P2: Perception auditive

Daniel Pressnitzer

Laboratoire des Systèmes Perceptifs, CNRS
& Département d'études cognitives, Ecole normale supérieure
29 rue d'Ulm, 75230 Paris cedex 05

daniel.pressnitzer@ens.fr

Plan du cours

I. Bases, méthodes et concepts

acoustique, psychophysique, physiologie

II. Caractéristiques élémentaires et applications

champ audible, masquage, bande critique, non-linéarités, MP3, implants

III. Attributs perceptifs

sonie, hauteur, timbre, localisation

IV. Analyse des scènes auditives

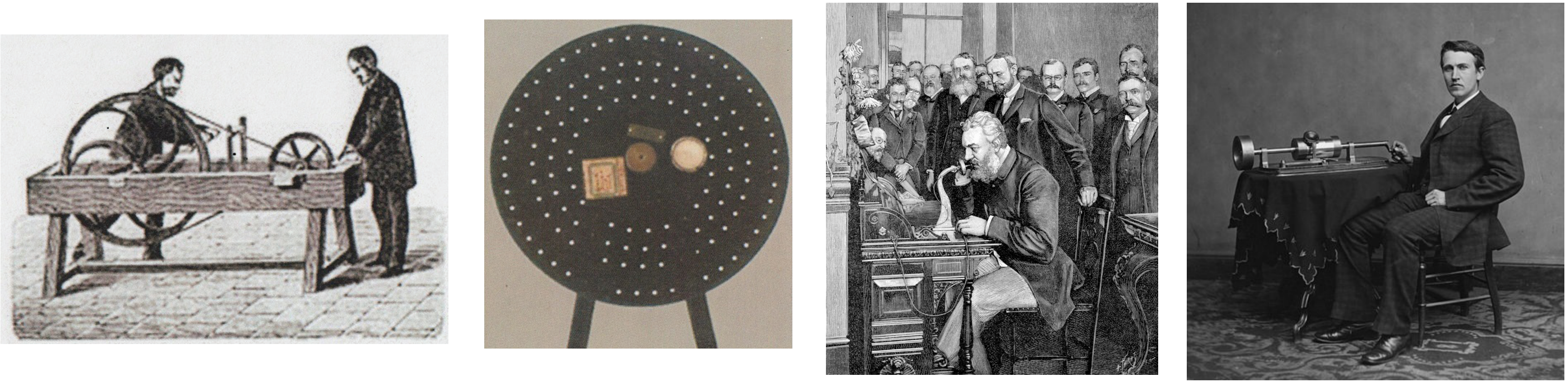
organisation auditive, musique

V. Etudes en cours

mémoire auditive, effets de contexte

II.1 Caractéristiques élémentaires

Introduction



- Helmholtz, Seebeck: résonateurs, diapasons, sirènes, etc…
- 1876: Transmission et reproduction du son par Bell et Edison
- Création des Bell Labs
- Transistors, théorie de l’information – et surdité

Yost, 2015

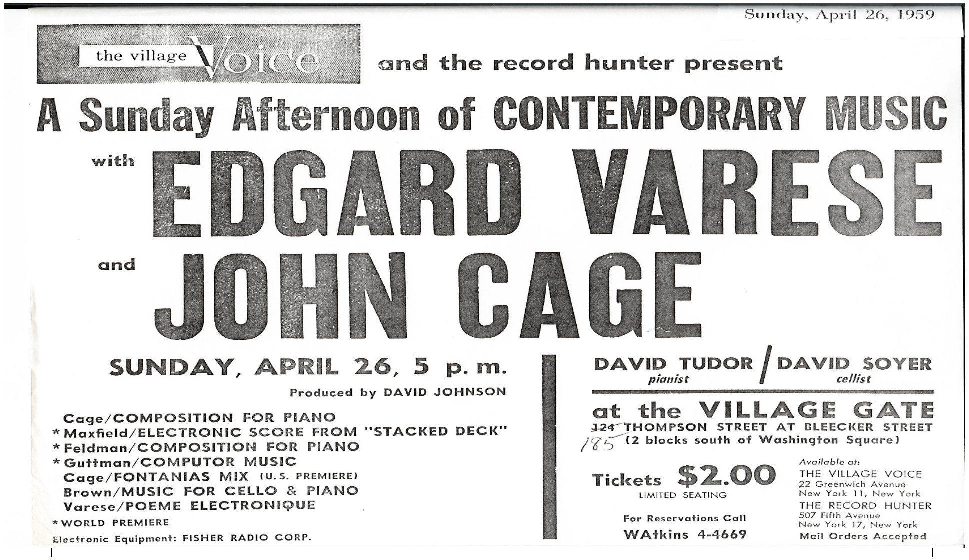
II.1 Caractéristiques élémentaires

Bell Labs

- Un IBM 704 synthétise la première musique numérique, “In the Silver scale”, par Newman Guttman et Max Mathews

II.1 Caractéristiques élémentaires

Bell Labs



Sunday, April 26, 1959

the village Voice and the record hunter present

A Sunday Afternoon of CONTEMPORARY MUSIC

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and **JOHN CAGE**

SUNDAY, APRIL 26, 5 p. m.

Produced by DAVID JOHNSON

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*Maxfield/ELECTRONIC SCORE FROM "STACKED DECK"
*Feldman/COMPOSITION FOR PIANO
*Guttman/COMPUTOR MUSIC
Cage/FONTANIAS MIX (U.S. PREMIERE)
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Varese/POEME ELECTRONIQUE

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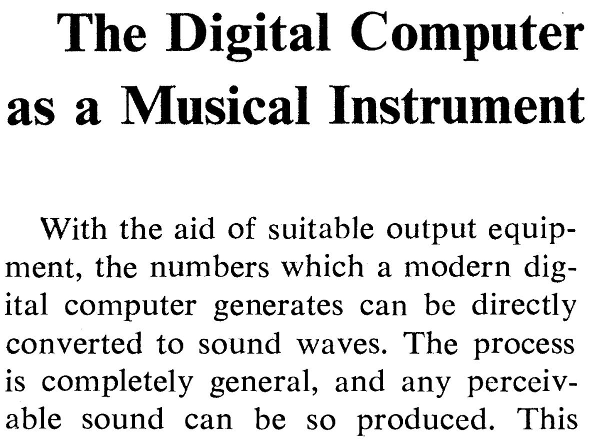
- Un IBM 704 synthétise la première musique numérique, "In the Silver scale", par Newman Guttman et Max Mathews

- "Pitch variations", Newman Guttman, 1957

II.1 Caractéristiques élémentaires

Bell Labs



The Digital Computer as a Musical Instrument

With the aid of suitable output equipment, the numbers which a modern digital computer generates can be directly converted to sound waves. The process is completely general, and any perceivable sound can be so produced. This

Max Mathews, Science, 1963

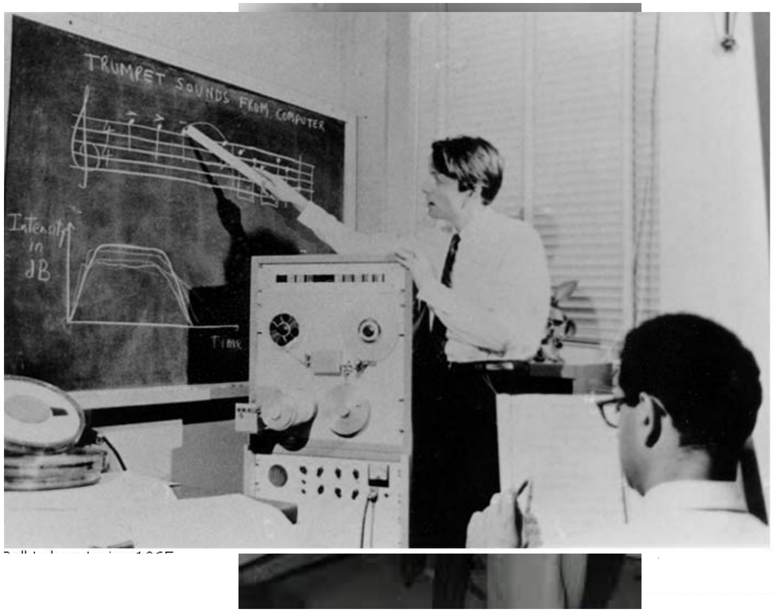
- Un IBM 704 synthétise la première musique numérique, “In the Silver scale”, par Newman Guttman et Max Mathews

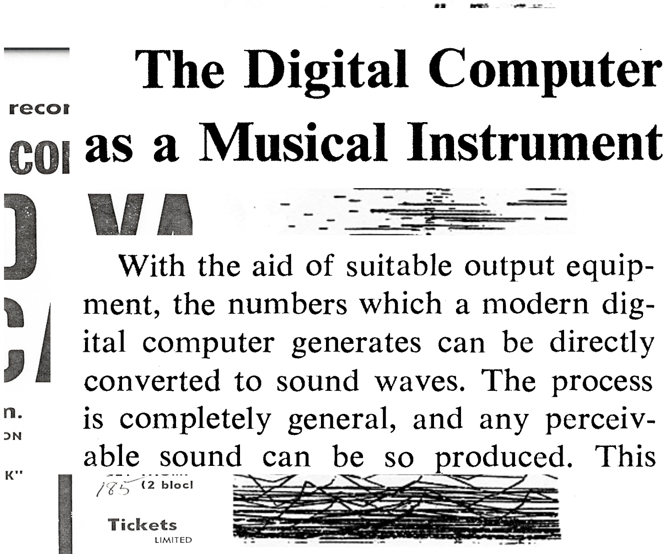
- “Pitch variations”, Newman Guttman, 1957

- Possibilités techniquement illimitées

II.1 Caractéristiques élémentaires

Bell Labs





The Digital Computer as a Musical Instrument

With the aid of suitable output equipment, the numbers which a modern digital computer generates can be directly converted to sound waves. The process is completely general, and any perceivable sound can be so produced. This

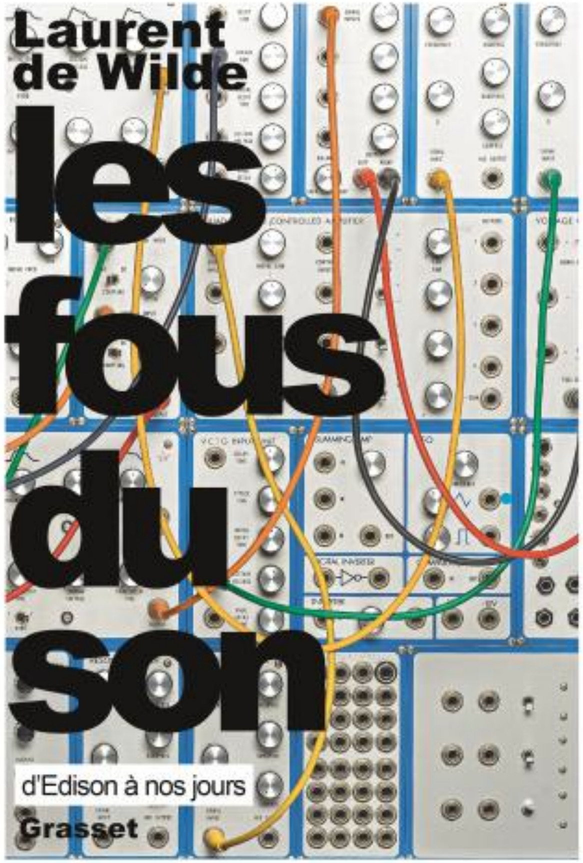
Jean-Claude Risset, “Catalogue”, 1969

Max Mathews, “Science”, 1963

- “Pitch variations”, Newman Guttman, 1957
- Possibilités techniquement illimitées
- Composer le son: enjeux liés à la perception auditive

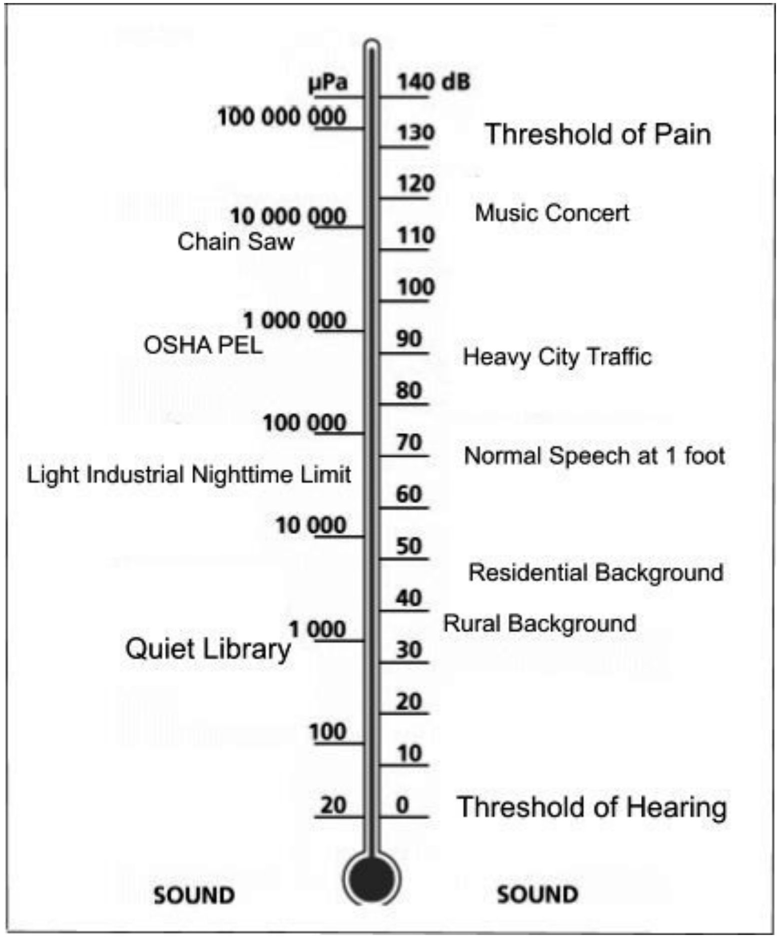
II.1 Caractéristiques élémentaires

Digression…



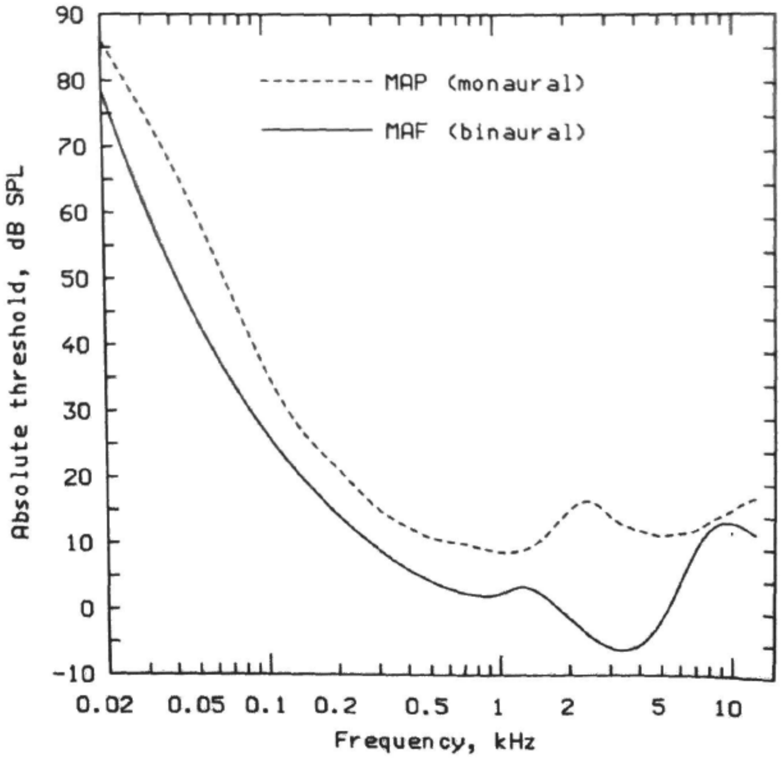
II.1 Champ audible

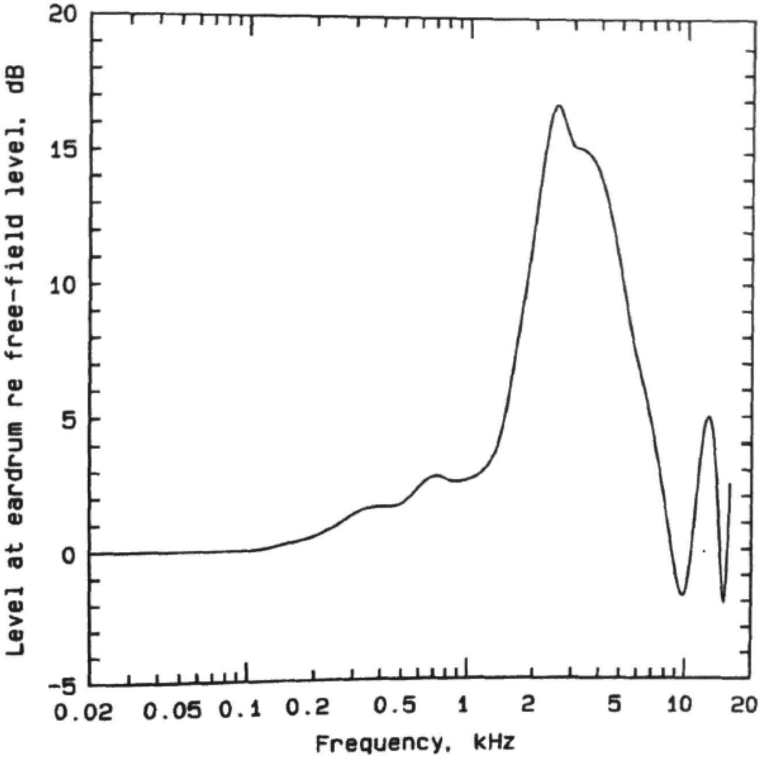
- Plage d’existence: échelle dB SPL



II.1 Champ audible

- Son pur à différentes fréquences: pressure vs field





Killion, 1978; Shaw, 1974; reprinted in Moore, 2013

II.1 Champ audible

Demo [ASA 17]:

Sons purs à 125, 250, 500, 1000, 2000, 4000 et 8000Hz

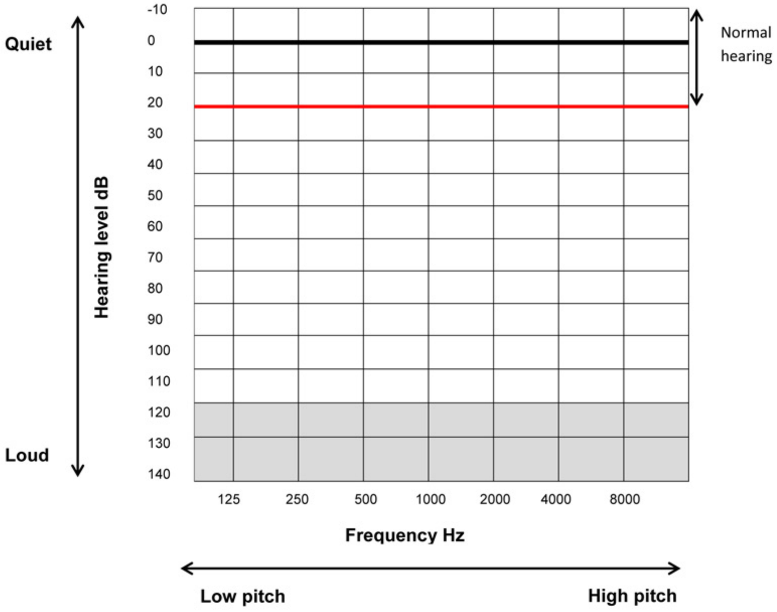
Présentés avec une intensité décroissante, par pas de 5dB

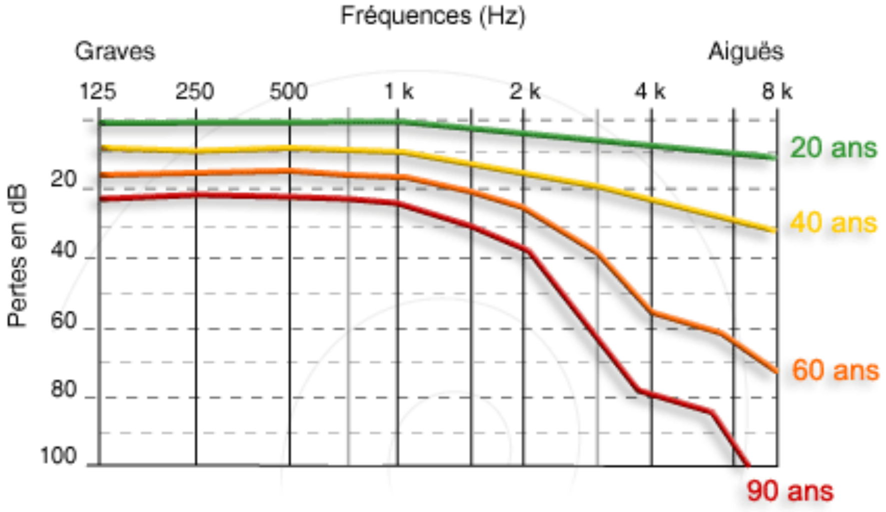
Compter combien de pas sont entendus pour chaque fréquence

II.1 Champ audible

Audiogramme

- Echelle clinique: dB HL (Hearing Level)
- Presbyacousie

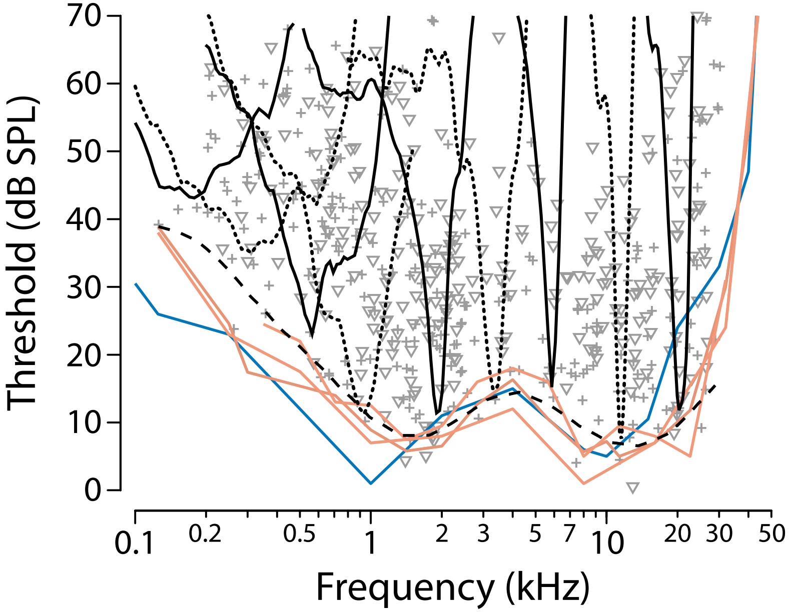




II.1 Champ audible

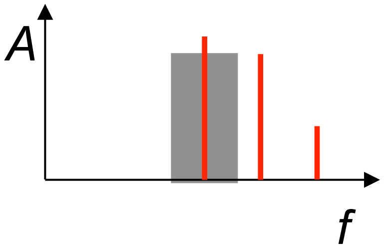
Audiogramme

- Lien entre seuils et activité dans le nerf auditif



Joris et al., 2011

II.2 Masquage simultané



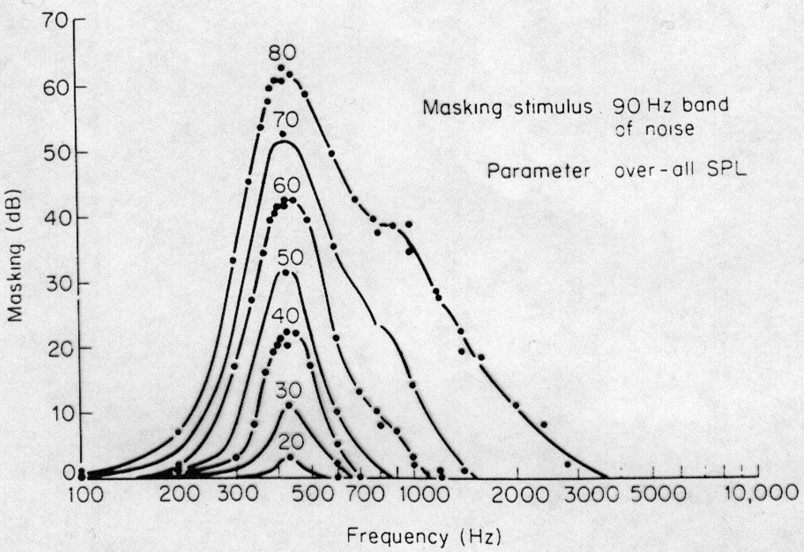
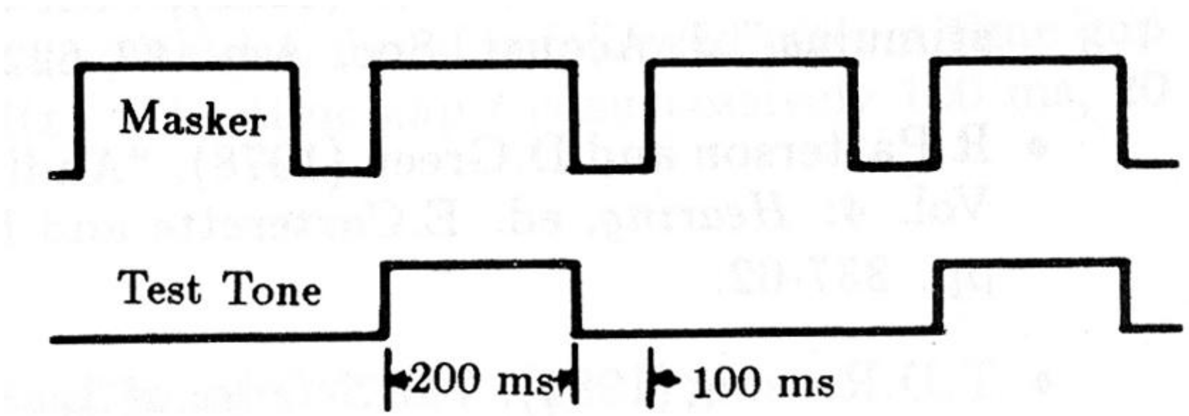


FIG. 3.10 Masking patterns (masked audiograms) for a narrow band of noise centred at 410 Hz. Each curve shows the elevation in threshold of a pure tone signal as a function of signal frequency. The overall noise level for each curve is indicated in the figure. Adapted from Egan and Hake (1950), by permission of the authors and *J. Acoust. Soc. Am.*

II.2 Masquage simultané



Demo [ASA 22]: Un masqueur est présenté avec un signal d ’amplitude décroissante (plusieurs répétitions pour chaque amplitude)

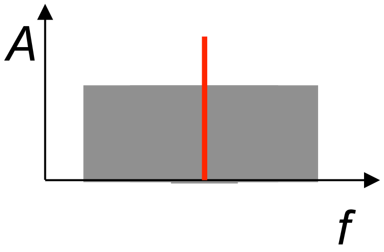
Compter combien de pas sont entendus pour le signal

A) Masqueur = 1200Hz, Signal = 2000Hz

B) Masqueur = 2000Hz, Signal = 1200Hz

II.2 Masquage simultané

La bande critique



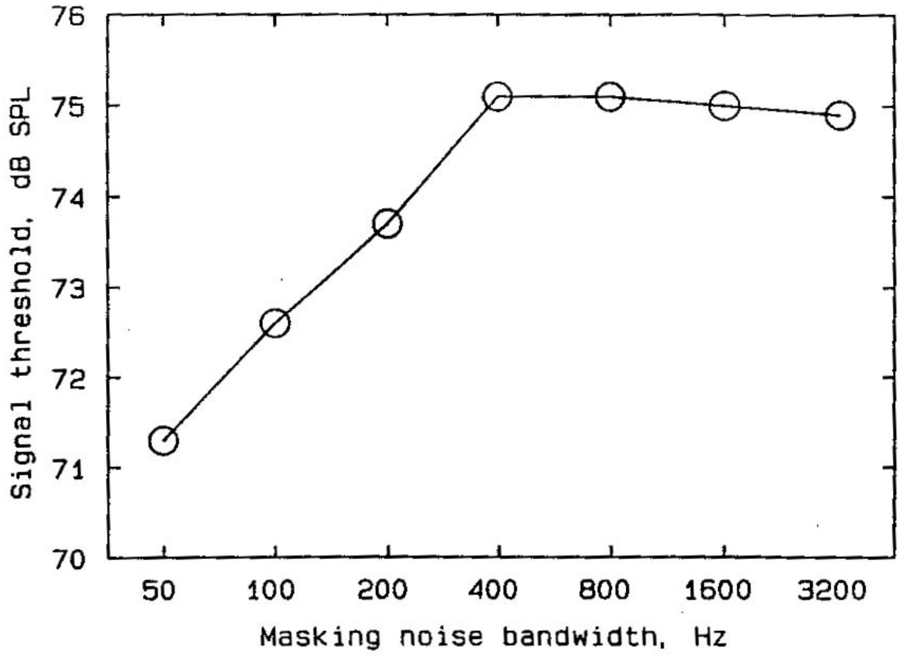


FIG. 3.1 The threshold of a 2000-Hz sinusoidal signal plotted as a function of the bandwidth of a noise masker centred at 2000 Hz. Notice that the threshold of the signal at first increases with increasing masker bandwidth and then remains constant. From Schooneveldt and Moore (1989).

II.2 Masquage simultané

La bande critique

Demo [ASA 2-6]

Le signal est un son pur à 2000Hz

A) signal seul

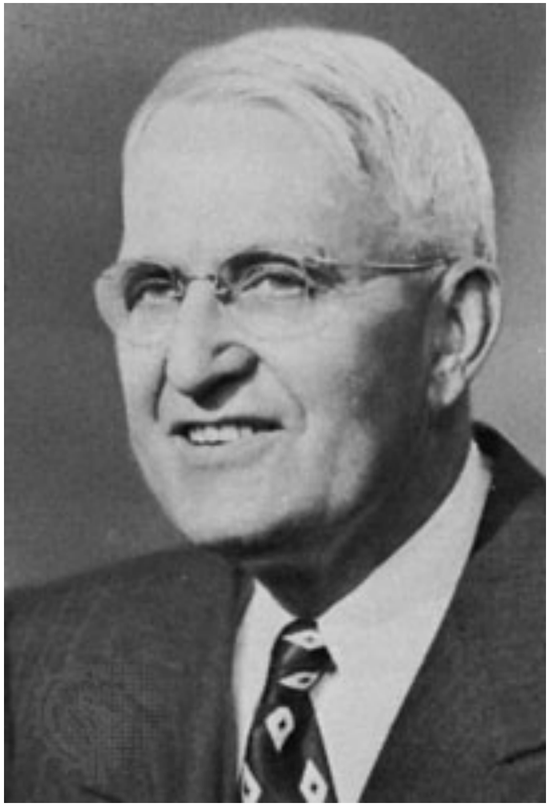
B) masqué par un bruit large bande

C) masqué par une bande de bruit de largeur 1000Hz

D) largeur 250Hz

E) largeur 10Hz

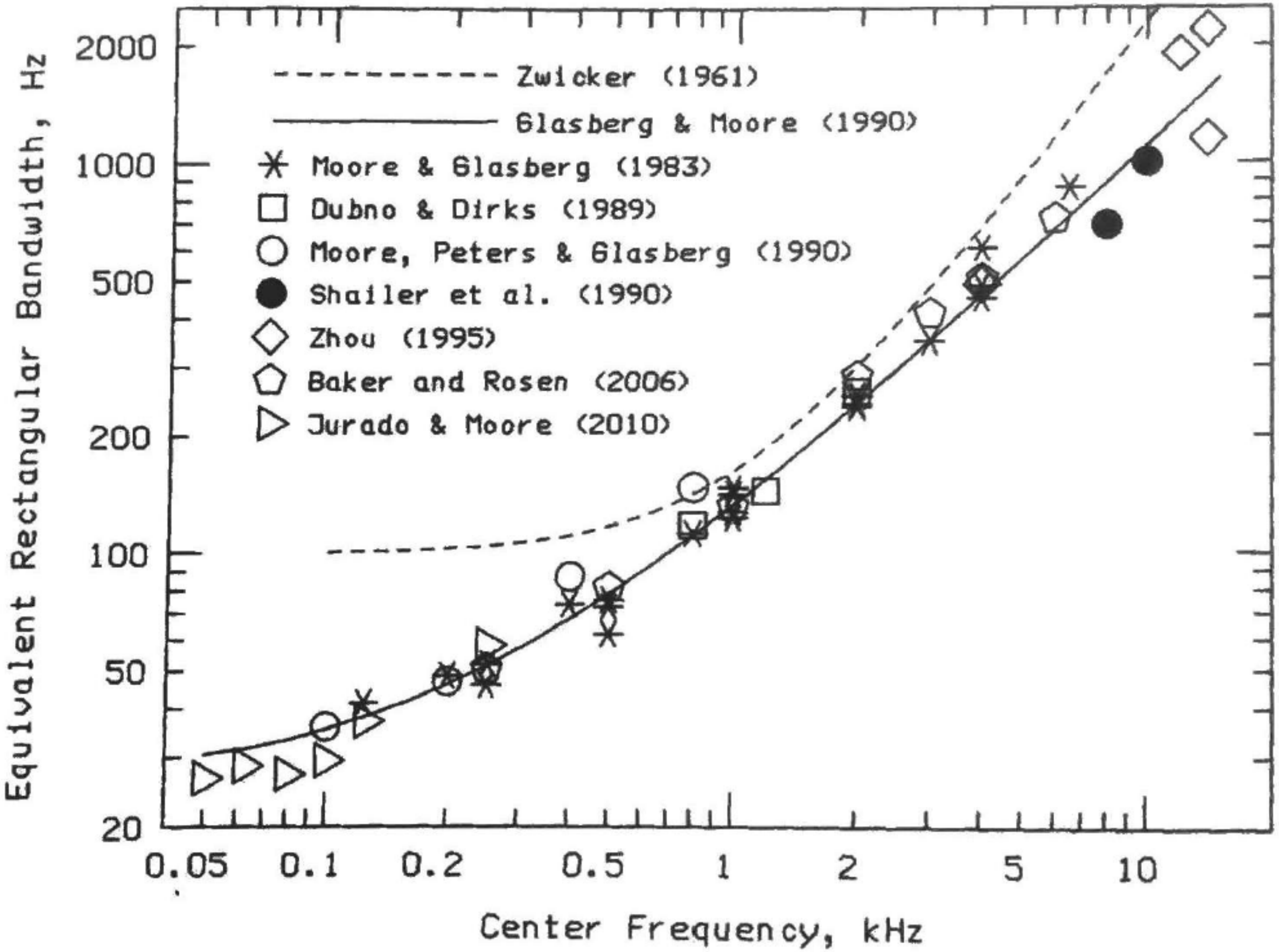
II.2 Masquage simultané



Harvey Fletcher, Speech and Hearing (1922)

II.2 Masquage simultané

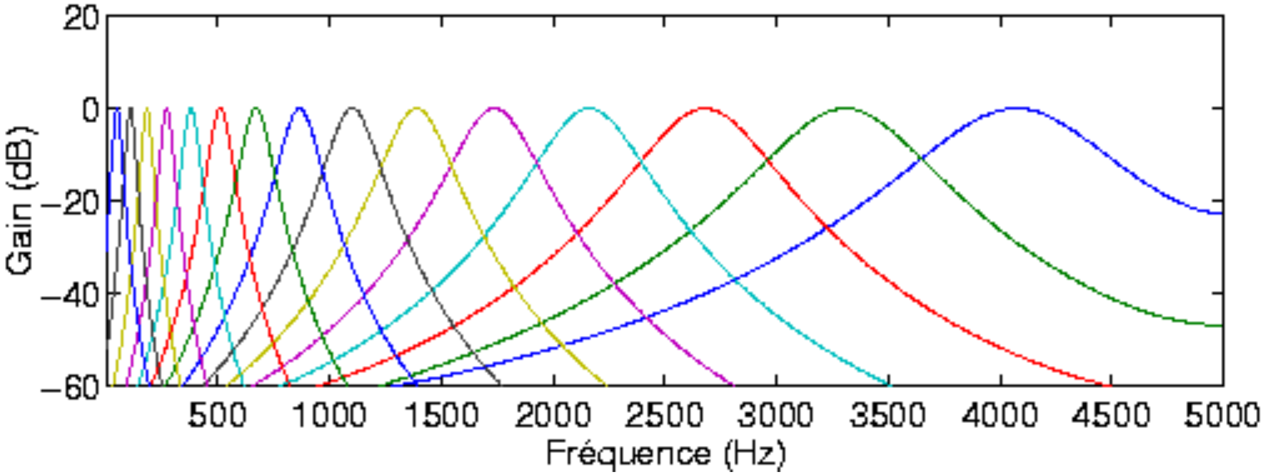
La bande critique



II.2 Masquage simultané

La bande critique

- Filtres auditifs



II.2 Masquage simultané

La bande critique

- Filtres auditifs
- Lien avec masquage

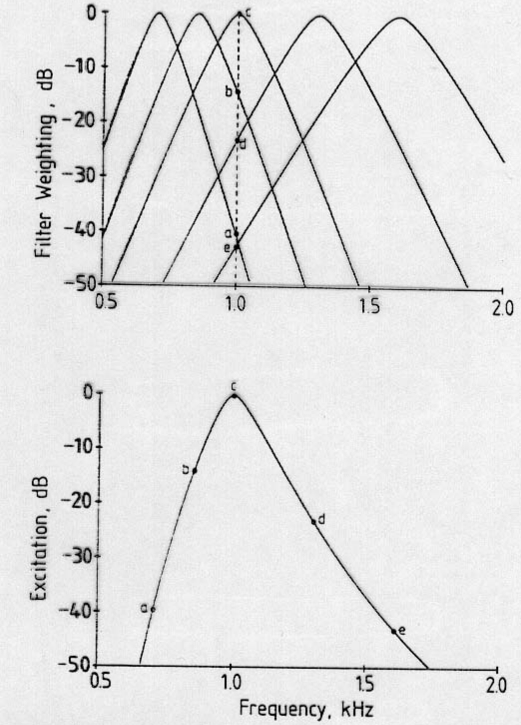
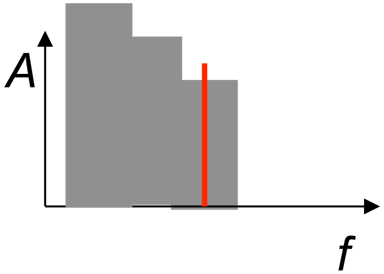
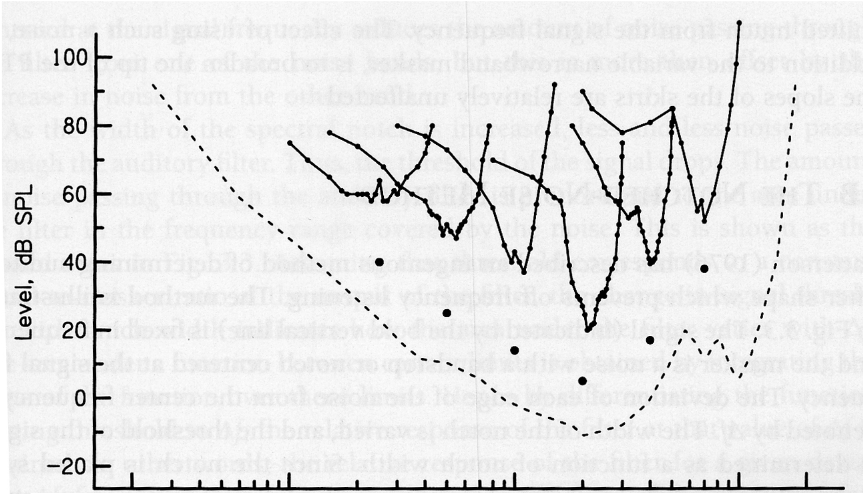
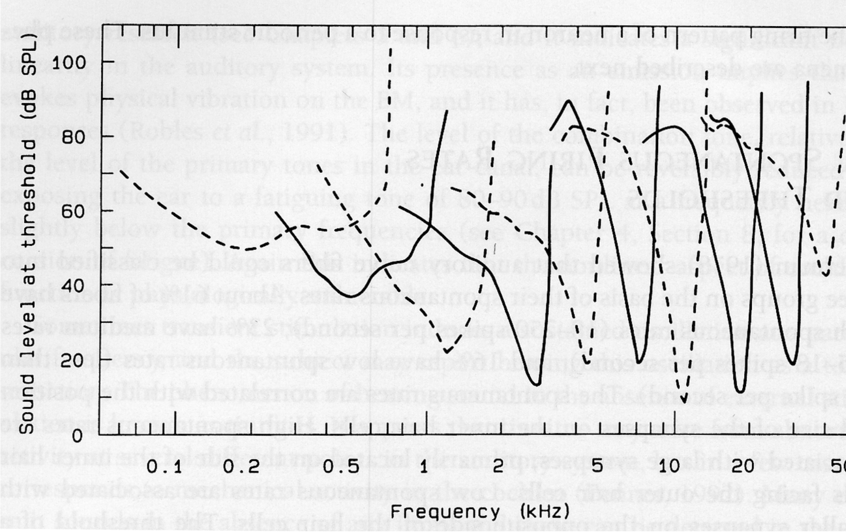


FIG. 3.11 An illustration of how the excitation pattern of a 1 kHz sinusoid can be derived by calculating the outputs of the auditory filters as a function of their centre frequency. The top half shows five auditory filters, centred at different frequencies, and the bottom half shows the calculated excitation pattern. See text for details. From Moore and Glasberg (1983a).

II.2 Masquage simultané







II.2 Masquage simultané

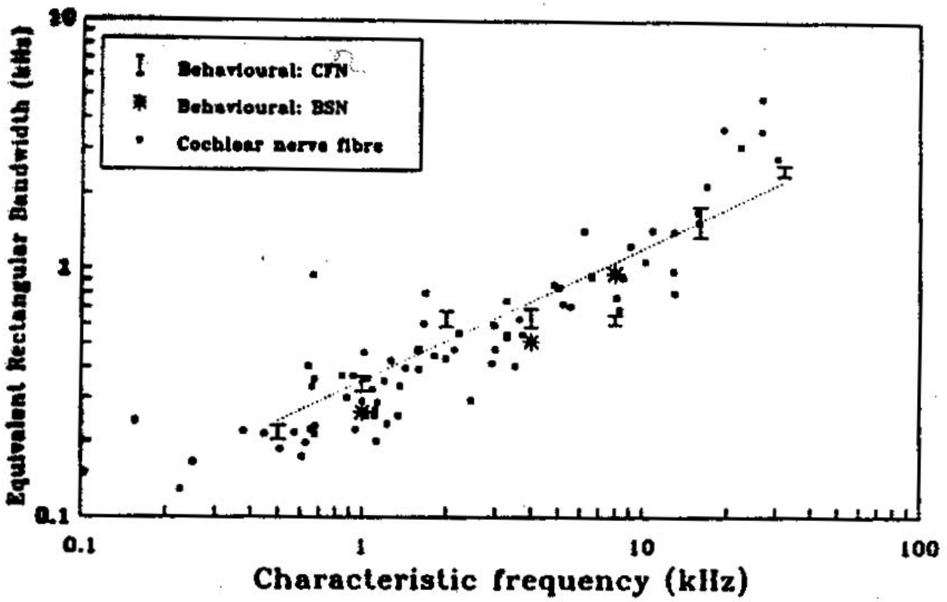
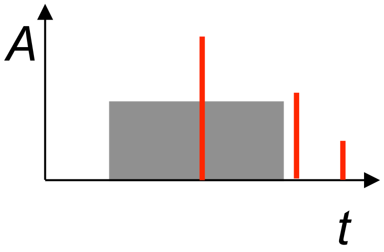
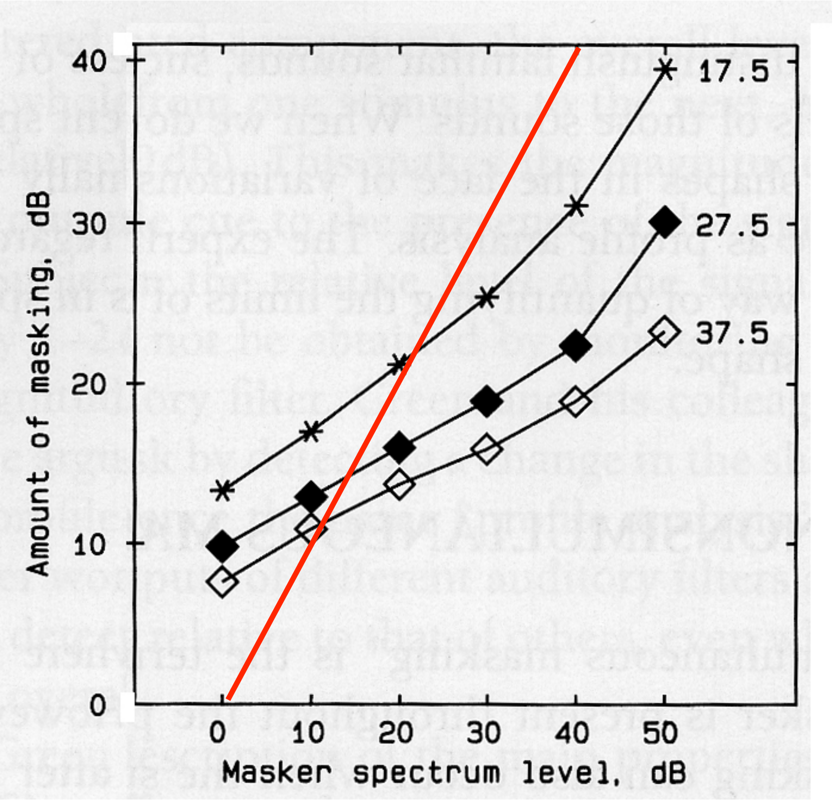


FIG. 3.12 A comparison of ERBs estimated from behavioural masking experiments and from neurophysiological measurements of the tuning curves of single neurones in the auditory nerve. All data were obtained from guinea pigs. There is a good correspondence between behavioural and neural data. From Evans *et al.* (1989).

II.3 Masquage temporel

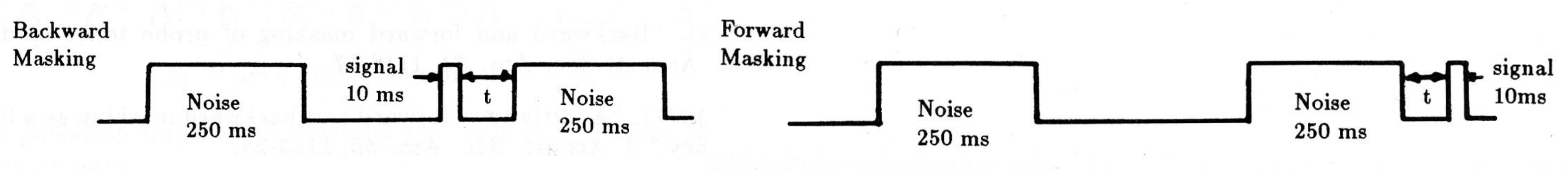
Masquage pro-actif





Moore & Glasberg, 1983

II.3 Masquage temporel



Demo [ASA 23-25]

Le signal est un son pur. Compter blah blah…

A) Signal seul

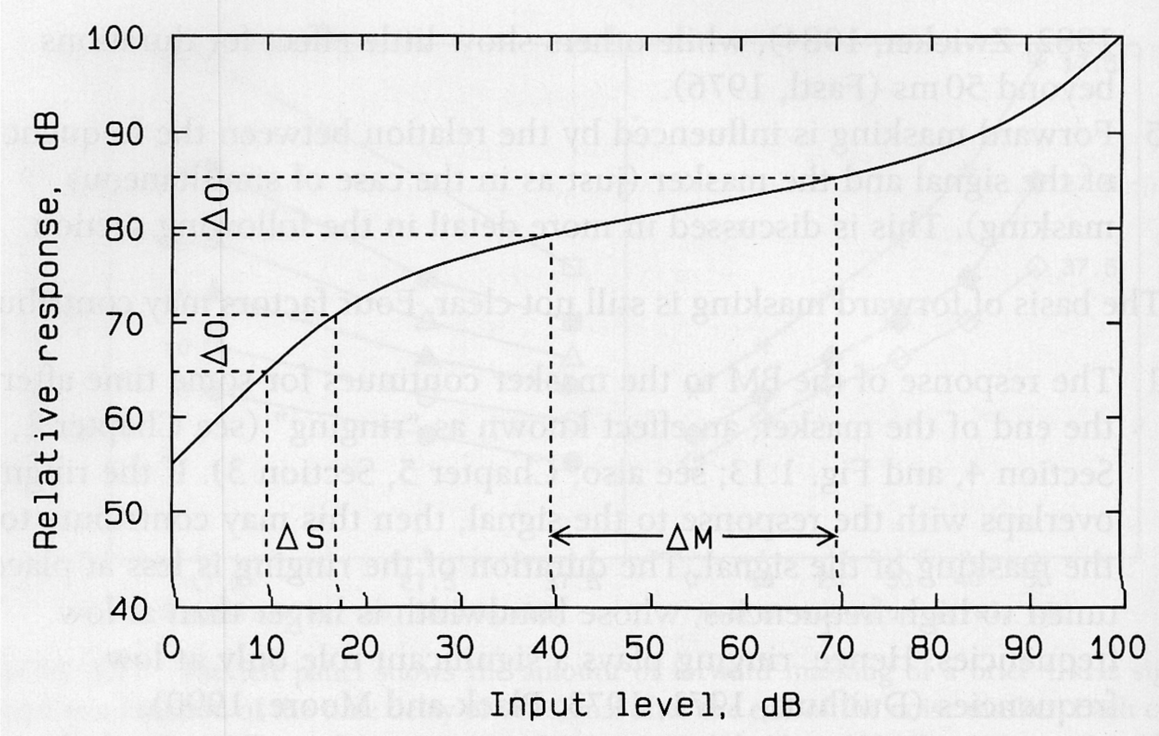
B) Signal suivi (t=100ms, 20ms, 0ms) par un bruit

C) Signal précédé par le bruit

II.3 Masquage temporel

Masquage pro-actif

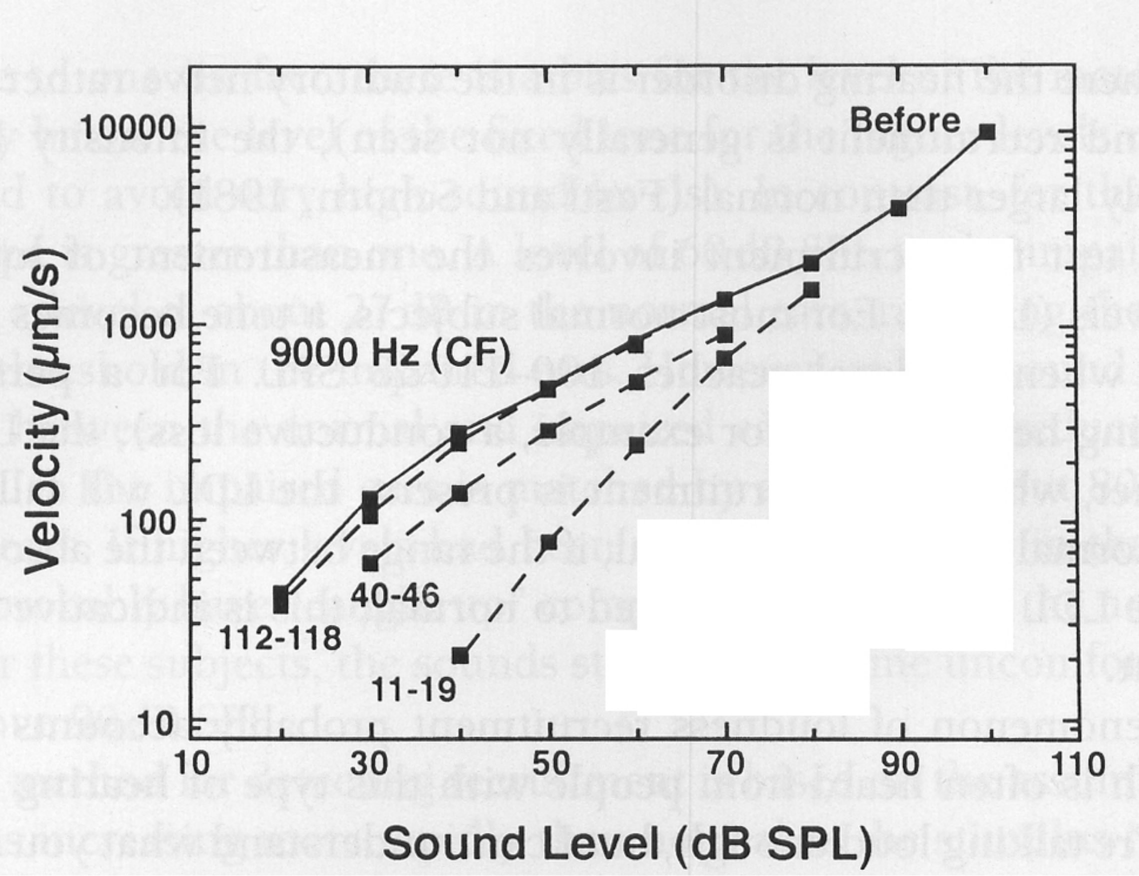
- Existence d’un mécanisme de “compression”



II.3 Masquage temporel

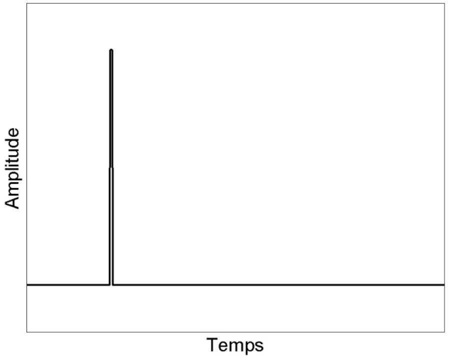
Masquage pro-actif

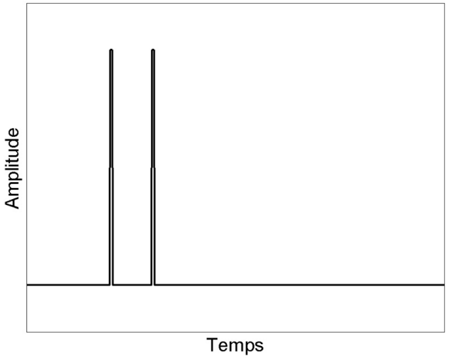
- Existence d’un mécanisme de “compression”



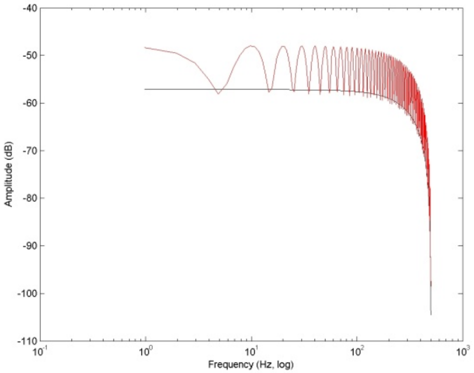
II.4 Résolution temporelle

- Intuitivement: séparer deux évènements dans le temps



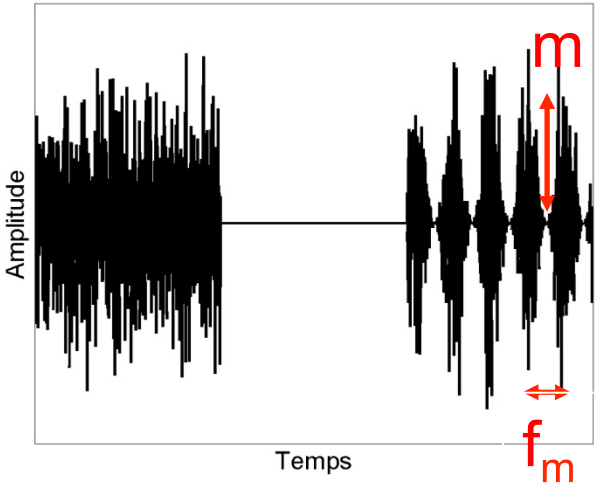


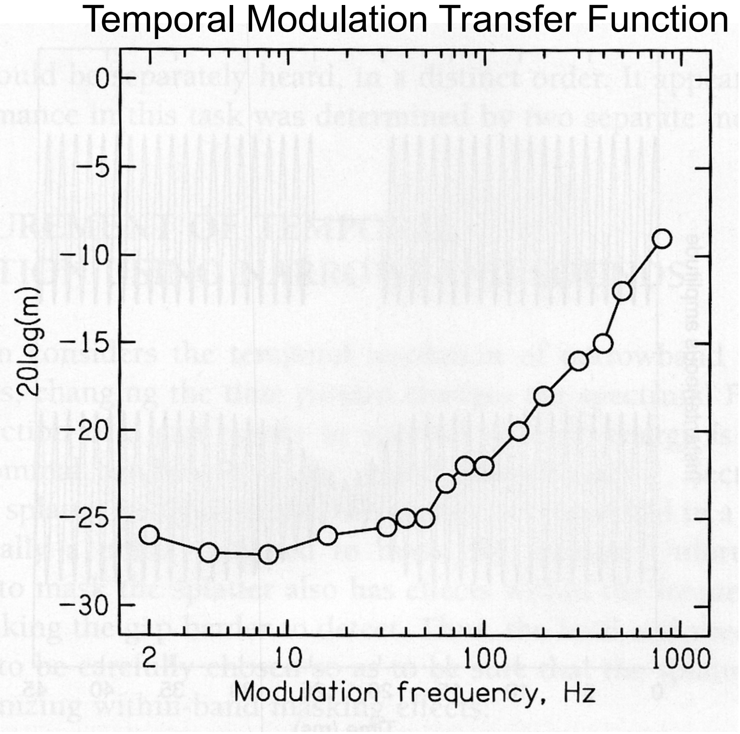
- Paires de clicks: ~ 20 microsec
- … mais indices spectraux



II.4 Résolution temporelle

- Détection de modulation d'amplitude

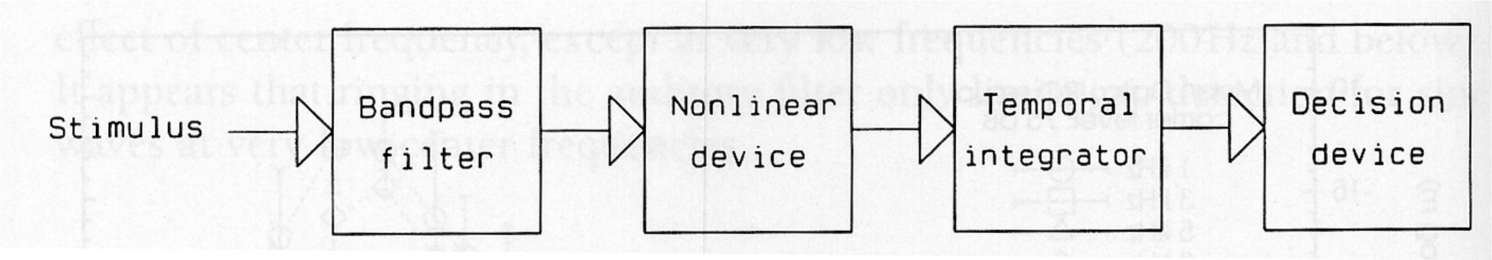


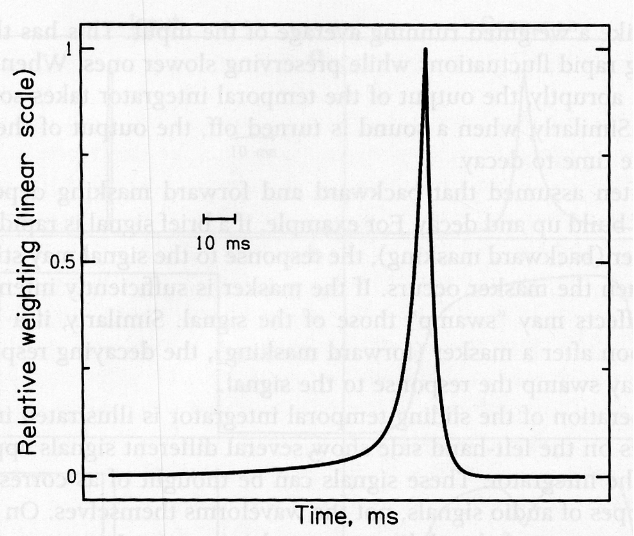


Viemeister, 1979

II.4 Résolution temporelle

- Modèle de fenêtre d'intégration





Plack & Moore, 1990

II.5 Produits de distortion

TRATTATO
DI
MUSICA
SECONDO LA VERA SCIENZA
DELL' ARMONIA.

IN PADOVA, MDCCLIV.
Nella Stamperia del Seminario.
Appresso Giovanni Manfrè.
CON LICENZA DE' SUPERIORI, E PRIVILEGIO.

Tartini: *Trattato di Musica*. First edition (1754). The famous violinist's important treatise.

400 & 500 Hz
= 4th and 5th
harmonics of
100 Hz

400 & 533 Hz
= 3rd and 4th
harmonics of
133 Hz

400 & 600 Hz
= 2nd and 3rd
harmonics of
200 Hz

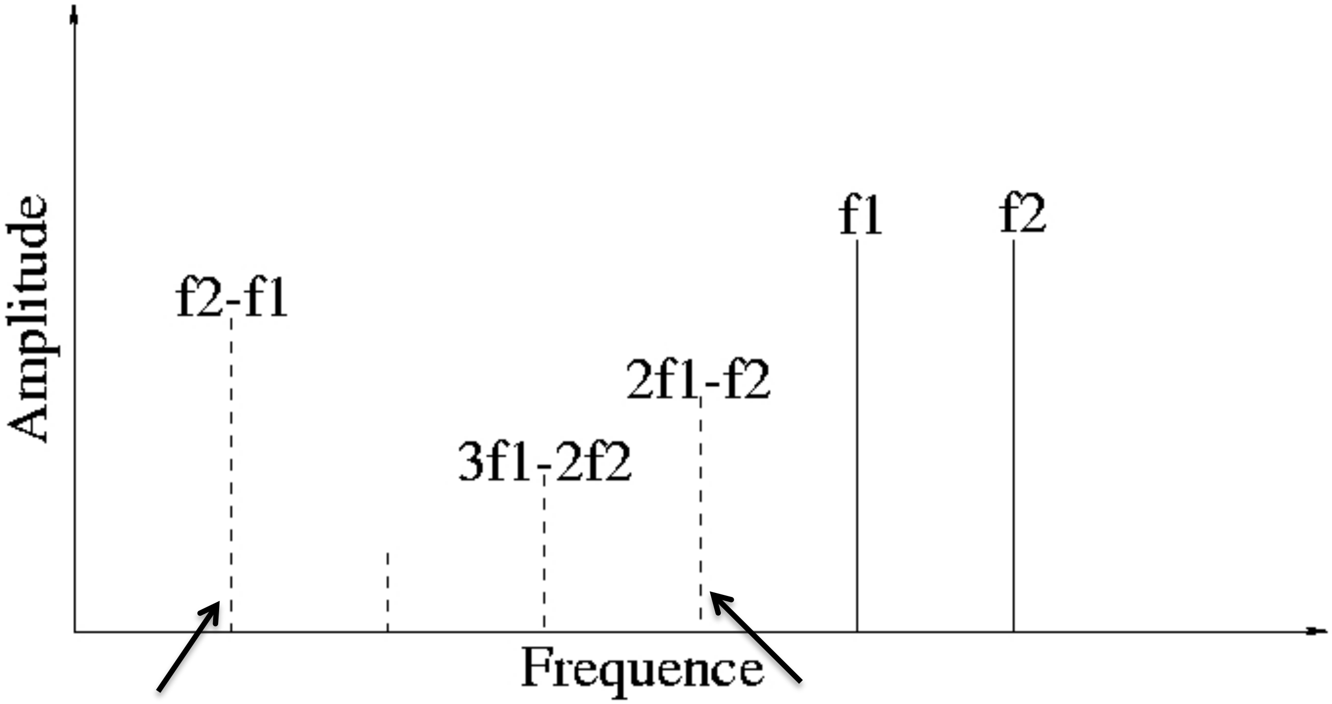
Difference tone:
500 − 400 Hz
= 100 Hz

Difference tone:
533 − 400 Hz
= 133 Hz

Difference tone:
600 − 400 Hz
= 200 Hz

II.5 Produits de distortion

- Avec deux sons purs f1 et f2

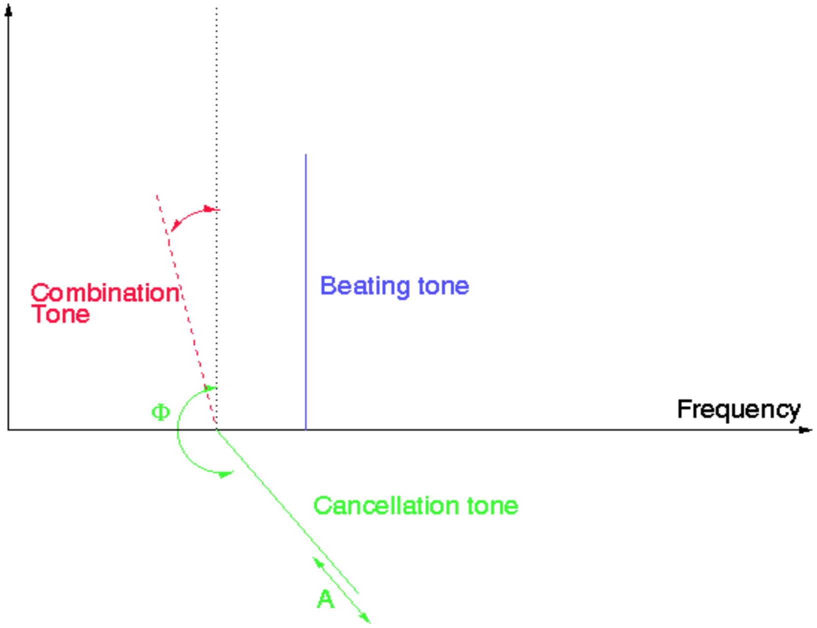


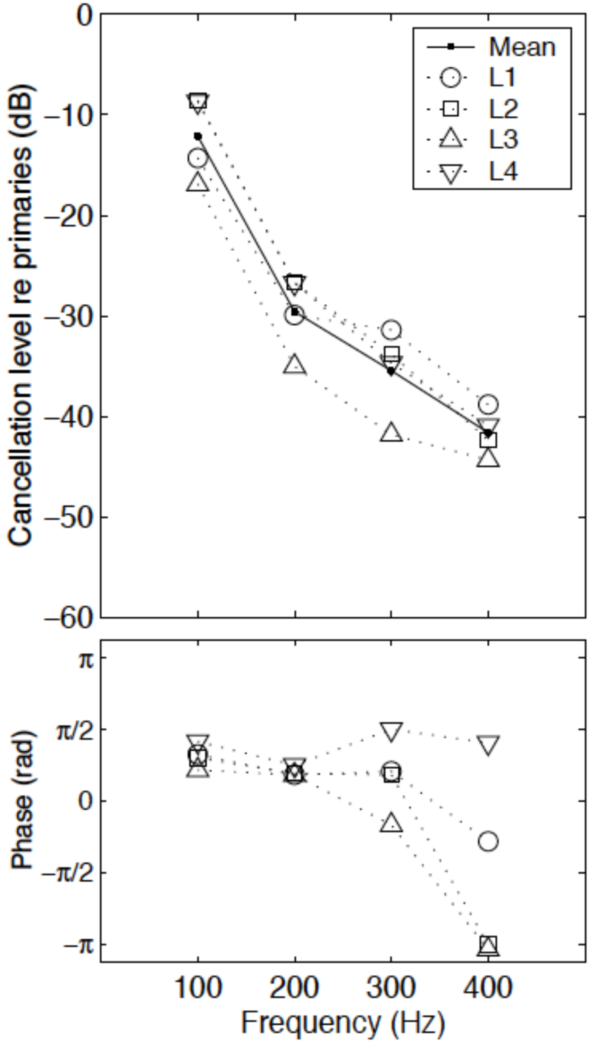
Quadratique

Cubique

II.5 Produits de distortion

- Mesure comportementale





10 primaires
Pressnitzer & Patterson, 2001

II.5 Produits de distortion

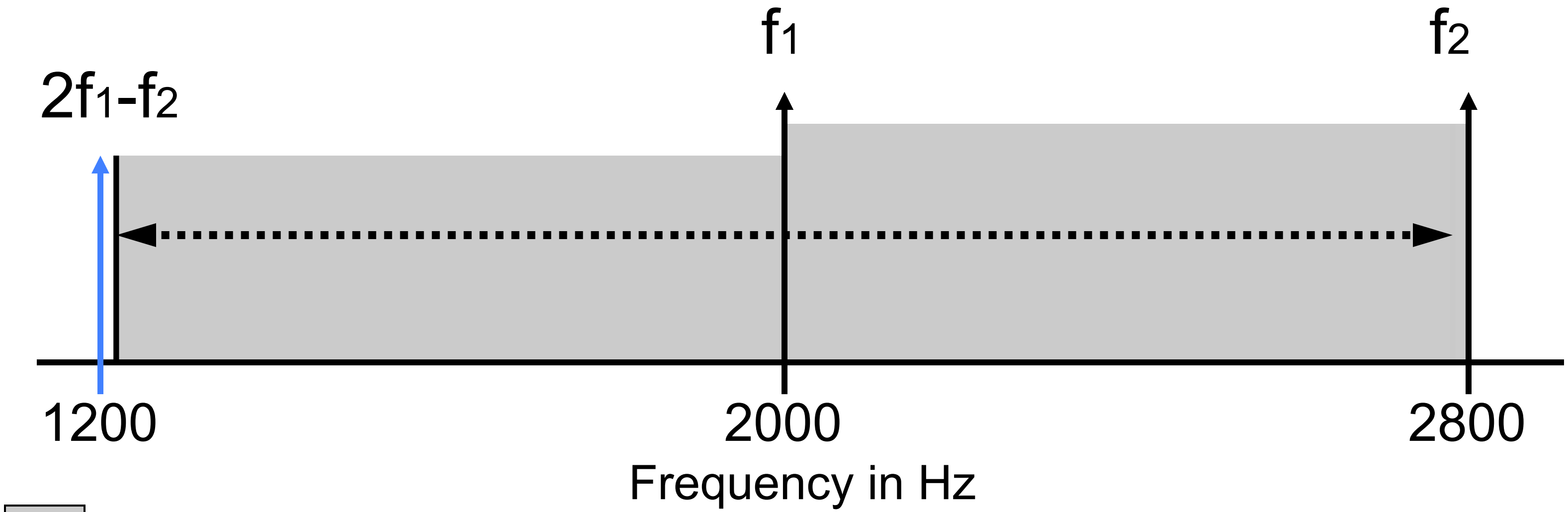
Demo [ASA 68]

Deux sons purs sont présentés à 1000 et 1200Hz

On rajoute un son pur à 804Hz

Nb: 2f1-f2 = 800Hz….

II.5 Produits de distortion



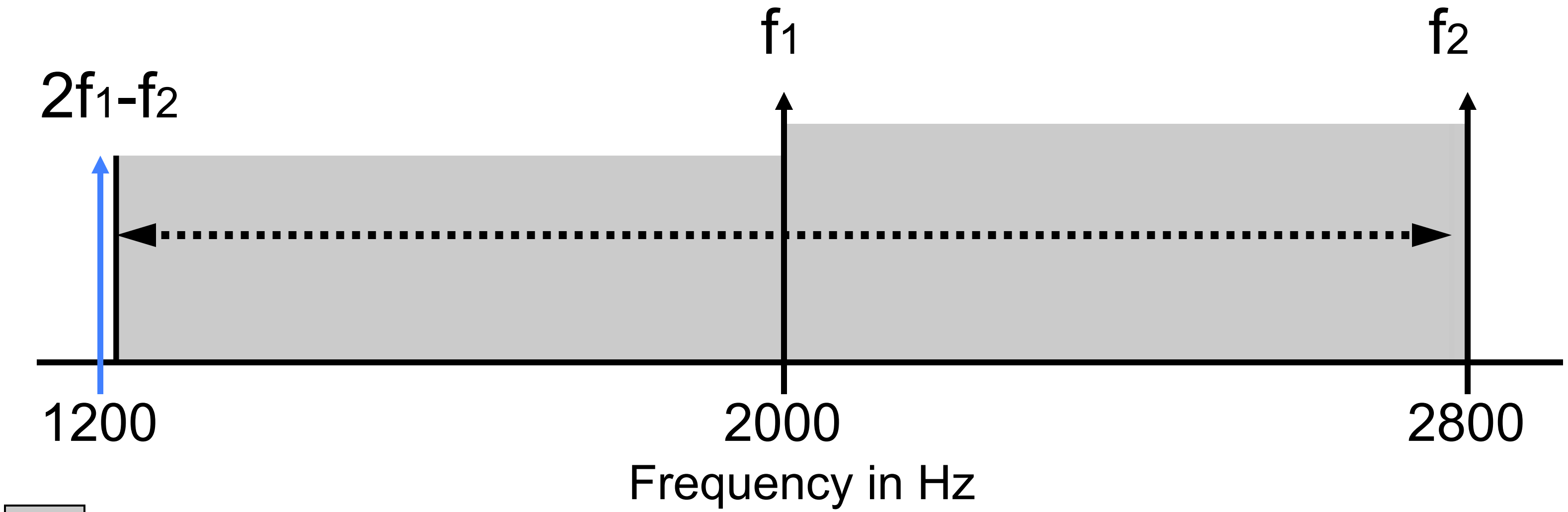
🔊 primary tone f_1

🔊 primary chirp f_2

🔊 f_1 and f_2

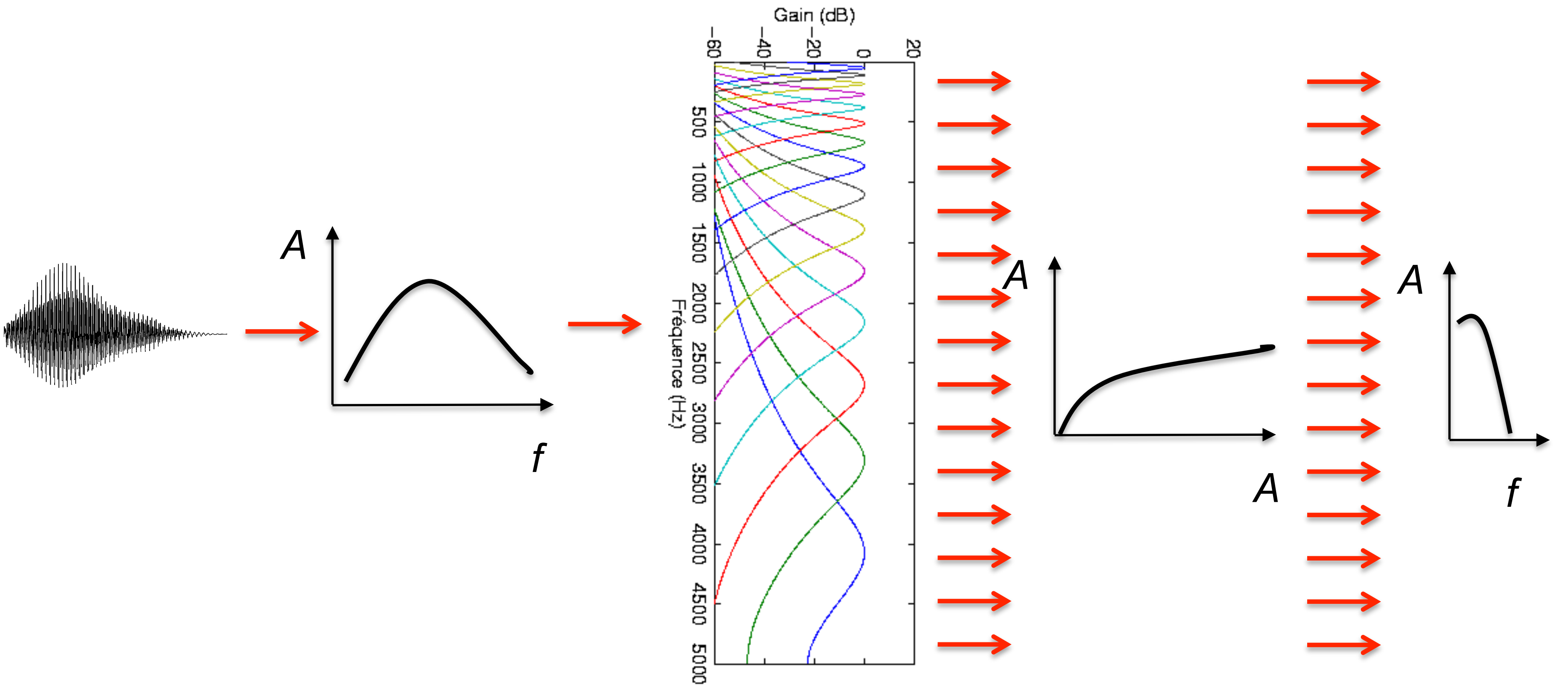
Demo from Stefan Uppenkamp

II.5 Produits de distortion



- 🔊 primary tone f_1
- 🔊 primary chirp f_2
- 🔊 f_1 and f_2

II.6 Modèles



Pré-emphase

Banc de filtre

Compression

Passe-bas

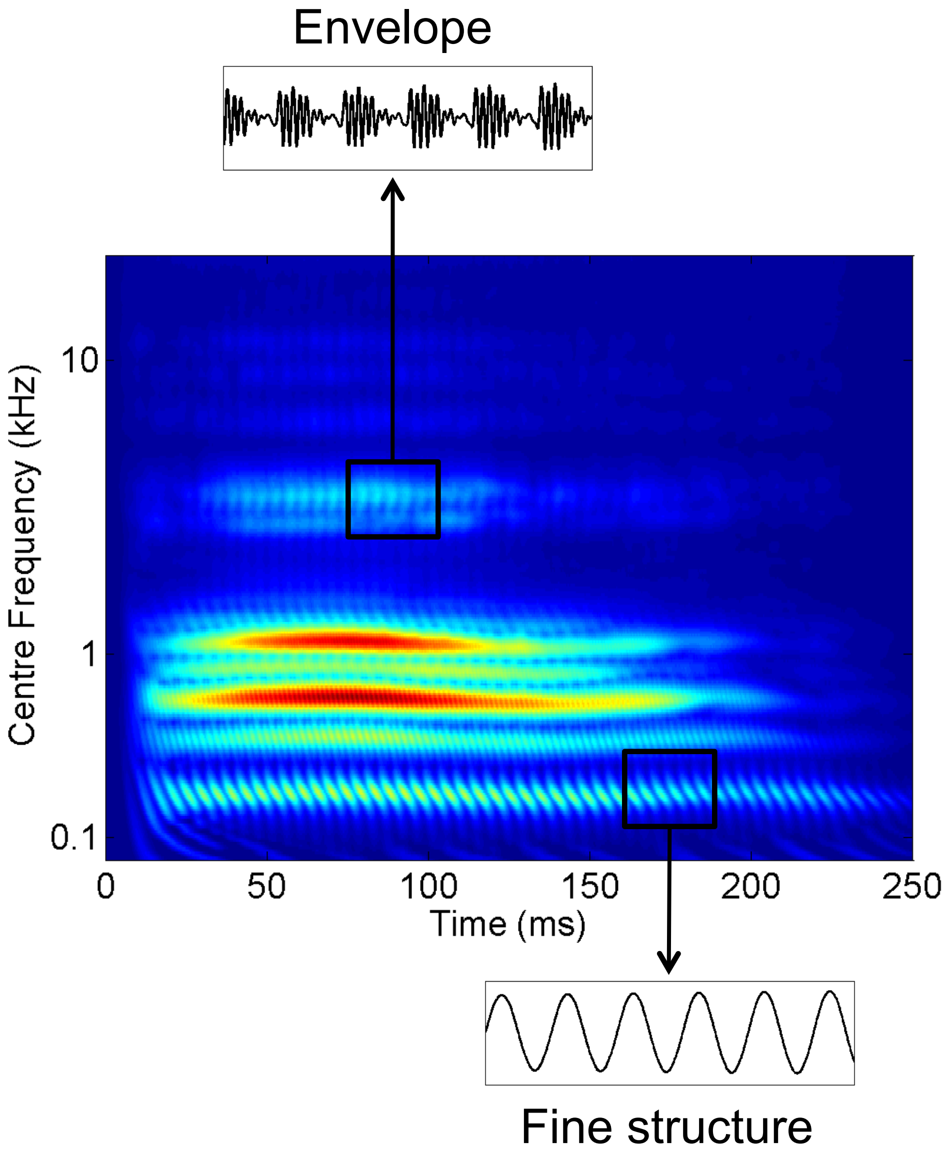
Oreille ext/moy

Membrane basilaire

Mécanisme actif

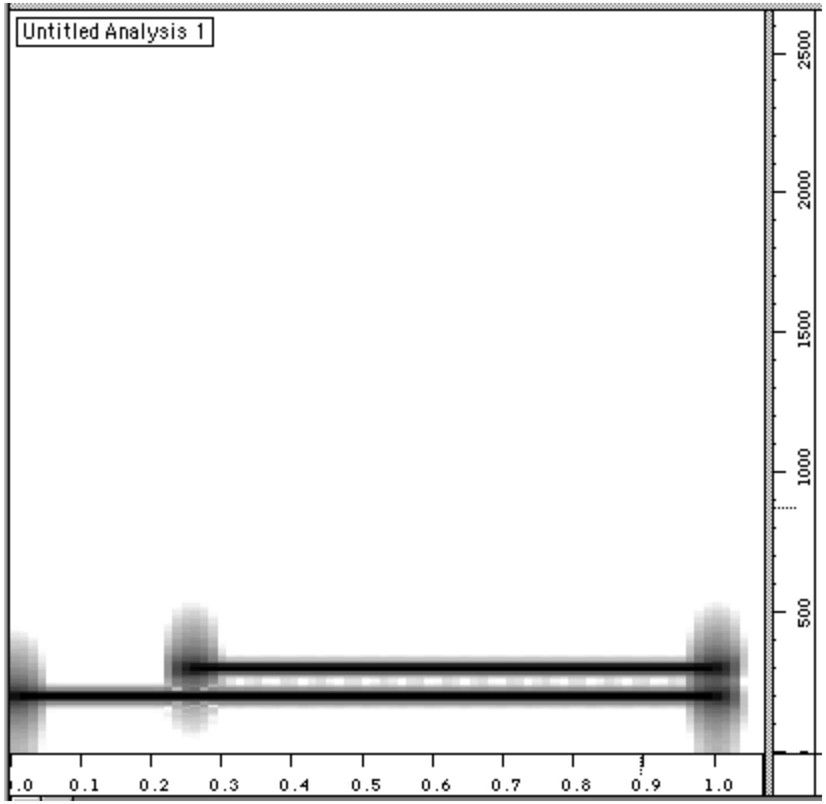
Res. temp.

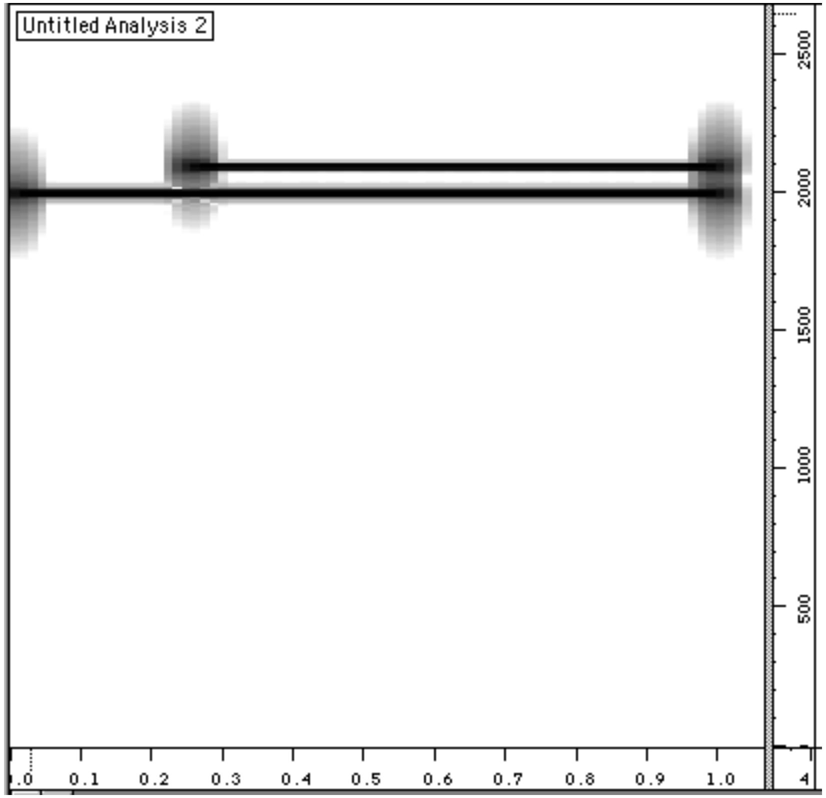
II.6 Modèles


Envelope
Centre Frequency (kHz)
10
1
0.1
0
50
100
150
200
250
Time (ms)
Fine structure

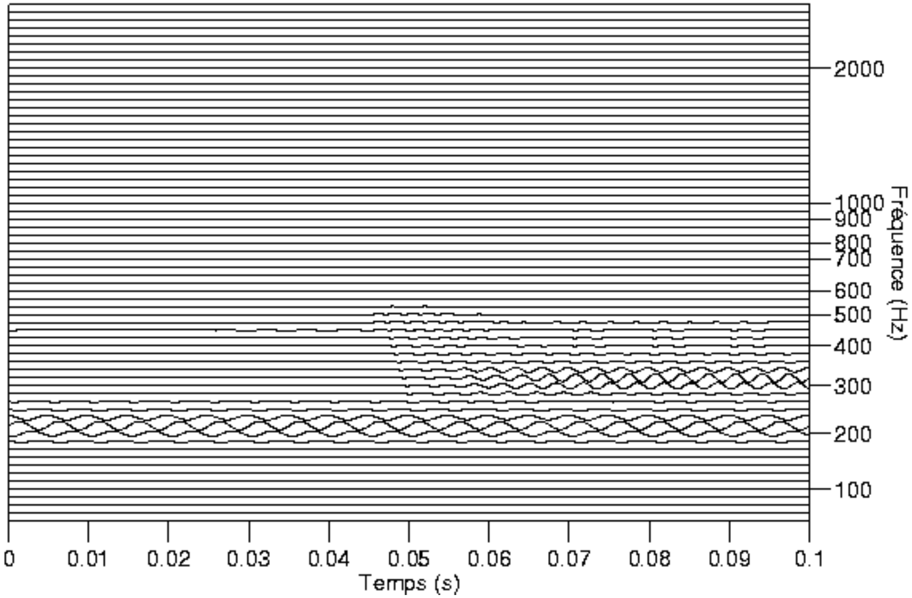
I.1 Acoustique

Représentations

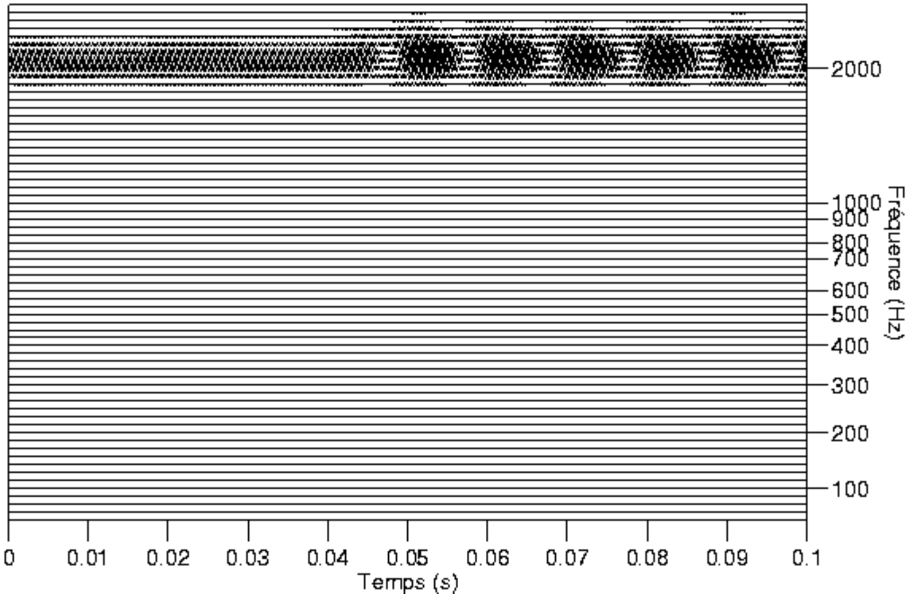




II.6 Modèles



2000
1000
900
800
700
600
500
400
300
200
100
Fréquence (Hz)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Temps (s)

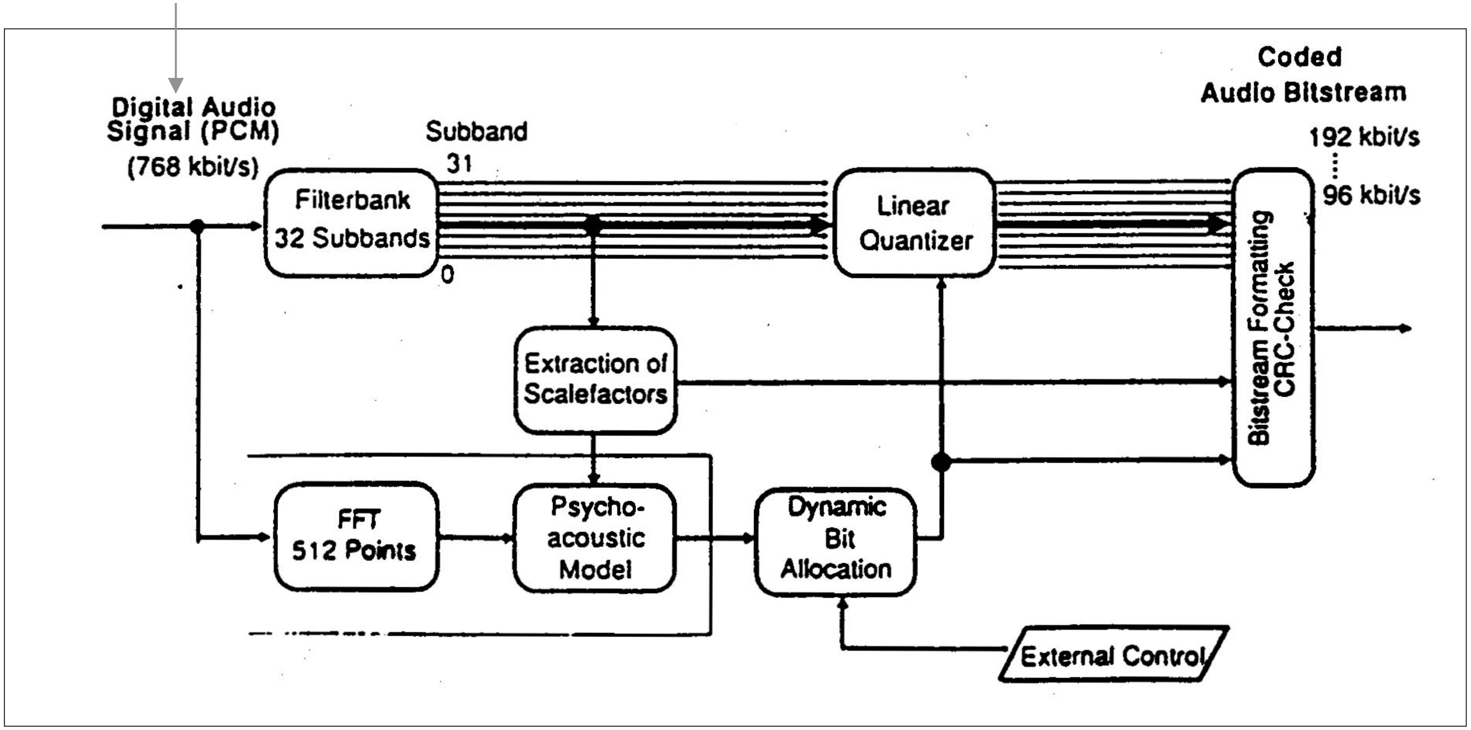


2000
1000
900
800
700
600
500
400
300
200
100
Fréquence (Hz)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
Temps (s)

II.7 Applications

Codage audio: MP3

mono@48kHz



II.7 Applications

Codage audio: MP3

CD stereo: 44.1*16*2 = 1410 kbps

Compression MP3 (Lame, www.mp3dev.org)

256 kbps
128 kbps
64 kbps
32 kbps

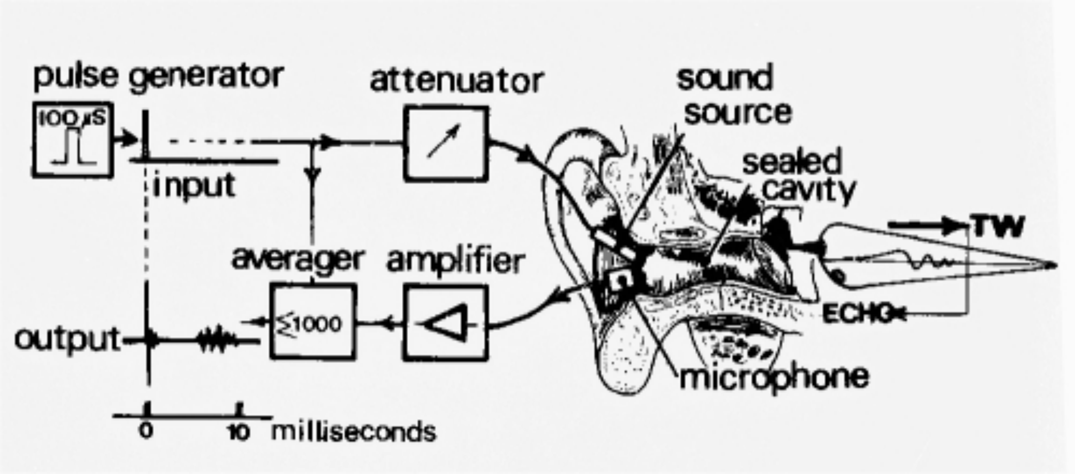
Bruit résiduel

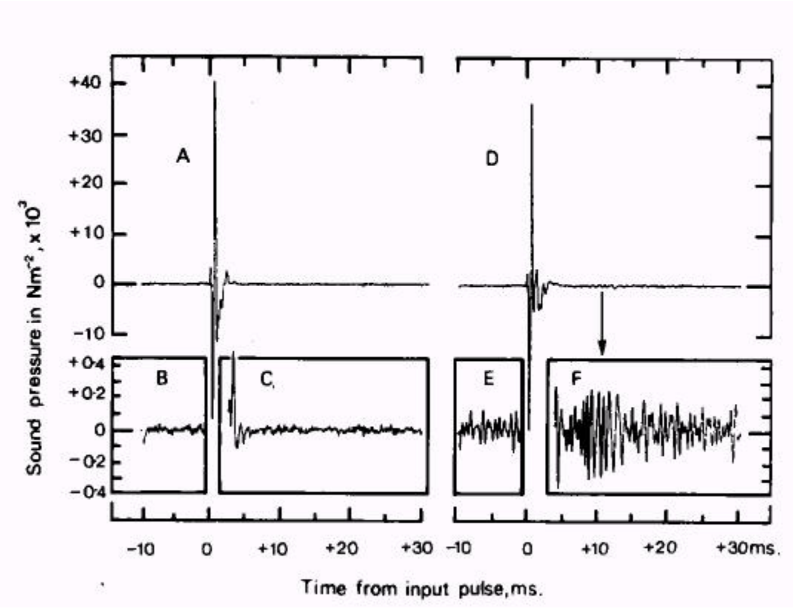
Comparaison:
fs = 8kHz (256 kbps)
fs = 4kHz (128 kbps)
8 bits (512 kbps)

II.7 Applications

Oto-émissions

- Mesure acoustique du mécanisme actif



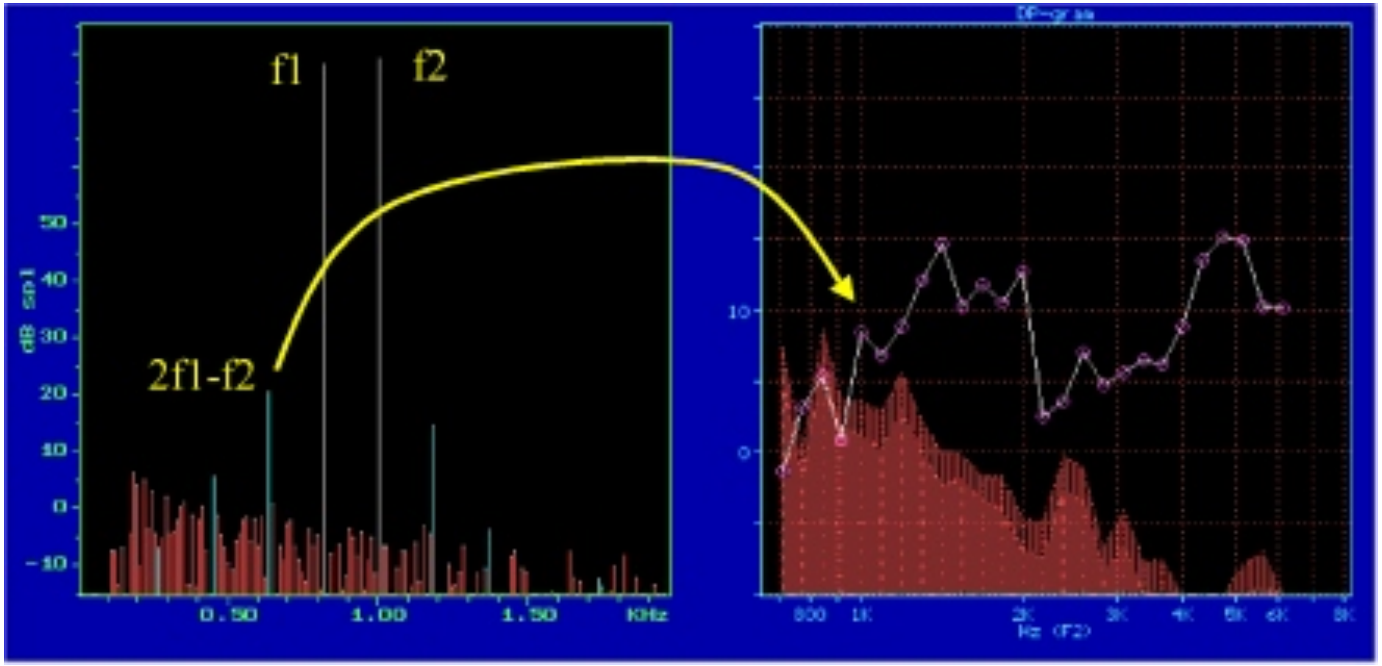


Kemp, 1977

II.7 Applications

Oto-émissions

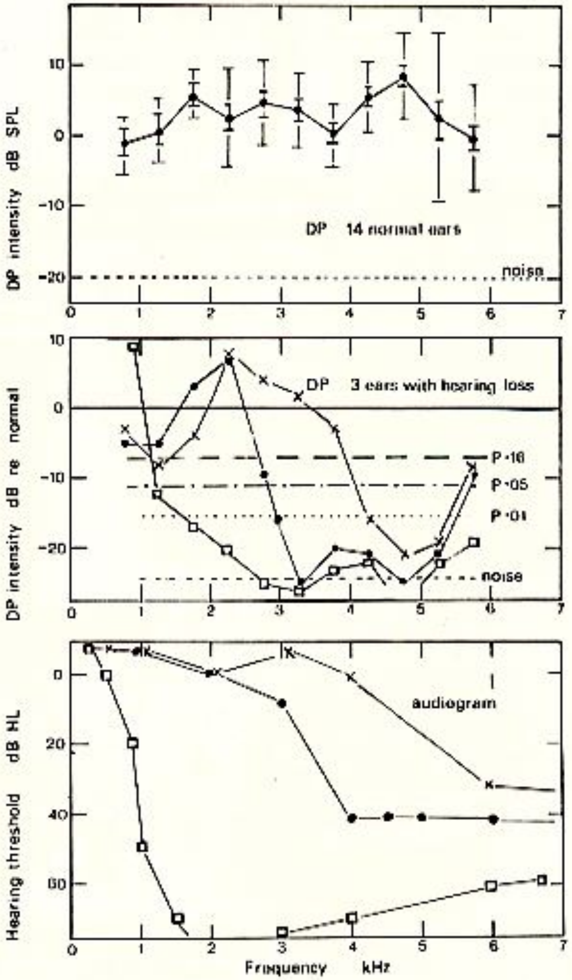
- Mesure acoustique du mécanisme actif



II.7 Applications

Oto-émissions

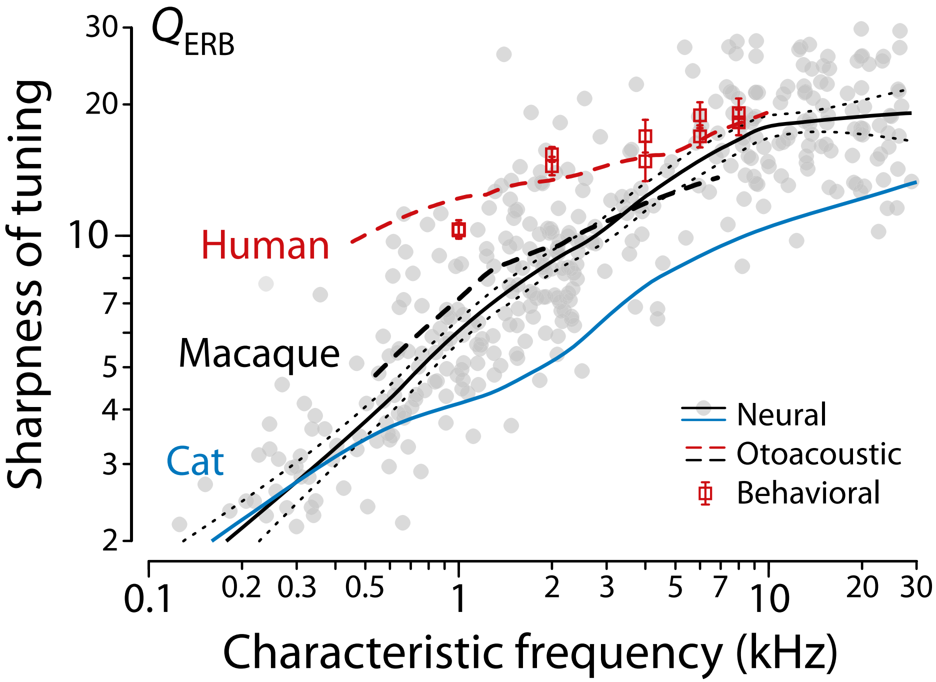
- Mesure acoustique du mécanisme actif
- Corrélation avec pertes auditives



II.7 Applications

Mesure (indirecte) de sélectivité

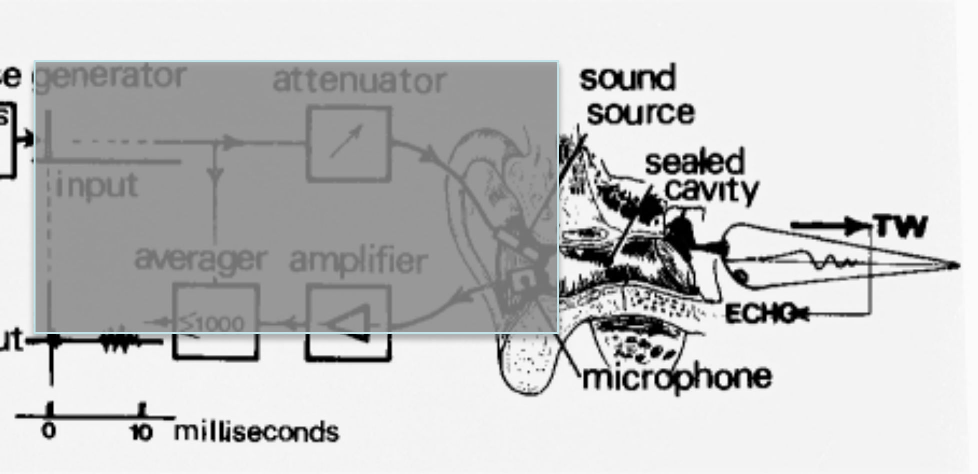
- Lien entre délai de l'OAE et sélectivité
- Sélectivité exceptionnelle chez l'humain ?

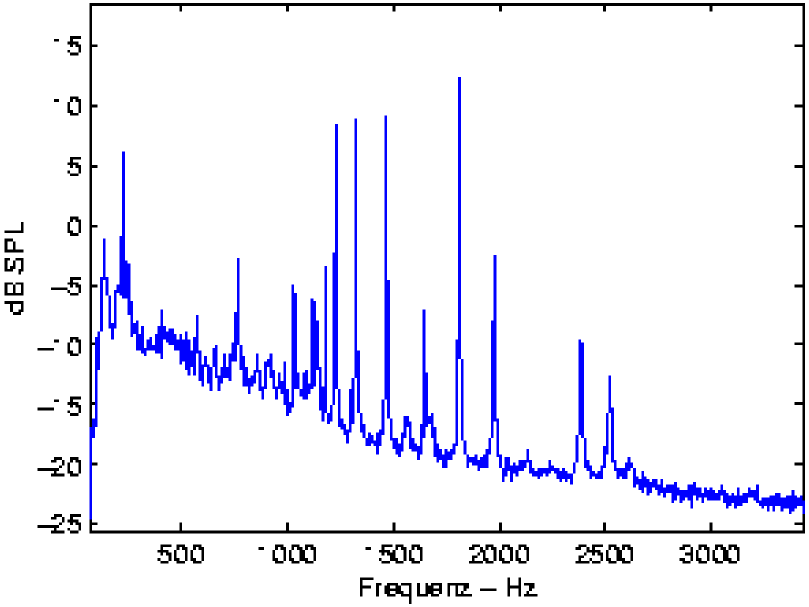


Joris et al., 2011

II.7 Applications

Oto-émissions spontanées

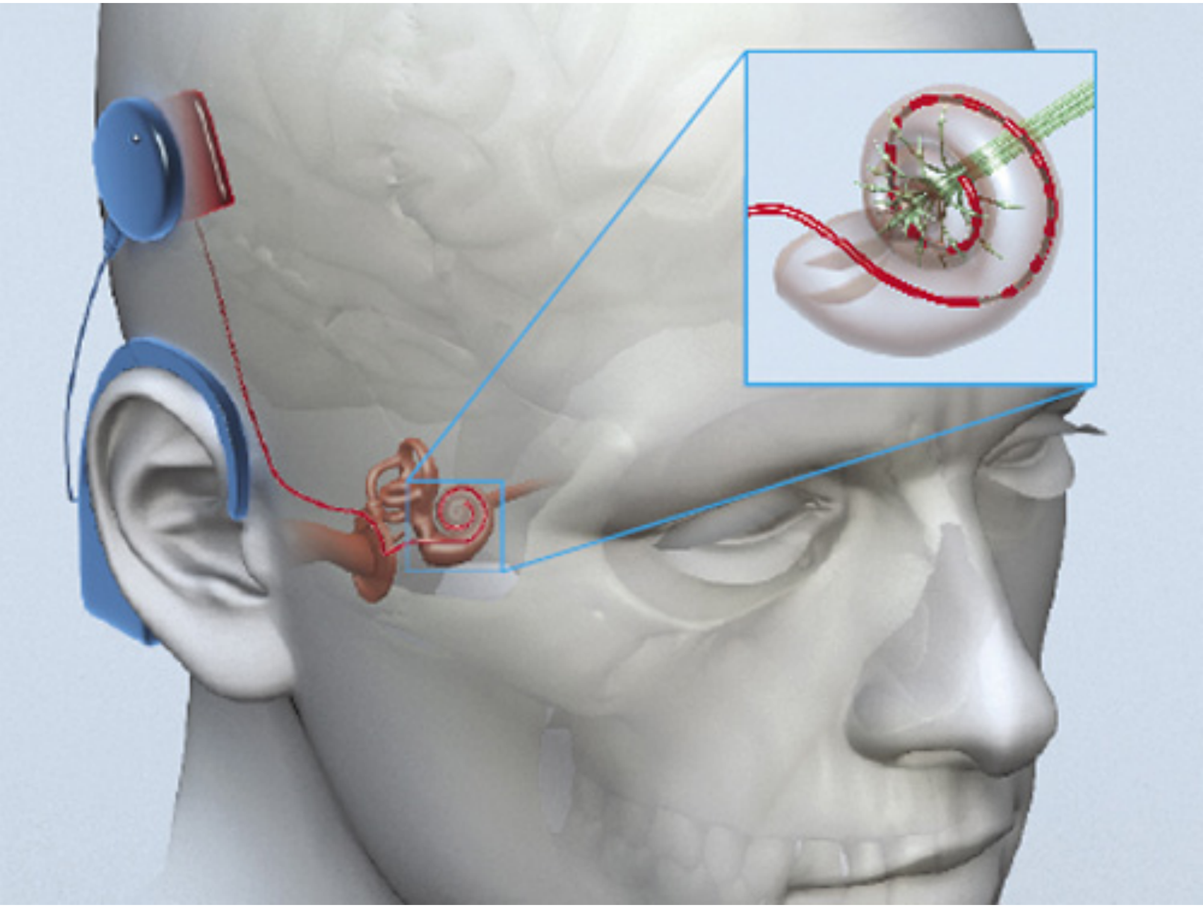




Oreille avec SOAE Coupleur

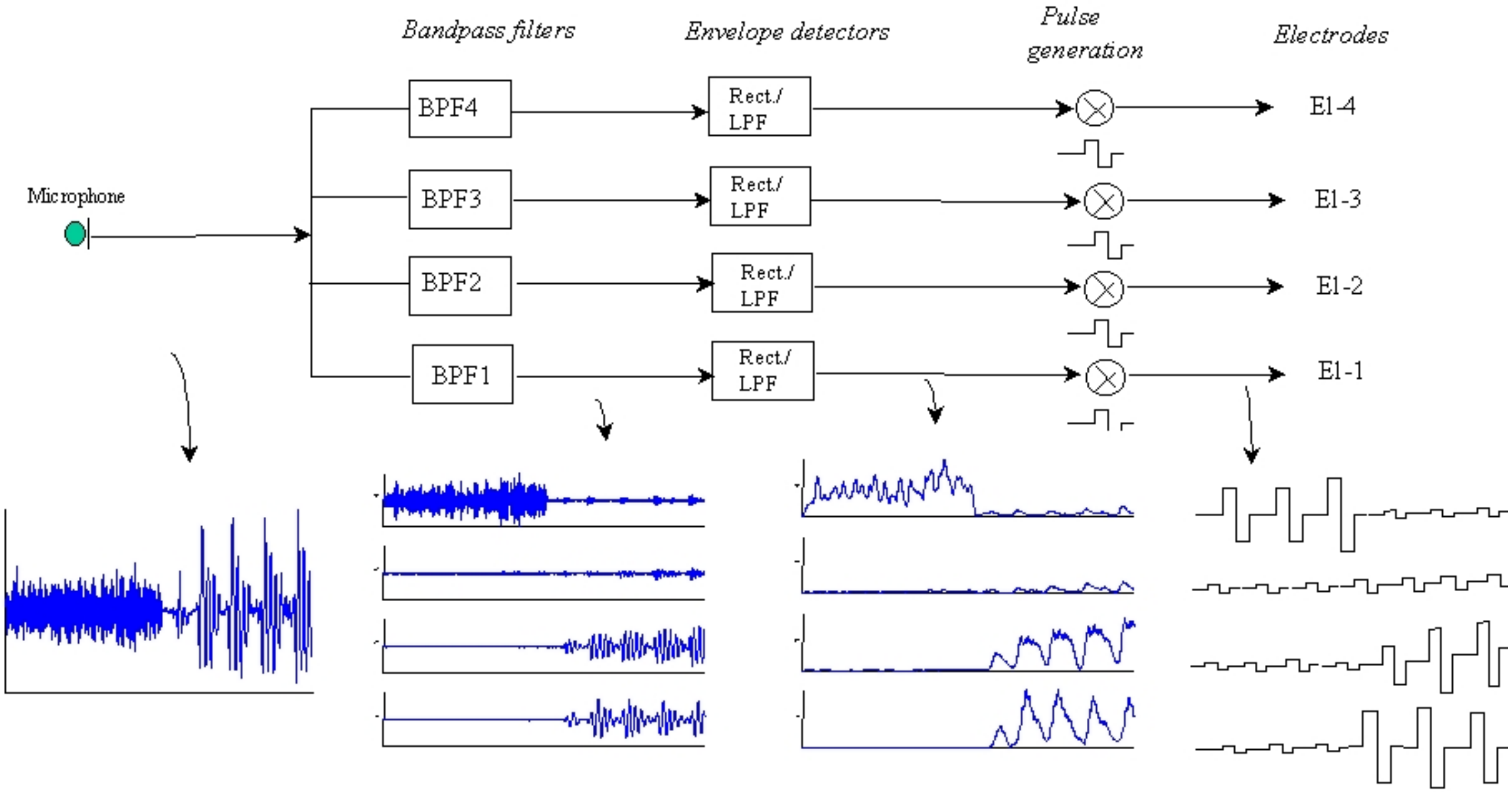
II.7 Applications

Implants cochléaires



II.7 Applications

Implants cochléaires



II.7 Applications

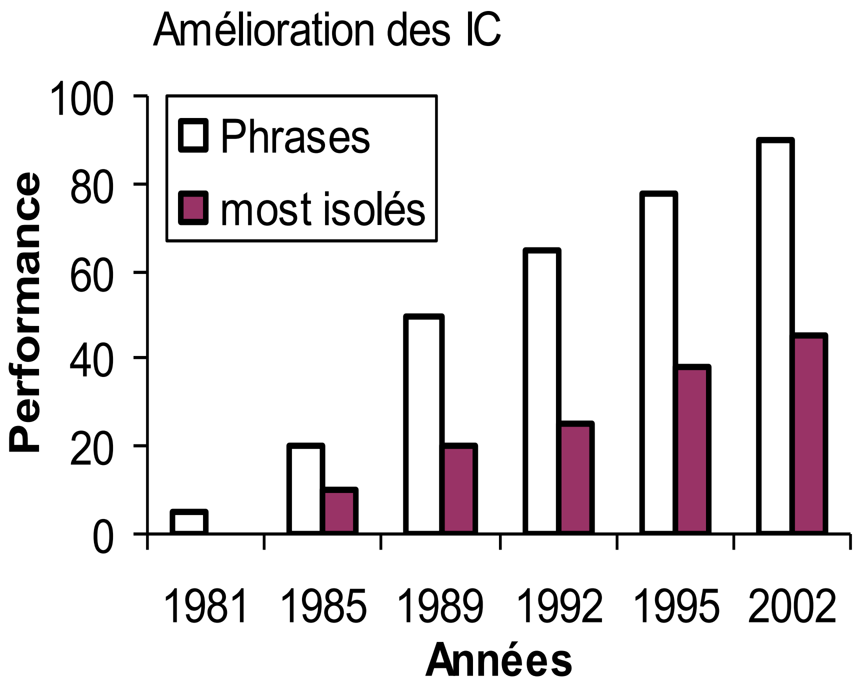
Implants cochléaires

Simulations de l'algorithme de traitement

Bandes	1	2	3	4	6	8
	🔊	🔊	🔊	🔊	🔊	🔊

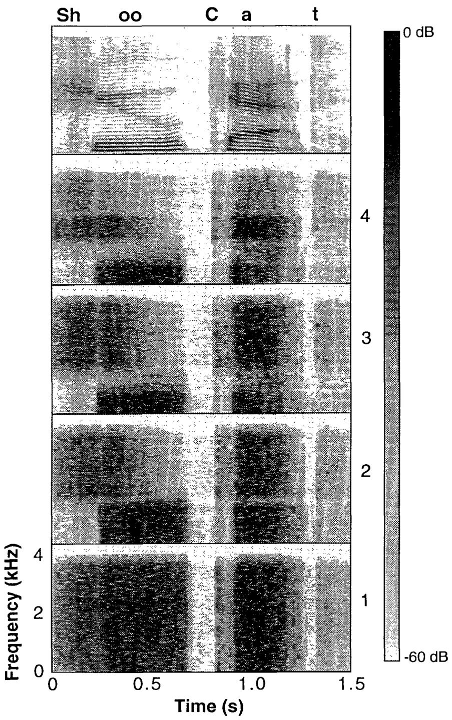
II.7 Applications

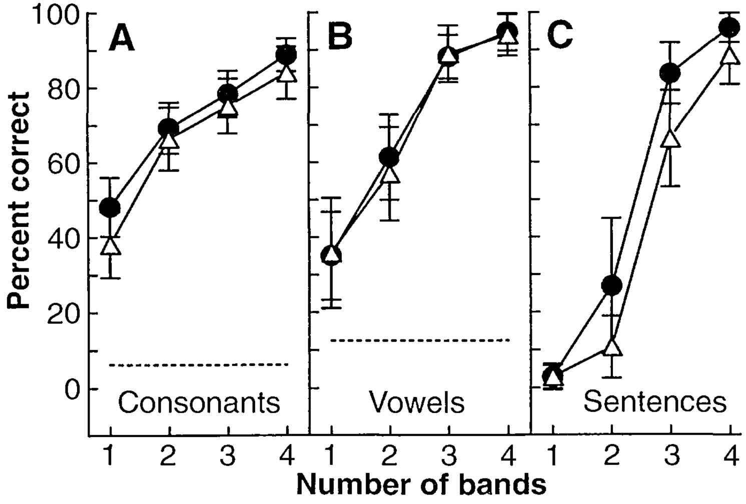
Implants cochléaires



II.7 Applications

Indices multiples pour la parole



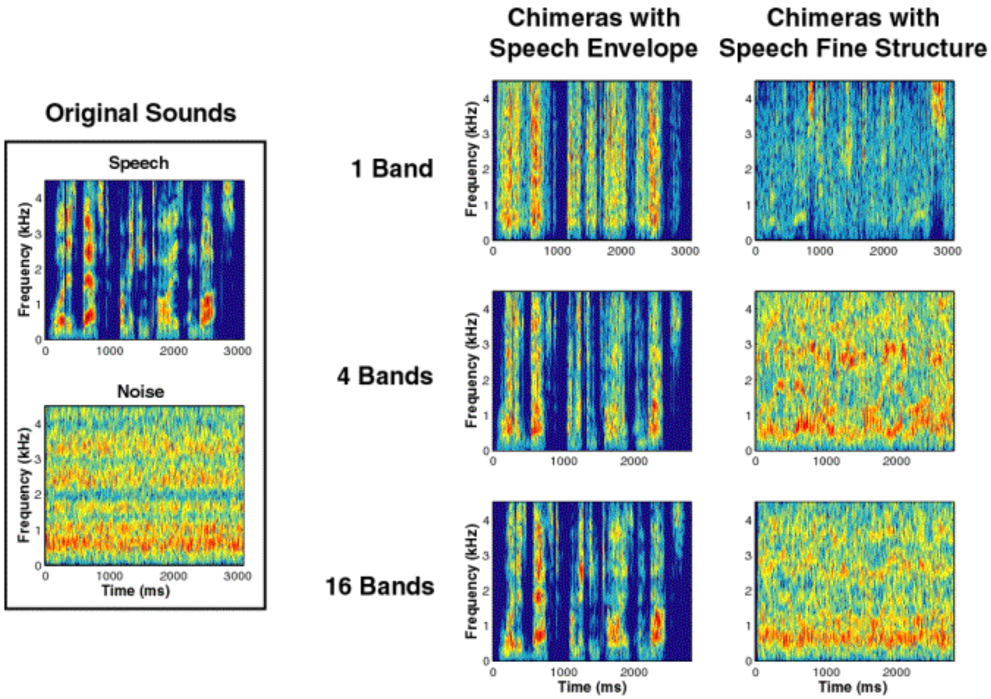


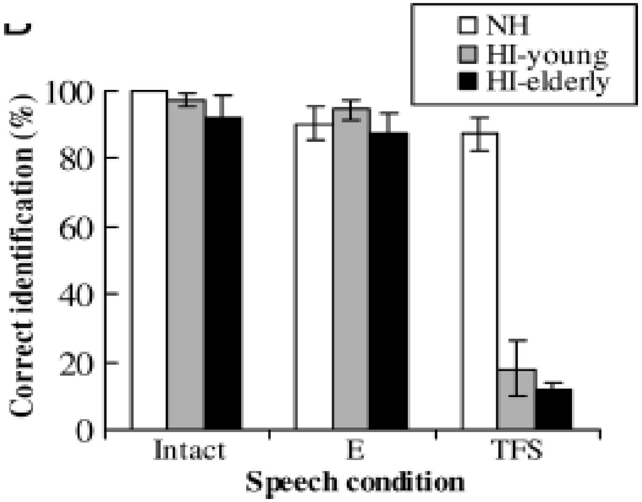
- Enveloppe

Shannon et al., 1995

II.7 Applications

Indices multiples pour la parole



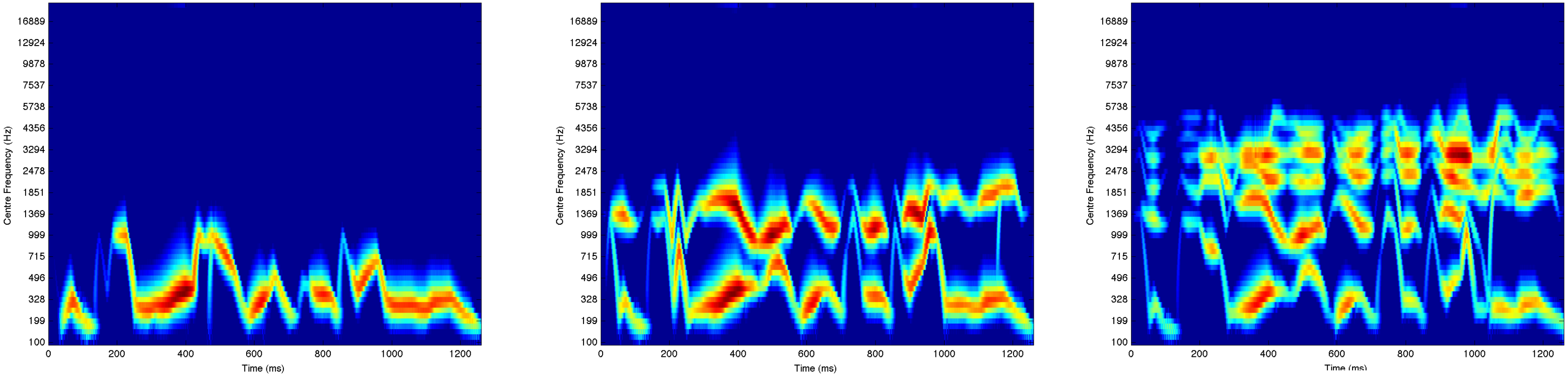


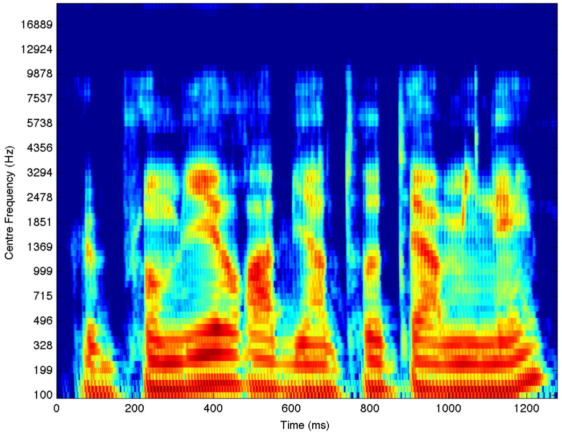
- Structure temporelle fine

Lorenzi et al., 2006; Smith et al., 2002

II.7 Applications

Indices multiples pour la parole





- Fréquence des formants

Remez et al., 1981