Challenges and opportunities for further improving cochlear implants

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Sonova

Hearing instruments

- Behind-The-Ear hearing instruments (BTE)
- FM systems
- Custom In-The-Ear hearing instruments (ITE)
- Hearing protection
- Wireless communication systems
- Earphones
- Invisible extended-wear hearing instruments

Hearing implants

- Cochlear implants

Sonova
European Research Center

Locations

- **AB Hauptsitz**
  - Stäfa (CH)
  - Kitchener (CAN)
  - Murten (CH)
  - Ho Chi Minh City (VN)

- **Sonova & Phonak Hauptsitz**
  - Suzhou (CN)

- **Unitron Hauptsitz**
  - Valencia (USA)
  - Newark (USA)

- **Phonak Communications Hauptsitz**
  - Valencia (USA)

- **InSound Hauptsitz**
  - Valencia (USA)

- **Produktion**
  - Valencia (USA)

- **Gruppengesellschaften**

- **Distributoren**
- Principle: Electrical auditory nerve stimulation
- Indication: Severe or profound sensorineural hearing loss
Challenges and opportunities

- Sound coding
- Anatomy
- Neural interface
- Surgical challenge
- System design
Hearing Performance

- Impact of noise on CI hearing performance (study from 2011 below on all brands)
- Still communication challenges in many daily-life situations
- Advances in sound coding required. AB profits a lot from Phonak’s 20 years experience in Directional Microphone Technology and Noise Reduction Algorithms

HSM Speech Test Results (S0N0)

- Speech Intelligibility [%]

CI data: 480 recipients, duration of deafness <10 years, all brands, newest technology, by courtesy of Prof. A. Buechner, MH Hannover, 2011, NH Data: 40 subjects, Schmidt et al, 1997

CI Performance
### Cochlea
- Spiral shaped bony canal
- Fluid filled
- 2.5-3 turns
- Tonotopic organisation (frequency-place mapping)

*uCT scans of cochlea and cochlea implant electrode array*
Findings

- Human cochleae show large inter-individual variability in size and morphology*

*Data published in *Variations in microanatomy of the human cochlea*  
Avci E, Nauwelaers T, Lenarz T, Hamacher V, Kral A
Electrode array portfolio
- AB offers peri-modiolar and lateral-wall arrays
- Depending on patient's need and surgeon's decision
- 0.5-0.7 mm cross-sectional diameter

Material selection
- Proven materials for long-term implantation
- Pt contacts, PtIr wires, liquid silicone rubber carrier

Current challenges
- Large spread-of-excitation (low number of channels)
- Electro-acoustic stimulation (Shorter arrays vs. electrical performance)
- Market demand for thinner electrode arrays
- Manual and labor intensive production
Spread-of-excitation decrease
- Channel interaction: Current focusing
- Channel increase: Intra-neural stimulation, neurotrophins, optogenetics

Novel materials
- Contact pad (channel) density increase
- E.g. thin film based electrodes
- Long-term stability (10-30 years) unclear
- Substrate sourcing difficult

Surface functionalization
- Electrode insertion: Lubricious coating
- Foreign body response: Steroids, surface modification, nano-coating
- In general: Partially unproven, long-term and regulatory challenges
Without current steering

With current steering

Spatial Maxima/Peak

Spatial Peak
Goal

- Atraumatic electrode array insertion

Anatomical challenge

- High geometric variability of cochleae
- Fragile intra-cochlea structures

Clinical challenge

- No intra-op guidance or feedback for surgeons available today
- Current imaging technologies not sufficient
Totally implantable cochlea implant

**Background**
- Invisible hearing aid
- Usability improvement
- RF link and power consumption

**Technological challenges**
- Rechargeable batteries of sufficient capacity and longevity
- Implantable microphones
- Smaller implantable connectors
- Safety switch
Sound coding / speech performance
- Near normal performance in quiet situations, degrades in noise
- Phonak sound coding increases intelligibility in noise

Anatomy
- Spiral shaped, fluid filled bony canal
- Large geometric variability between cochleae

Neural interface
- Electrodes required to adapt to wrapping and vertical trajectory
- Current steering creates additional pitch percepts in CI users
- Drugs and coatings, unclear or unproven (long-term) performance

Clinical challenge
- No intra-op guidance for surgeons available today
- Current imaging technologies not sufficient

System design
- Long-term implantable and rechargeable batteries, connectors and safety