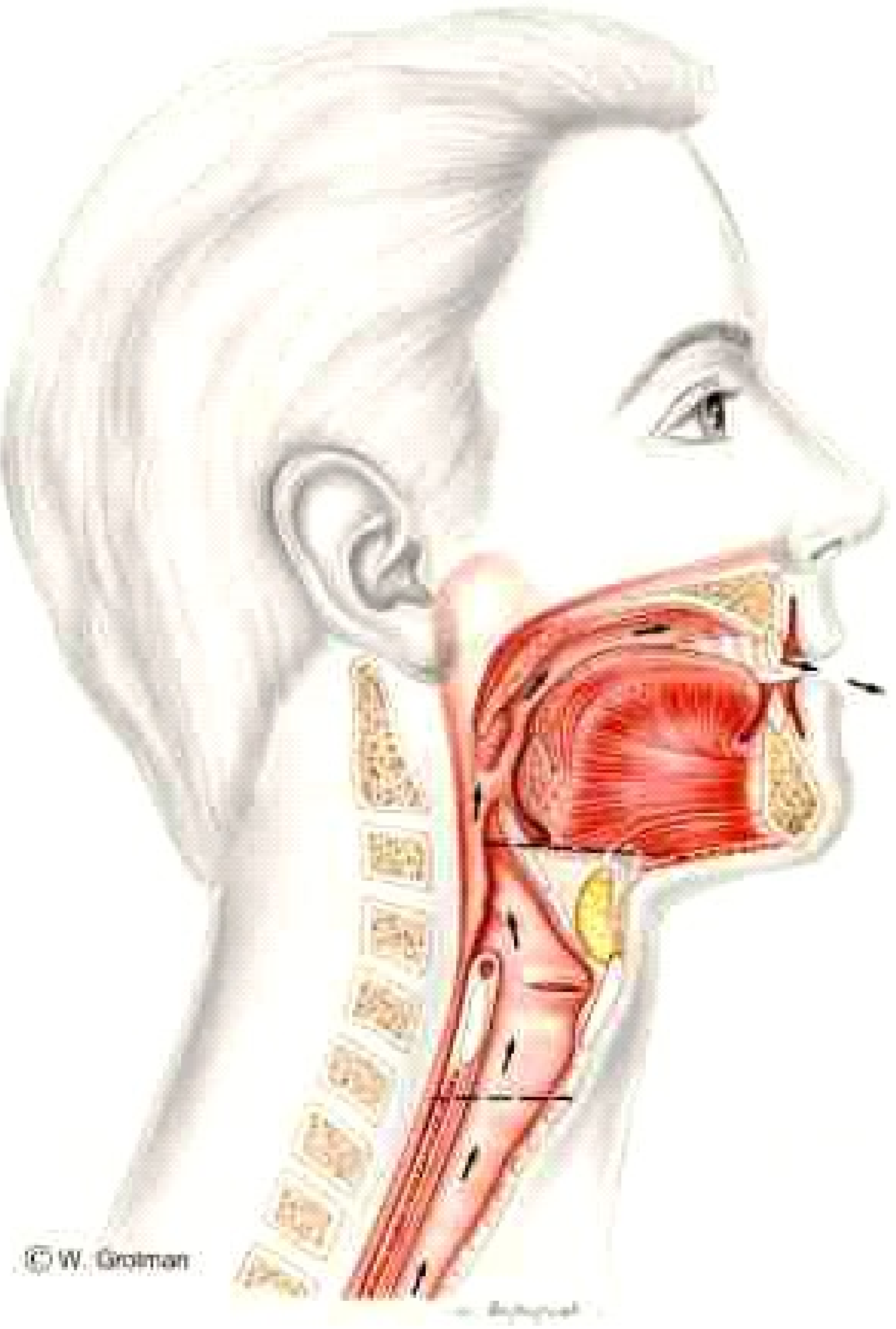
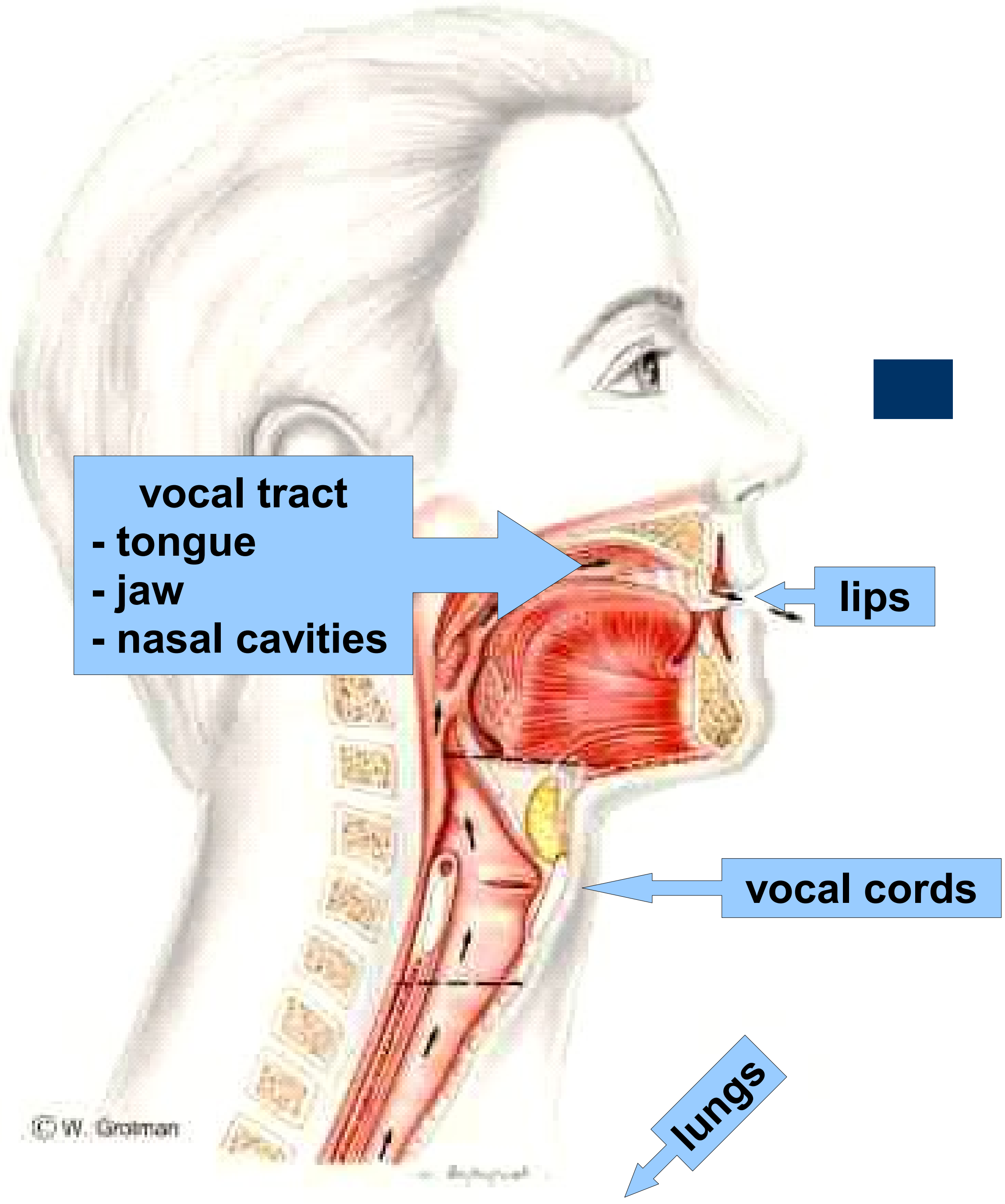
Research on (tele)communication tools for people with disabilities - selected topics

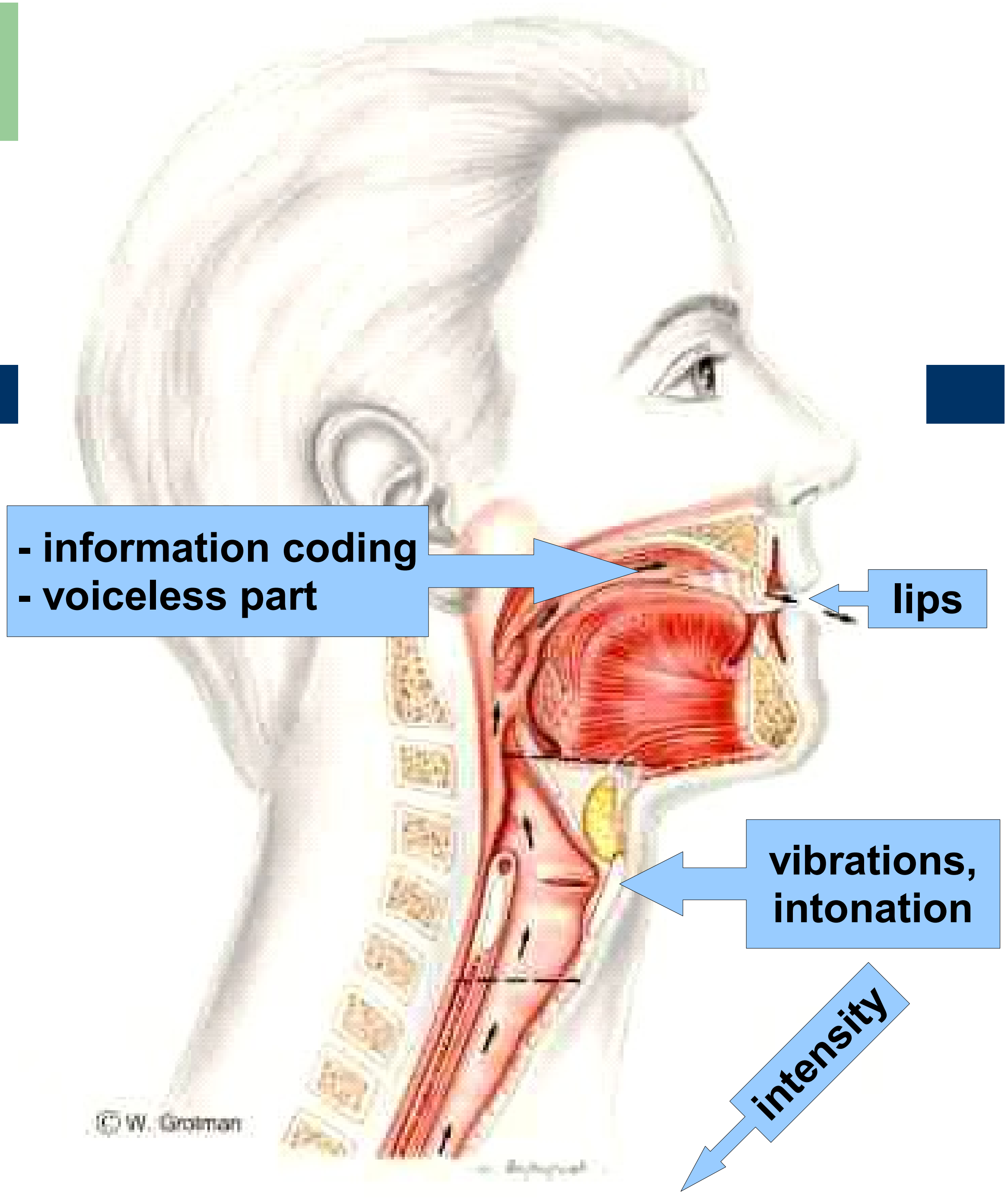
Jane 2011, Antoni Grzanka, Poland



General introduction to human voice production: source of energy – air flow



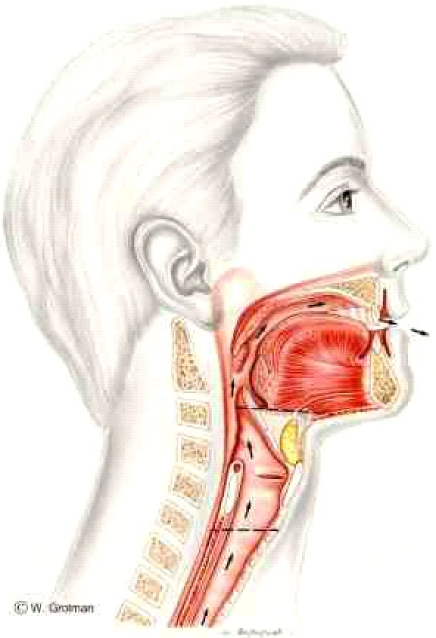
General introduction to human voice production: key elements

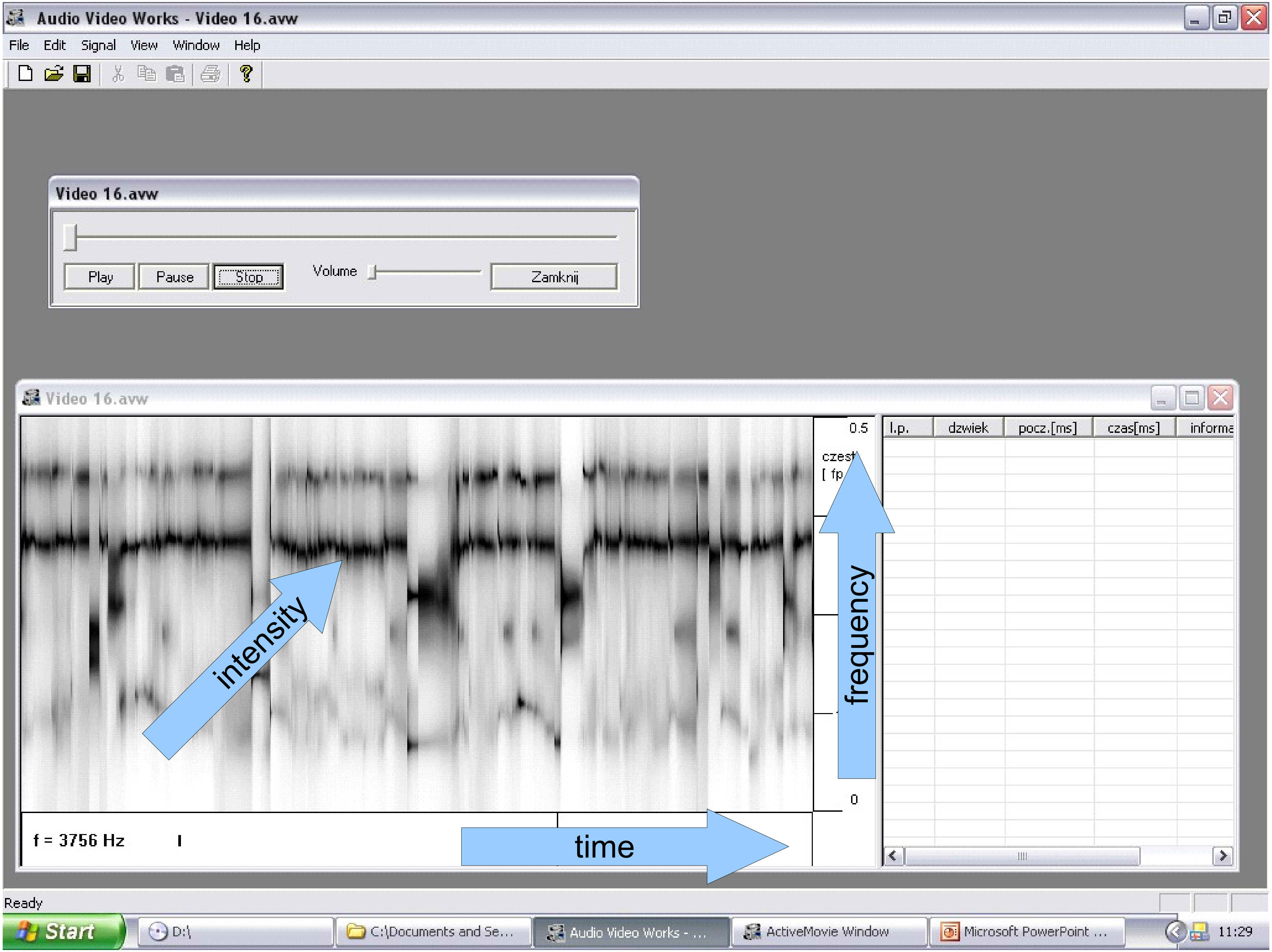


General introduction to human voice production: functions

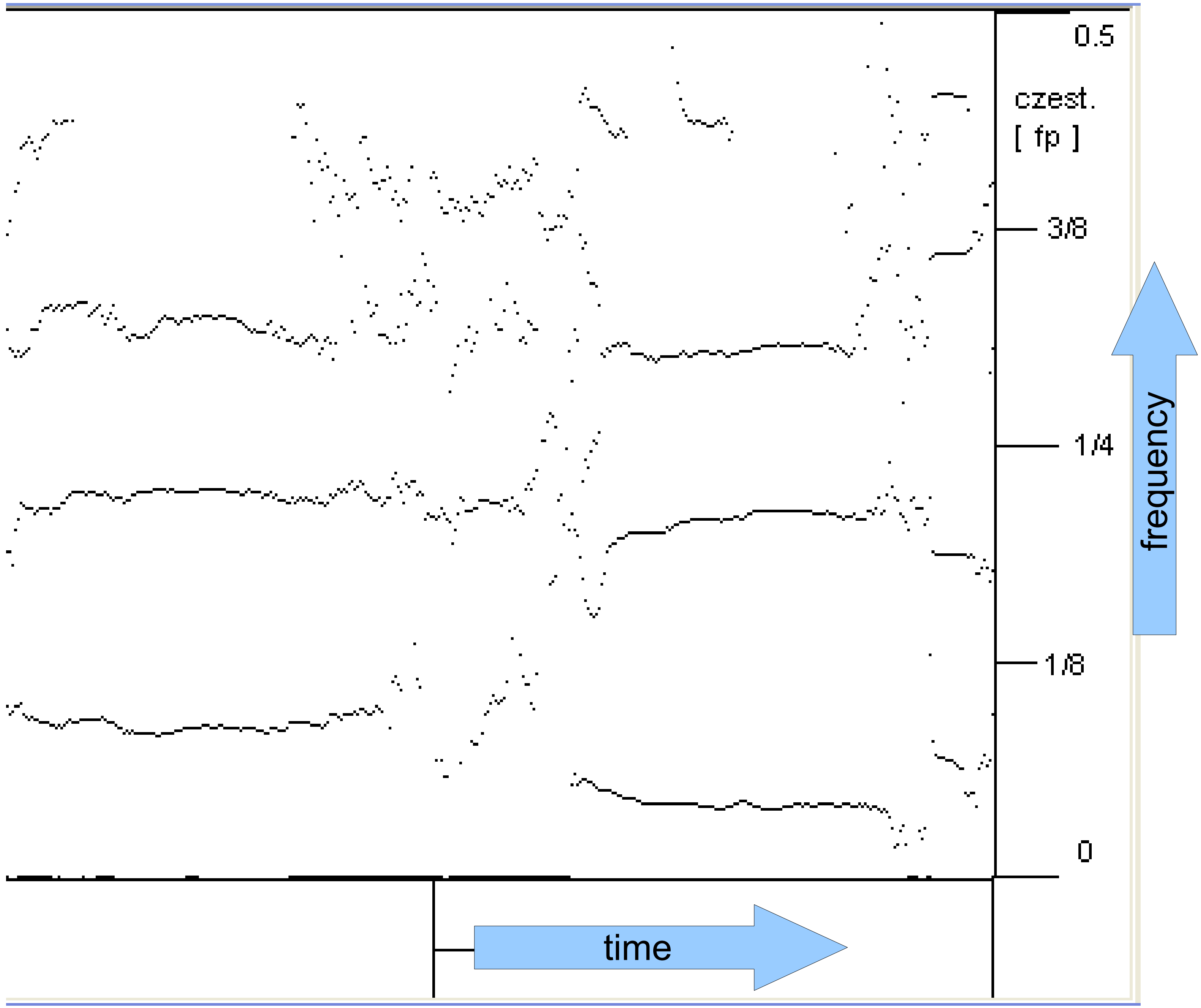
Speech: information layers:

- physical: acoustic wave
  - intensity
    - time dependant
    - frequency dependant (voice spectrum)
    - space dependant
- phonetic
  - phonems ≡ spoken „letters“, spoken “orthography”
- phonological
  - spoken „grammar“, semantics, perception

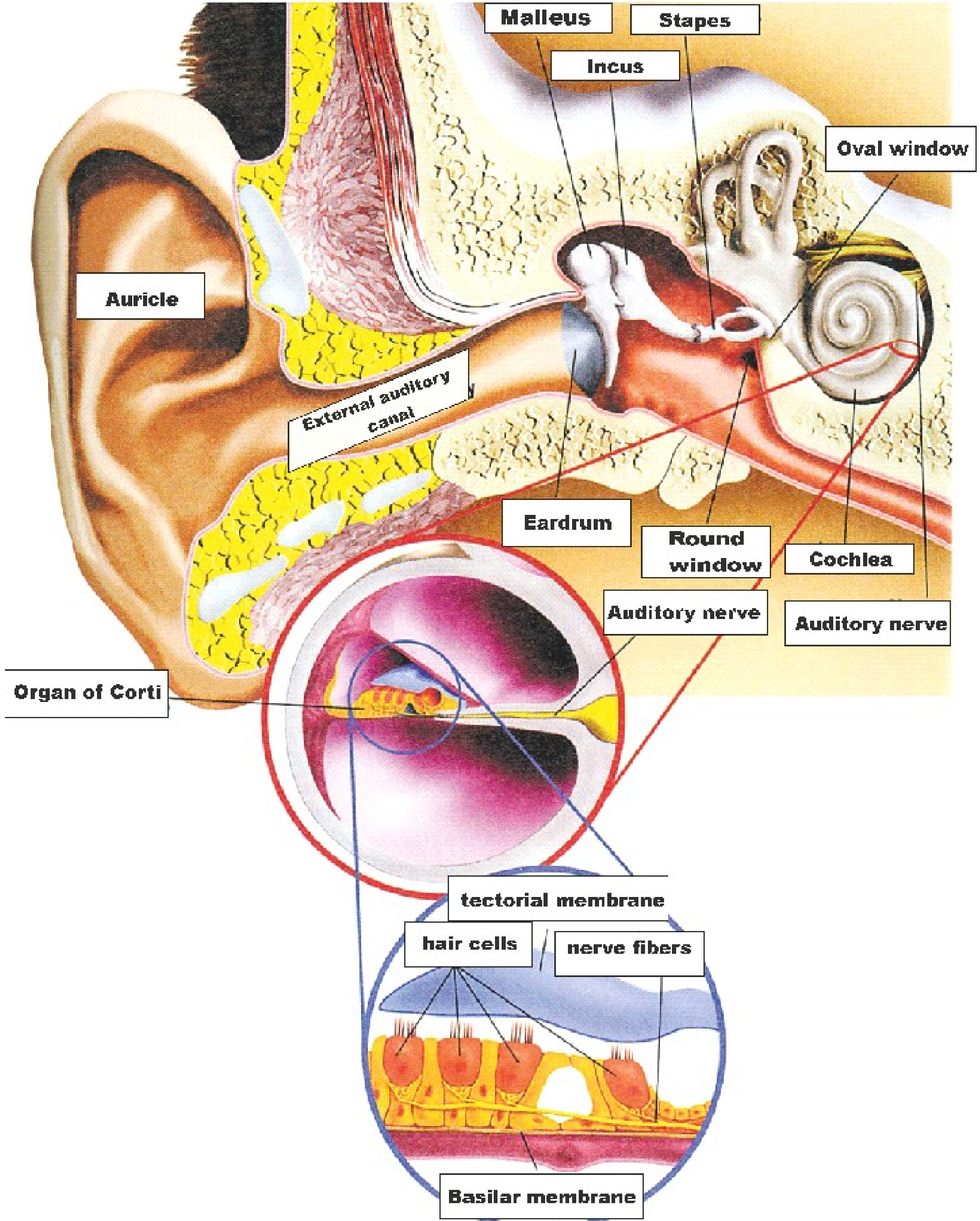




General introduction to human voice production: main dimensions on spectrogram



General introduction to human voice production: formants of phonemes /e/ /y/



Auditory path

Dimensions of voice in human perception: how does the auditory system work?

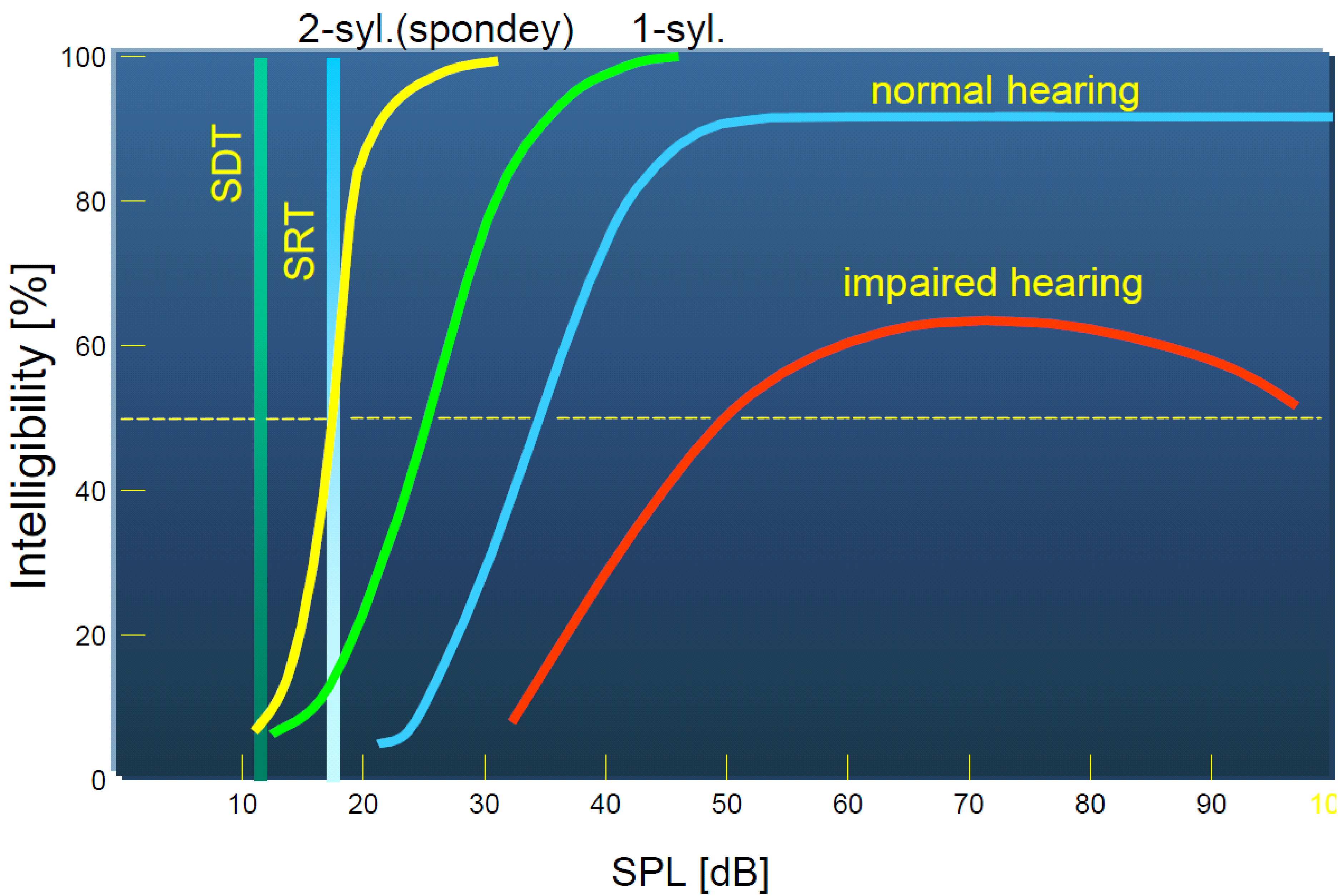
A B

The examination of hearing by means of a tuning fork
Weber Test within the parietal region (A), teeth (B)

audible frequency range	16-20 000 Hz
the range of the largest ear sensitivity	1000-3000 Hz
frequency range of human conversation	200-3000 Hz
hearing threshold	0 dB HL
threshold of pain	110-140 dB HL
hearing damage	150 dB HL
range of perceived acoustic pressures	0,00002-60 Pa
number of distinct pure-tones	3000
frequency resolution	1 Hz at 1000 Hz
angular resolution	1-4°
temporal resolution	0.05 sec
hearing loss vs age (18-50 years)	0.5 dB/year
hearing loss vs age (over 50 years)	1 dB/year
average hearing loss at 70 years	37 dB
Trail eye-to-mouth when reading aloud	0.5-2 sec

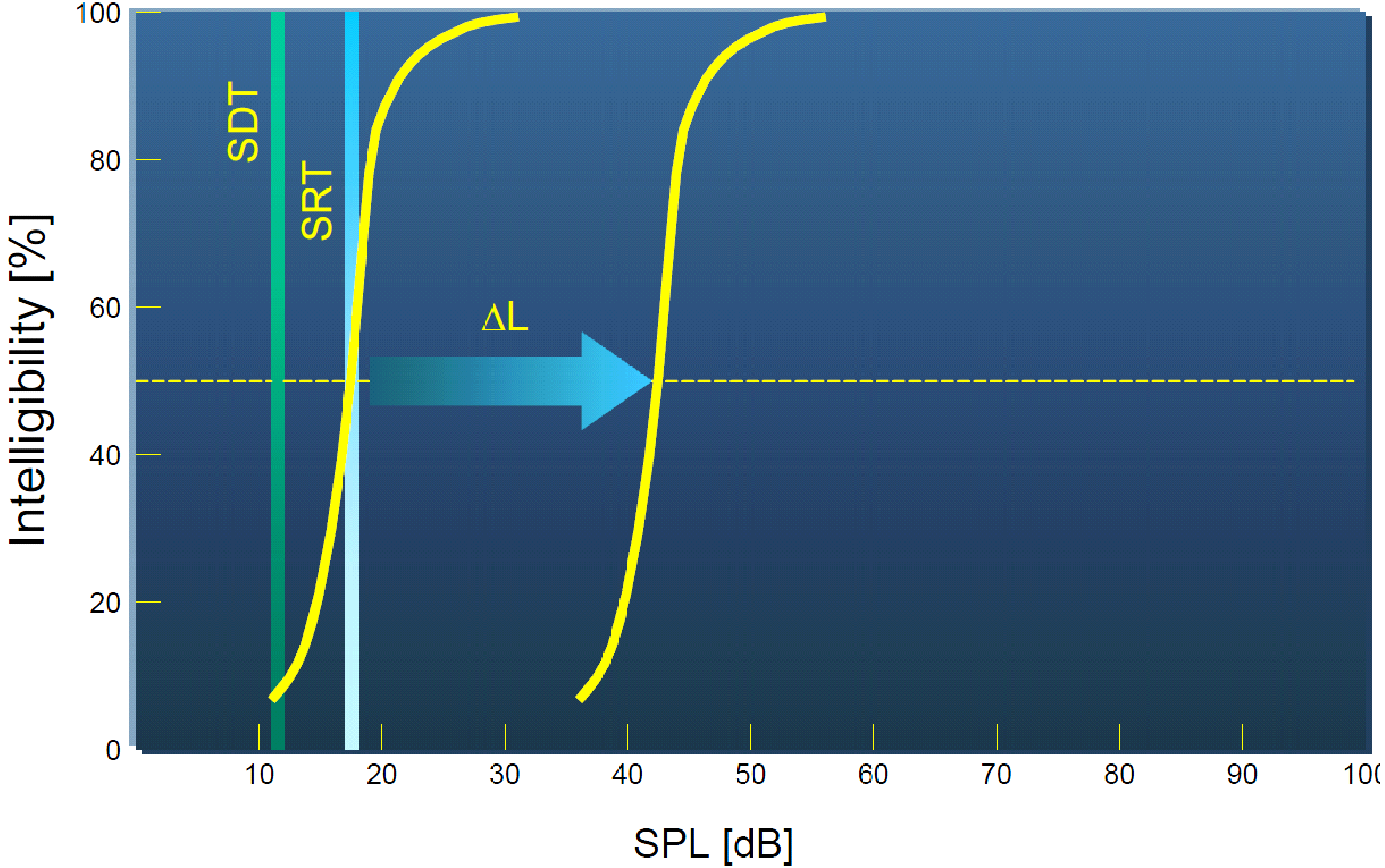
Source: Tablice Biologiczne. praca zbiorowa pod redakcją W. Mizierskiego. Warszawa: Adamantan, 2004. ISBN 83-7350-059-6.

Dimensions of voice in human perception: acoustic channel



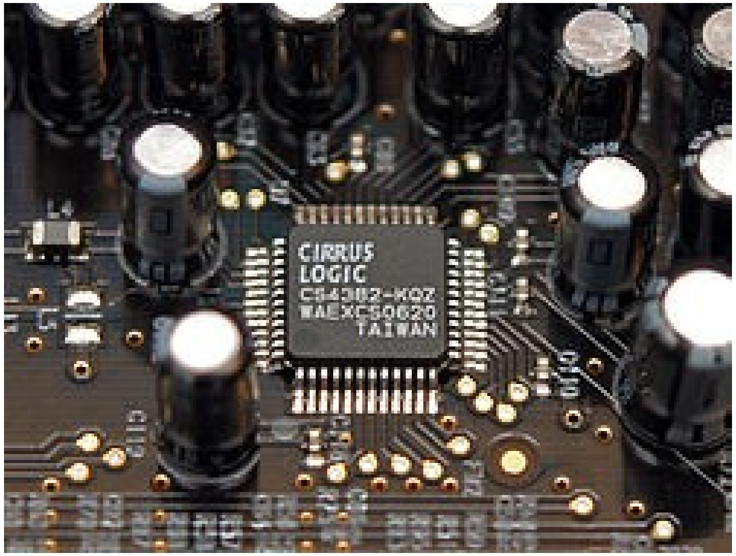
Dimensions of voice in human perception: speech perception without noise

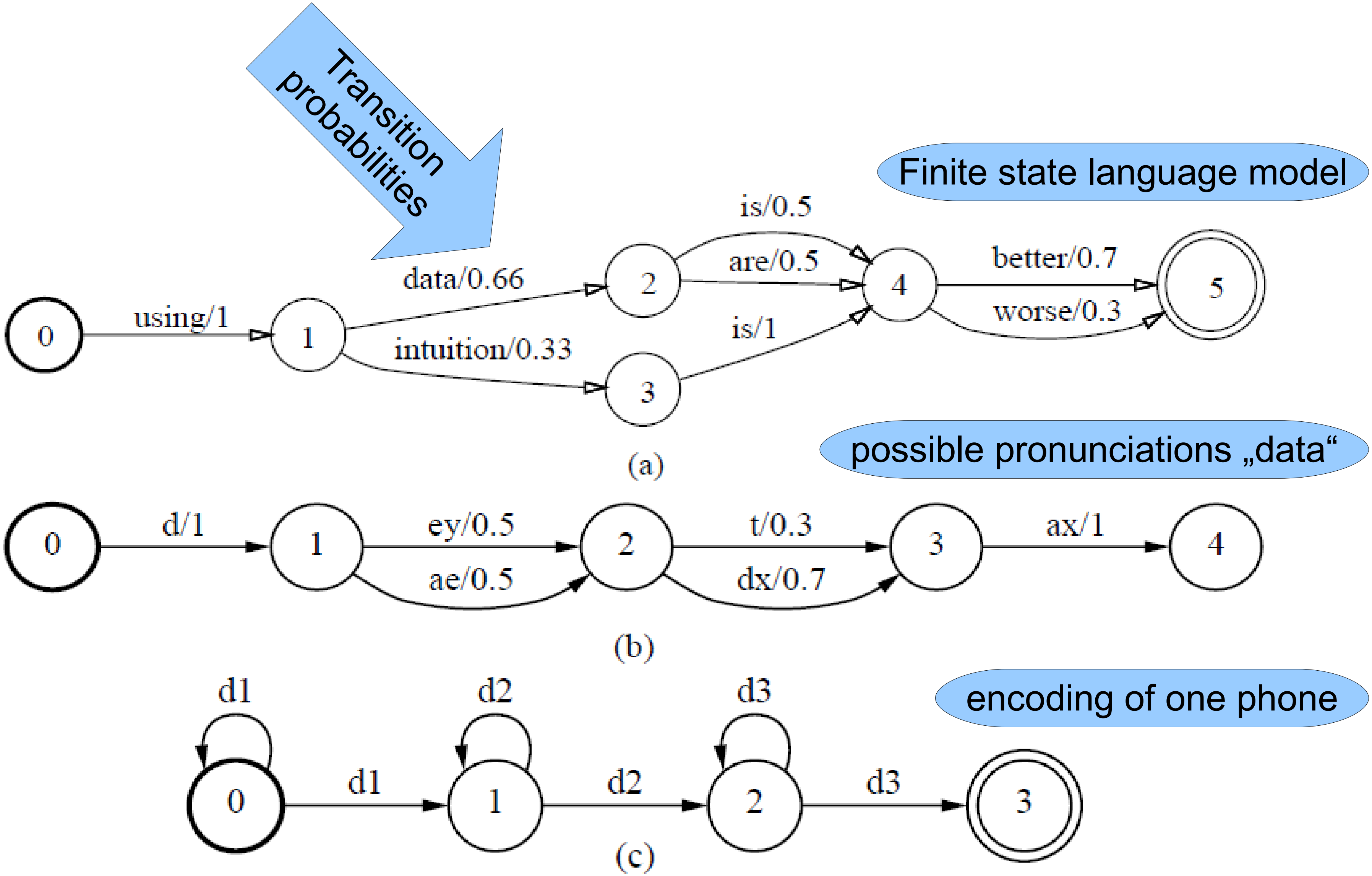
Speech audiometry with noise



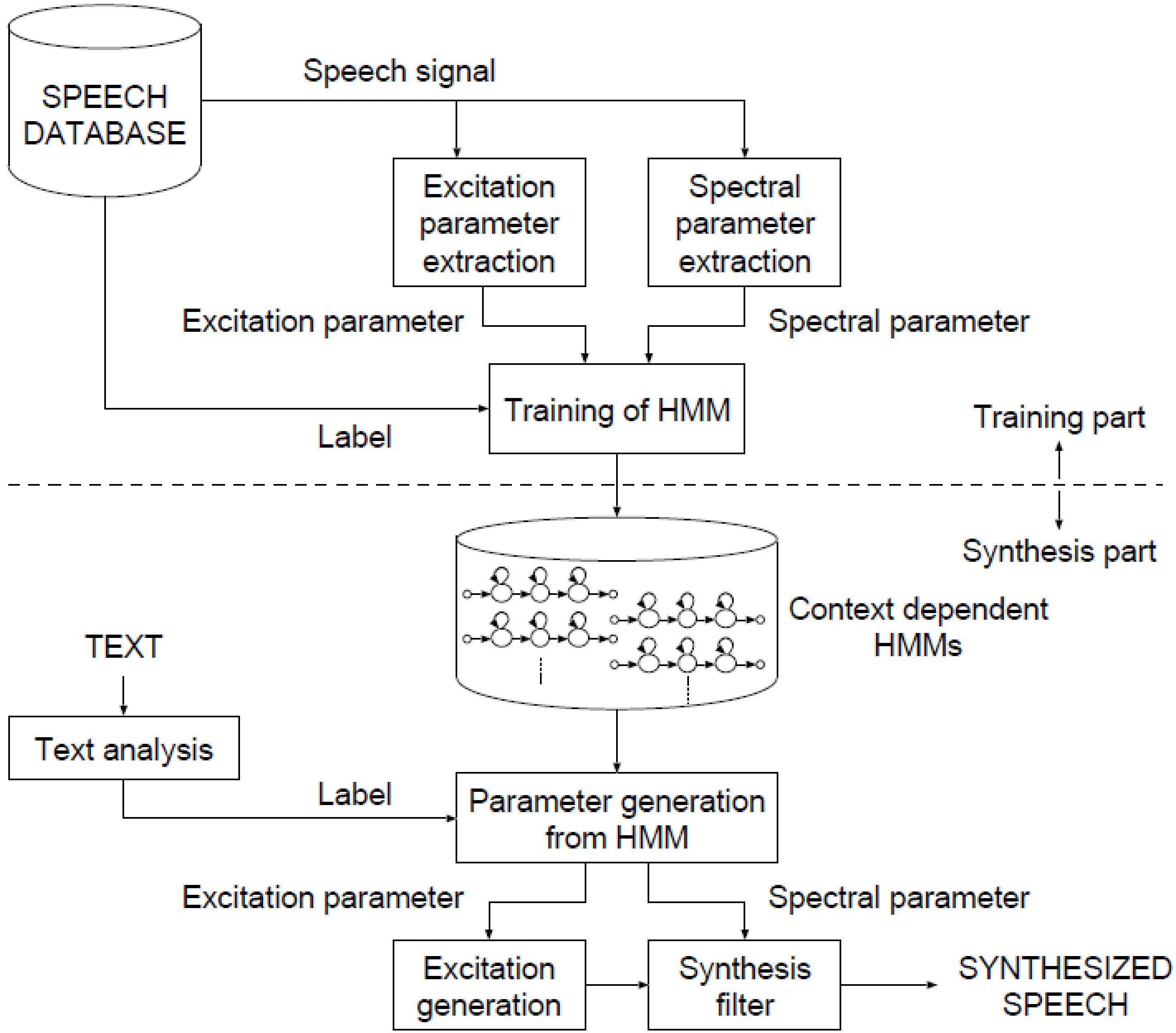
Dimensions of voice in human perception: speech perception with noise

- Microphone – acoustic transducer to electric voltage
  - omnidirectional microphones
  - directional microphones
  - arrays of microphones
- Amplifier, mixers, filters – conditioning of the voltage
- Analog to digital conversion on a sound card (special integrated circuit)
  - sampling (frequency > 2*highest frequency of the signal)
  - quantization (8 bits, 16 bits, 24 bits, ….)
- Formatting, compression and filing to the sequence of samples



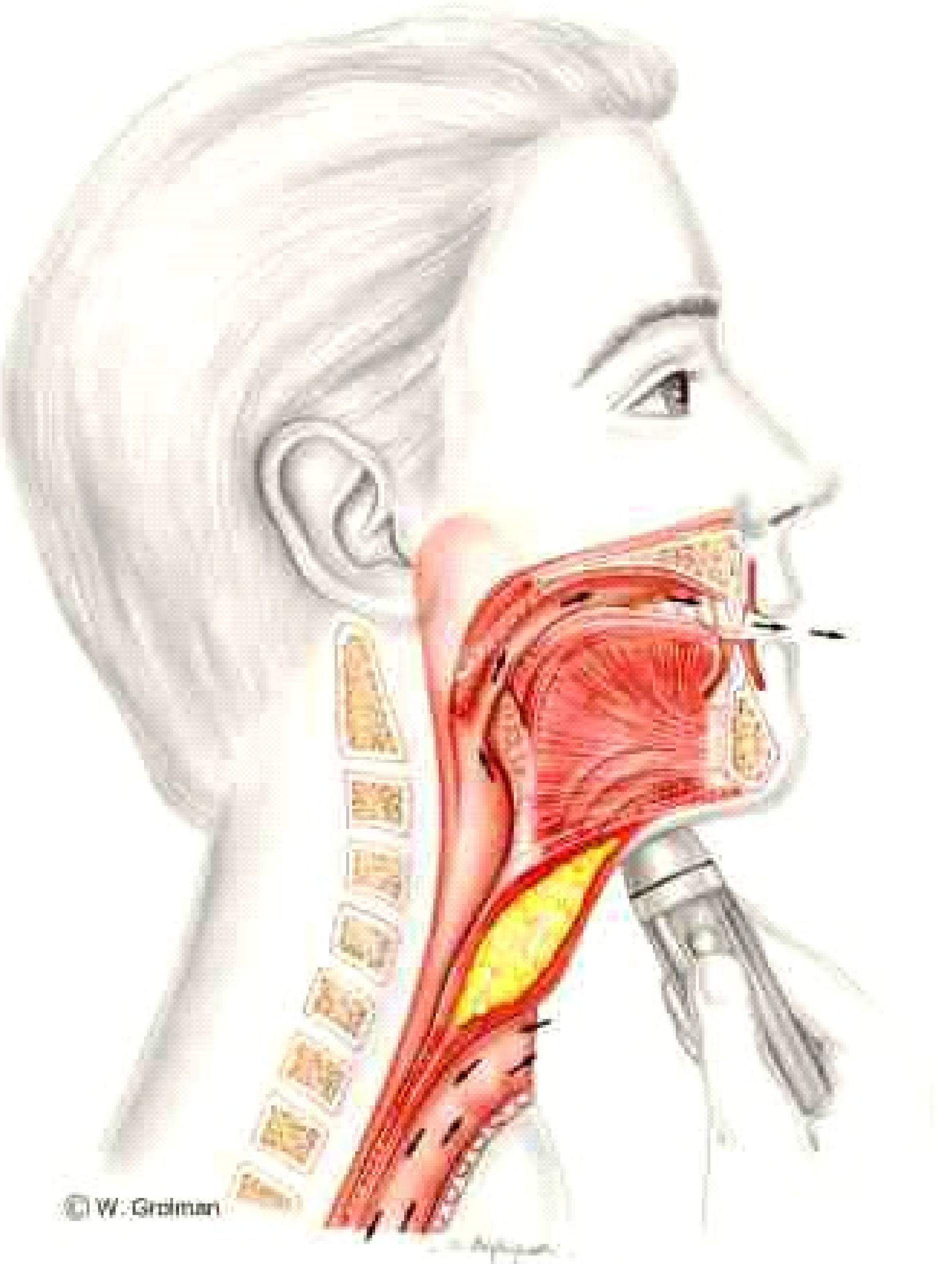


Mohri, M., Pereira, F., & Riley, M. (2002). Weighted finite-state transducers in speech recognition. Computer Speech and Language, 16, 69–88.



Source: K. Tokuda,H. Zen, A.W. Black: An HMM-based speech synthesis system applied to English, Proc. 2002 Workshop on Speech Synthesis, Santa Monica USA

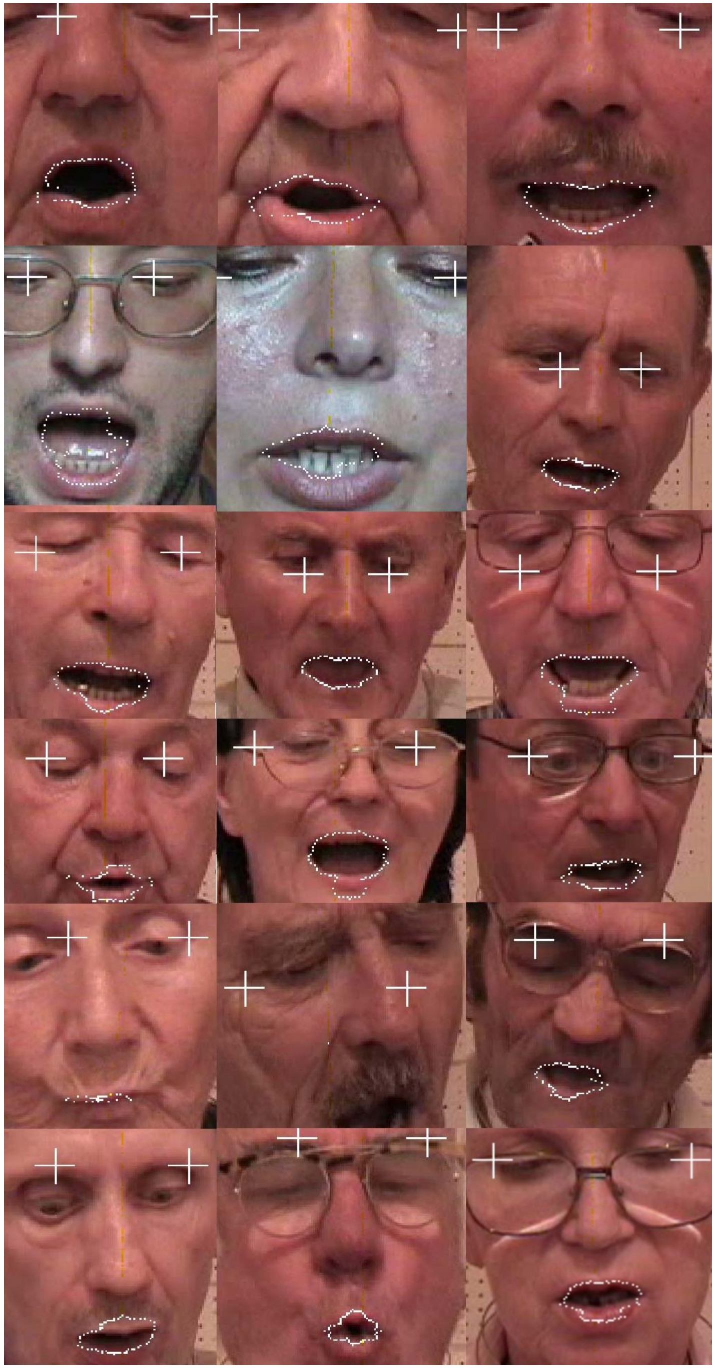
Technologies of speech acquisition by computers: speech production by computers


© W. Grolman

Sustained vowels recognition rates of acoustic (MFCC) and visual (mouth contour) modalities. Results obtained for all patients, alaryngeal voice (oesophageal and tracheoesophageal) and for pseudo-whisper (PW) group.

input	group	classifier	training	validation
MFCC	OE,TE,PW	SVM	91%	**75%**
		N. Bayes	60%	51%
		ANN	75%	57%
	OE,TE	SVM	100%	**98%**
		N. Bayes	92%	91%
		ANN	100%	93%
	PW	SVM	85%	**70%**
		N. Bayes	52%	45%
		ANN	73%	49%
Mouth Contour	OE,TE,PW	SVM	81%	**40%**
		N. Bayes	40%	39%
		ANN	79%	37%

Source: R. Pietruch, A. Grzanka: Vowel Recognition of Patients after Total Laryngectomy using Mel Frequency Cepstral Coefficients and Mouth Contour (w: Journal of Automatic Control). 2010. z. 1, 20. pp. 33-38.

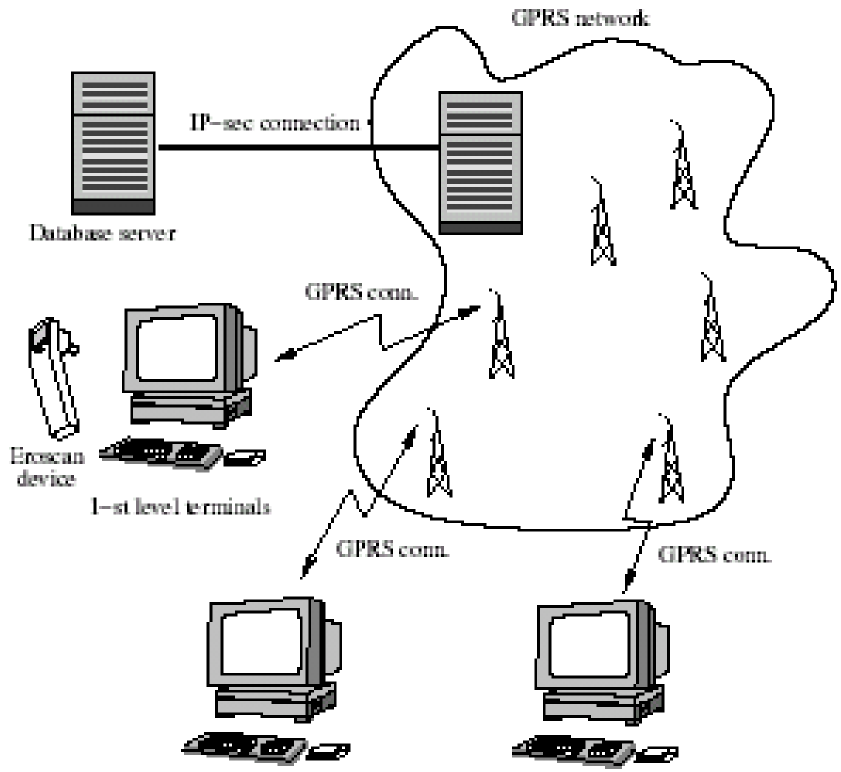


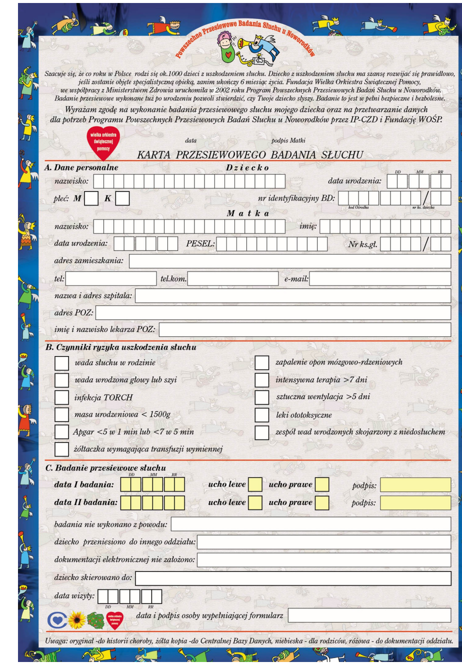
Source: R. Pietruch. Ph.D. Thesis, Warsaw 2009

Combination of acoustical and video information in machine speech perception: labiograms + acoustics

The application developed as open source (students circle) and promoted by large telecommunication company in Poland

To control the computer without hands – blink browser





Powszechne Przesiewowe Badania Słuchu u Noworodków

Szacuje się, że co roku w Polsce rodzi się ok.1000 dzieci z uszkodzeniem słuchu. Dziecko z uszkodzeniem słuchu ma szansę rozwijać się prawidłowo, jeśli zostanie objęte specjalistyczną opieką, zanim ukończy 6 miesiąc życia. Fundacja Wielka Orkiestra Świątecznej Pomocy, we współpracy z Ministerstwem Zdrowia uruchomiła w 2002 roku Program Powszechnych Przesiewowych Badań Słuchu u Noworodków. Badanie przesiewowe wykonane tuż po urodzeniu pozwoli stwierdzić, czy Twoje dziecko słyszy. Badanie to jest w pełni bezpieczne i bezbolesne.

Wyrażam zgodę na wykonanie badania przesiewowego słuchu mojego dziecka oraz na przetwarzanie danych dla potrzeb Programu Powszechnych Przesiewowych Badań Słuchu u Noworodków przez IP-CZD i Fundację WOŚP.

wielka orkiestra świątecznej pomocy

data   podpis Matki

KARTA PRZESIEWOWEGO BADANIA SŁUCHU

A. Dane personalne

Dziecko

nazwisko: data urodzenia: DD MM RR

płeć: M K   nr identyfikacyjny BD: kod Ośrodka / nr ks. dziecka

Matka

nazwisko: imię:

data urodzenia: PESEL: Nr ks.gł. /

adres zamieszkania:

tel: tel.kom.   e-mail:

nazwa i adres szpitala:

adres POZ:

imię i nazwisko lekarza POZ:

B. Czynniki ryzyka uszkodzenia słuchu

- wada słuchu w rodzinie
- wada wrodzona głowy lub szyi
- infekcja TORCH
- masa urodzeniowa < 1500g
- Apgar <5 w 1 min lub <7 w 5 min
- żółtaczka wymagająca transfuzji wymiennej
- zapalenie opon mózgowo-rdzeniowych
- intensywna terapia >7 dni
- sztuczna wentylacja >5 dni
- leki ototoksyczne
- zespół wad wrodzonych skojarzony z niedosłuchem

C. Badanie przesiewowe słuchu

data I badania: DD MM RR   **ucho lewe**   **ucho prawe**   podpis:

data II badania: **ucho lewe**   **ucho prawe**   podpis:

badania nie wykonano z powodu:

dziecko przeniesiono do innego oddziału:

dokumentacji elektronicznej nie założono:

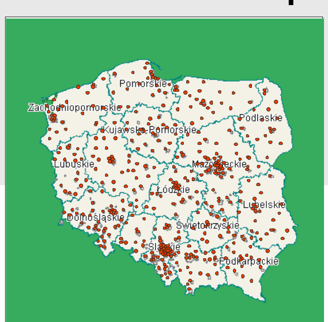
dziecko skierowano do:

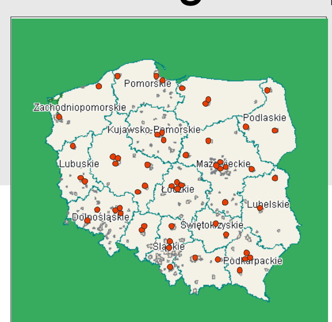
data wizyty: DD MM RR

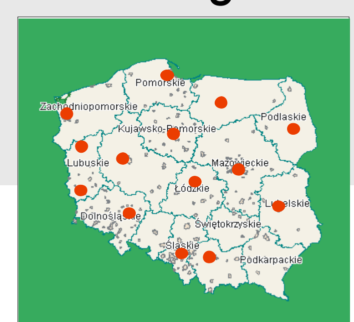
data i podpis osoby wypełniającej formularz

Uwaga: oryginał -do historii choroby, żółta kopia -do Centralnej Bazy Danych, niebieska - dla rodziców, różowa - do dokumentacji oddziału.

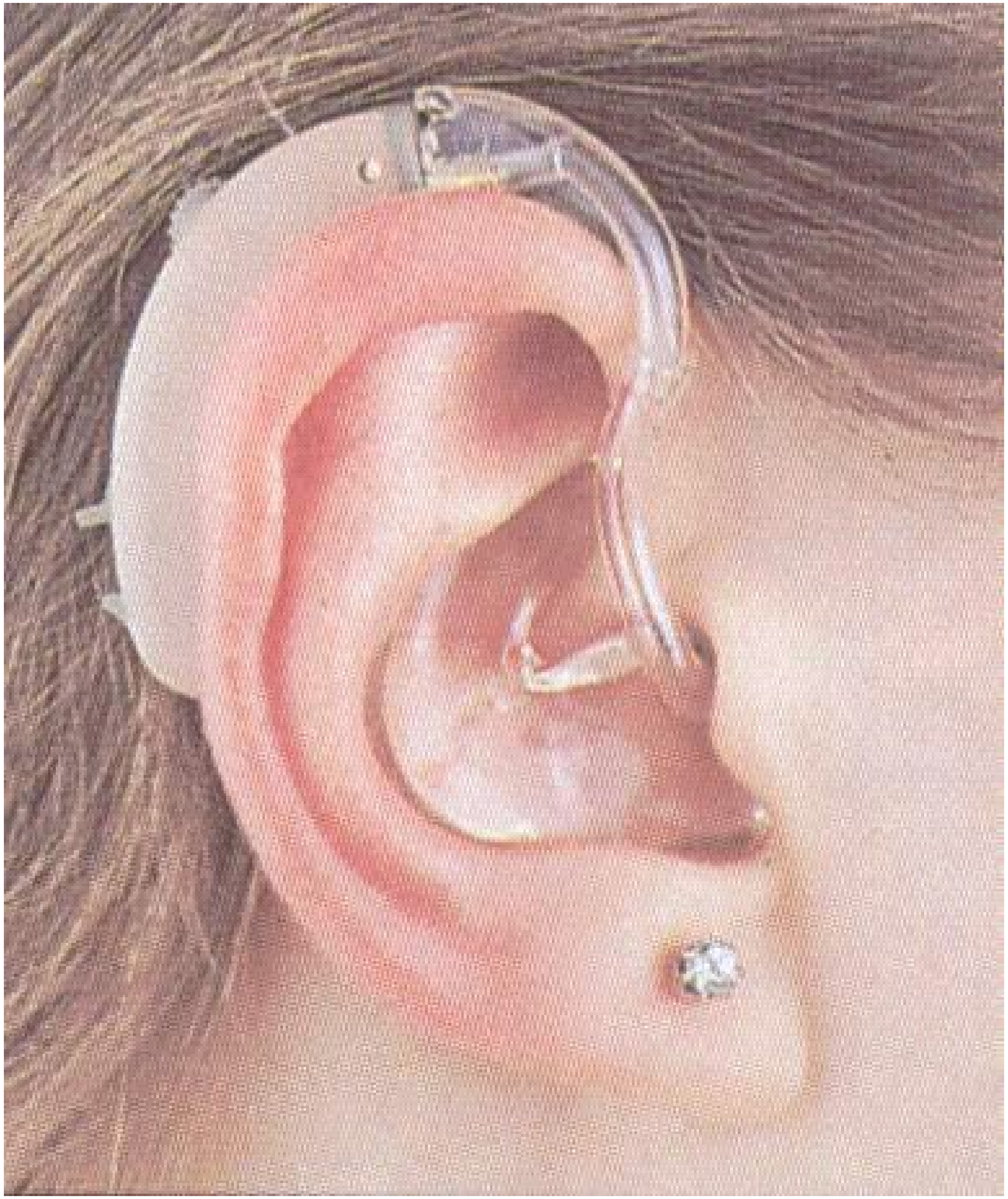
1st Level	2nd Level	3rd Level
448 neonatal dpt.	57 audiological dpt.	14 audiological dpt.







Modern methods of intervention in hearing problem: screening (2009)



- Employed persons who, for various reasons, have impaired hearing, and hearing aid often only gives them a chance to continue working
- Older people with physiological hearing loss for whom a hearing aid makes it possible to communicate with the environment

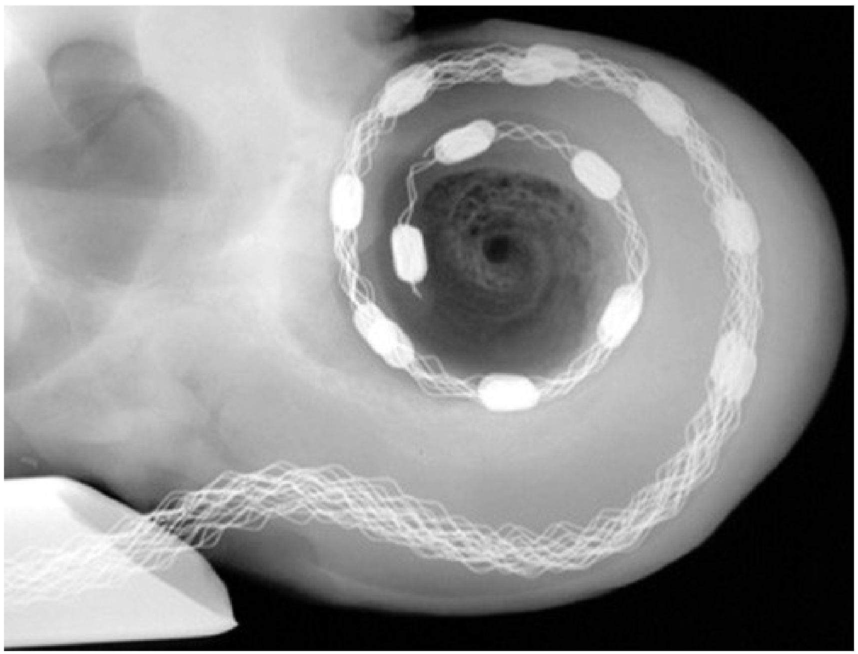
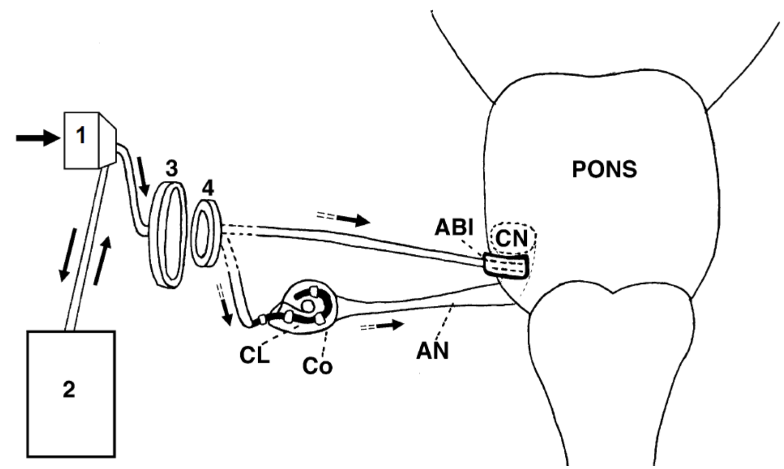


Image courtesy of Wolfgang Gstöttner, University of Frankfurt.
at http://www.americanscientist.org/issues/num2/the-design-and-function-of-cochlear-implants/1

1 microphone
2 signal processor
3,4 transmitter, receiver
CL cochlear implant
Co cochlea
AN auditory nerve
ABI auditory brainstem implant
CN cochlear nucleus



Source: Davis NL, Rappaport JM, MacDougall JC (Fall/Winter 1997). "Cochlear and Auditory Brainstem Implants in the Management of Acoustic Neuroma and Bilateral Acoustic Neurofibromatosis". McGill Journal of Medicine (3): 115–120.

Modern methods of intervention in hearing problem: hearing implants

Partial deafness treatment - Polish achievement

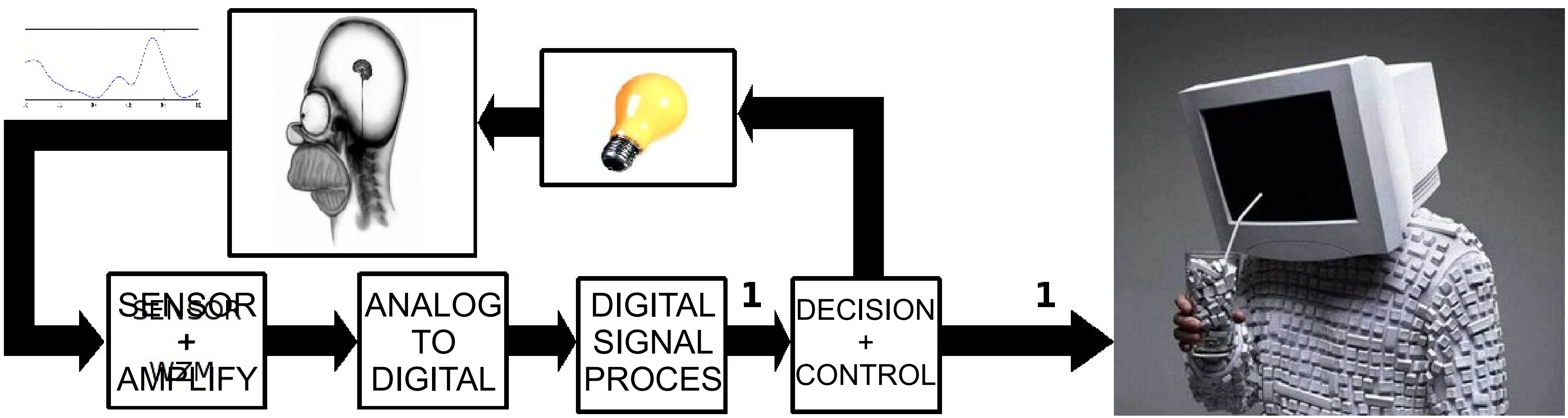
Gradually increasing clinical material consisting of children with preserved residual hearing have been consistently presented on the international forum by the team of the Institute. Owing to the continuous development of our program of surgical approach to the cochlea through its round window we have been able, as the first team in the world, to single out a completely new group of patients with a hearing impairment, who have extant large population of ganglions in the apex of the cochlea, representing normal tonotopy, thus enabling them to hear low frequency sounds, while being unable to hear high sounds - explains Prof. Skarżyński. Such condition of hearing had been named the partial deafness and it is treated using cochlear implants (Partial Deafness Cochlear Implantation - PDCI). Prof. Skarżyński, as the first surgeon in the world, performed a cochlear implantation in an adult patient with partial deafness in 2002. Fully satisfactory results had been presented in autumn that same year at the Hearing Preservation Workshop in Indianapolis. On following conferences of this series he presented very good results of implantation in further groups of patients. Satisfactory results of hearing preservation in over 93% of adult patients motivated the possibility of applying the same treatment to children. First in Poland and in the world child with a partial deafness had been operated by Prof. Skarzyński in the International Center of Hearing and Speech in Kajetany in 2004. Until present day the homogenous group of patients, children with almost 100% of hearing preservation , is constantly growing. It is the only such group presented in the literature in international congresses. Theoretical rudiments of complementing lost ability of hearing the high frequency sounds with cochlear implants had therefore been confirmed in praxis, proving the possibility of synergy between residual hearing, preserved in different degrees and possibly supplemented by the acoustic stimulation, and electrical hearing.

Institute of Physiology and Pathology of Hearing: http://pdt.ifps.org.pl/index_en.php

Brain Computer Interface is an innovative biomedical technology that use brain activity to control computer equipment. Computer can be used to control other devices and systems.

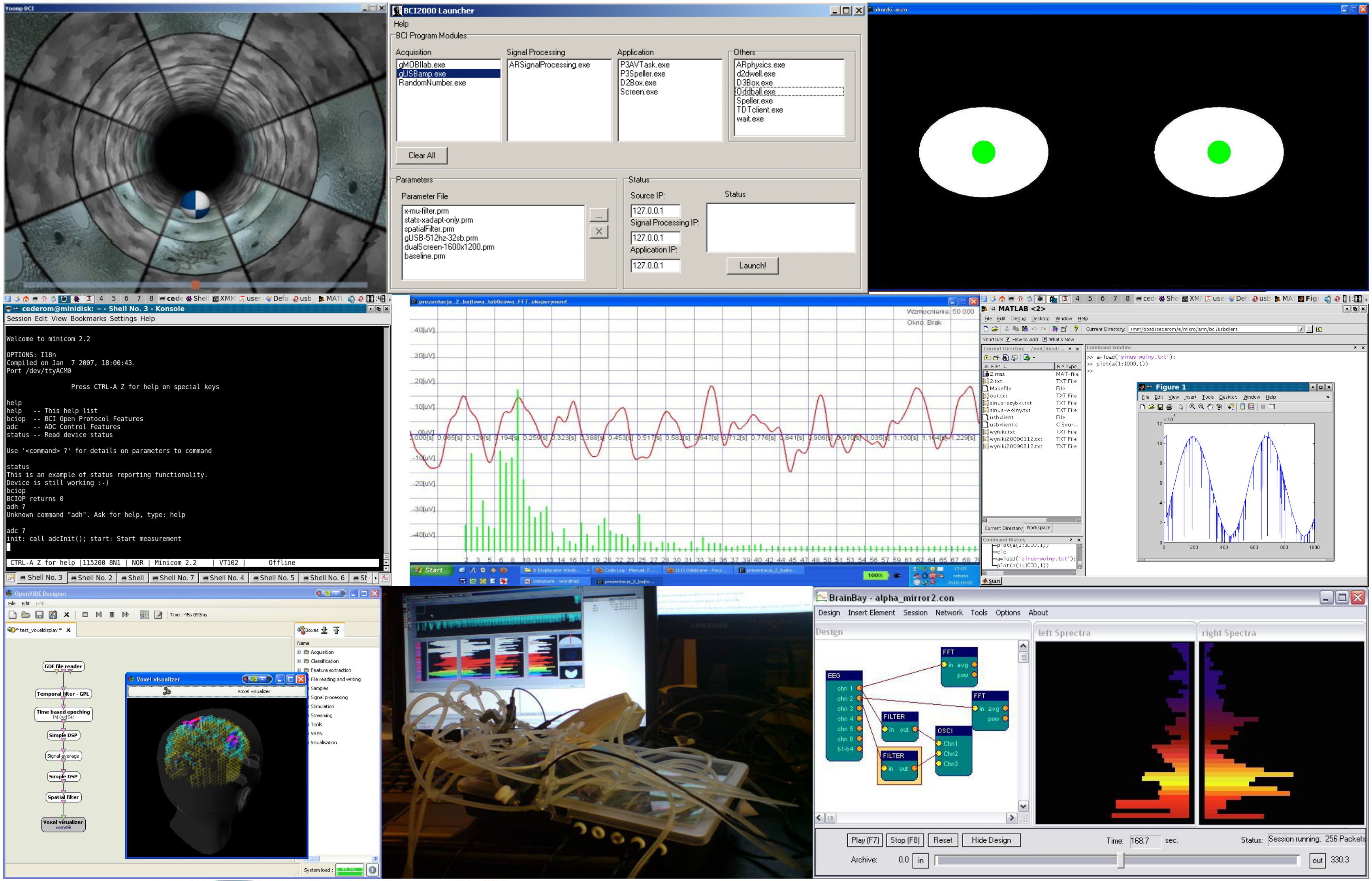
- Can use Invasive and Non-Invasive methods to acquire signals.
- Can use different methods of brain activity measurement (i.e. EEG, (f)MRI, ...).
- No signal input into brain except safe audio-visual feedback stimuli!
- Complex analog measurement systems working with ultra-low-voltage biological signals.
- Advanced digital structure for signal acquisition, processing and decision making.
- External software modules for universal measurement / result visualization.
- Use neuro-feedback mechanisms for closed-loop control.
- Interoperability with existing solutions / open-source software.

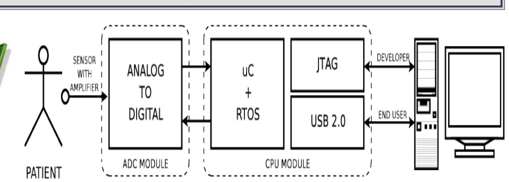
- We use self designed EEG equipment and firmware + Open-Source software tools.
- We plan to create inexpensive and affordable BCI/NFB equipment for home users.



Brain computer interface – the overview

Software: Open Source (BCI2000, OpenViBE, BrainBay, ..) + our own (Java, Python, Unix).





Brain computer interface: students' applications

Brain Computer Interface

Hardware: Self designed and developed from scratch. Existing for comparison.

Cybernetic Research Student Group, Warsaw University of Technology, http://cyber.ise.pw.edu.pl

Brain Computer Interface

Community: Science Festivals, Conferences, Seminars, Picnics, Workshops, ...

Cybernetic Research Student Group, Warsaw University of Technology, http://cyber.ise.pw.edu.pl

"The person who says it cannot be done should not interrupt the person doing it."

I love the Chinese proverb (after Bob Proctor),

Special thanks for help to:
professor Wiesław Konopka (Łódź, Poland)

my students:
Tomasz Cedro,
Magdalena Cieślicka