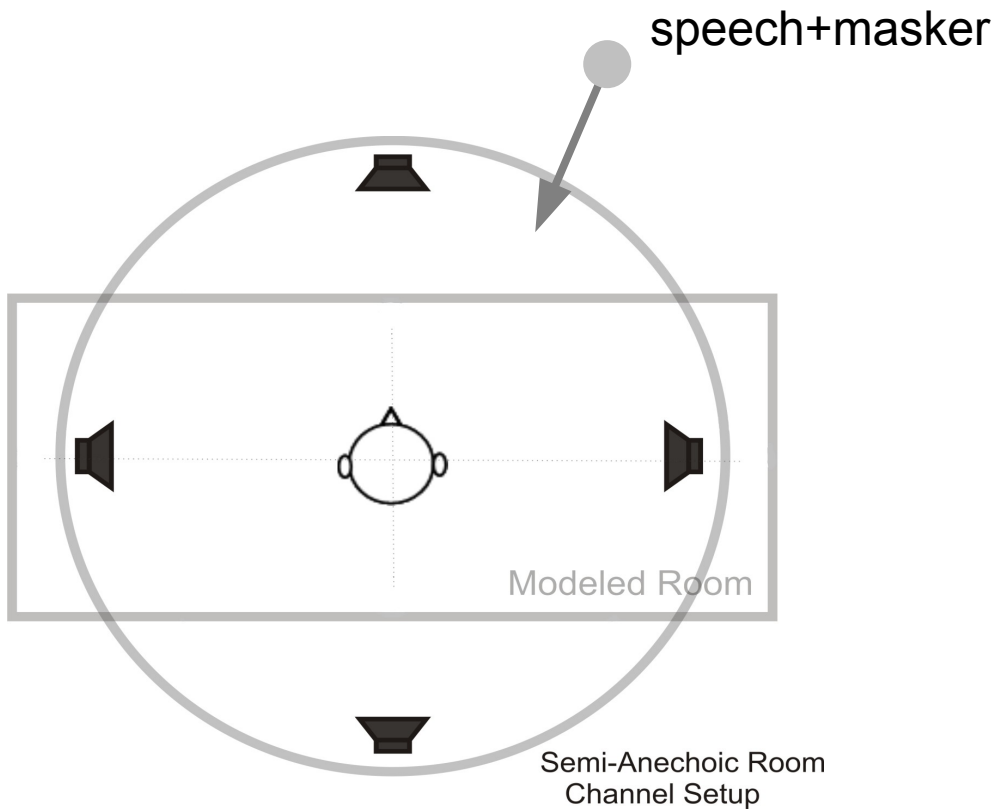
CONV_2people_e_adj_08dir1NW.wav

Gurgle Masker Directionality

Informal testing:

Directionality (spatialization)

Higher efficiency



Experiment 3: Annoyance

Effect on productivity tasks
involving *auditory/visual stimulation* and response

Procedure:

- Word-list presented to the subject
- Masker is turned on (30 secs)
- Subject answers to mental math questions
- Subject try to recall the word-list (masker off)

Some Results From Experiment 3

Masker	Precision rate	Speed of task	Word recall rate
Control	Baseline	Baseline	Baseline
FM	-14%	+10%	+18%
Gurgle	-0.5%	-17%	+43%
Mix	-22%	-28%	NA
MixALot	+8.5%	+2.4%	NA

mask_control.wav
mask_fm.wav
mask_gurgle.wav
MaskMix.wav
Mask_Mix_a_lot.wav

Conclusions and Future Work

1. We model real-world workplace
2. intruding speech representative of real-world situations
3. compare effectiveness & spatial arrangement
4. compare the annoyance & degradation of mental tasks

Conclusions and Future Work

Two main type of maskers:

"Energy" Maskers & ***"Information" Maskers***

Blend of both

Directionality (spatialization) seems to be of great importance

Questions? Discussion?