

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

JANUARY 2013

# Ear-EEG

## A novel brain monitoring methodology

Preben Kidmose, Ph.D., M.Sc.  
Docent (danish: Ingeniørdocent) in Biomedical Engineering  
Department of Engineering, Aarhus University



AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Outline

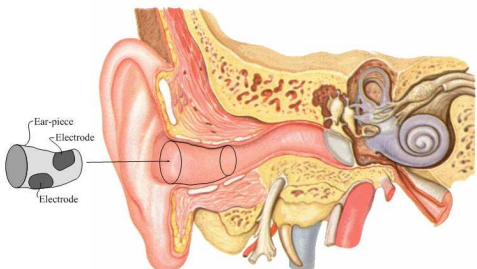
- The ear-EEG methodology
  - Principle
  - Experimental platform
  - Prior art
- Ear-EEG recordings
  - Characterization of ear-EEG signals
  - Comparison between ear-EEG and conventional on-scalp EEG recordings
- Advantages of the technology
  - Potential applications.
  - Examples.

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE

JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Ear-EEG (sketch of principle)

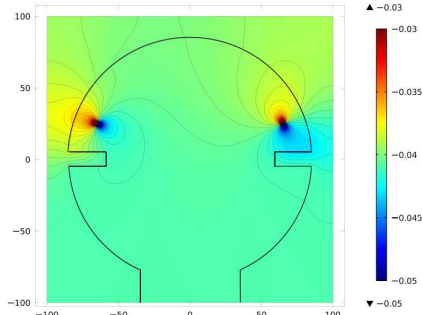


DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE

JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Scalp potentials - dipole models



DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE

JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## The experimental platform

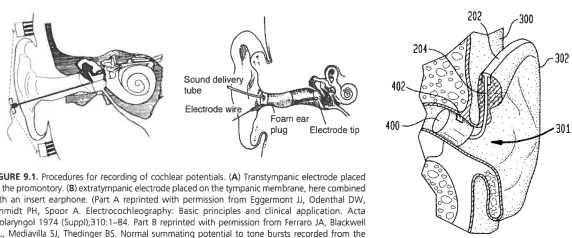


DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE

JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Prior art



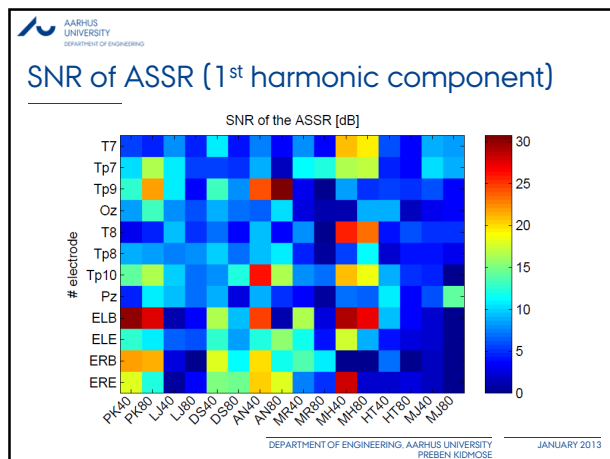
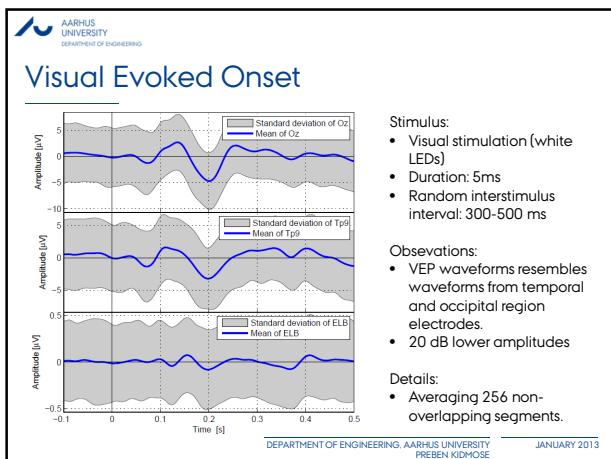
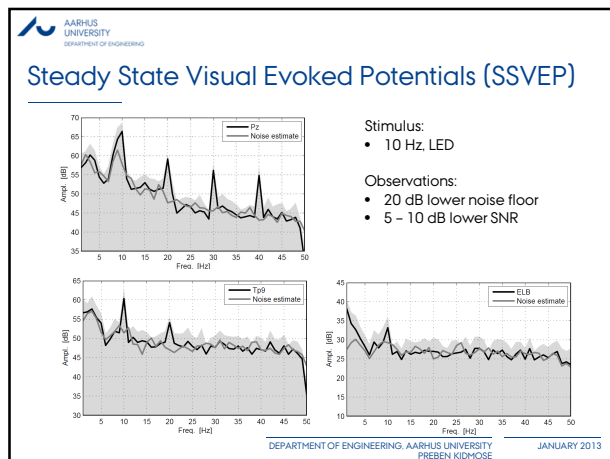
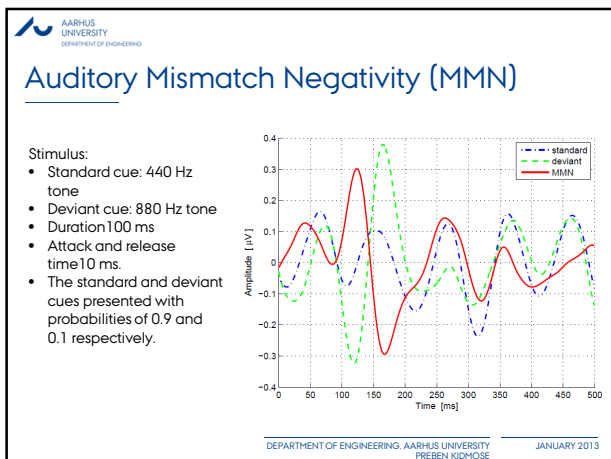
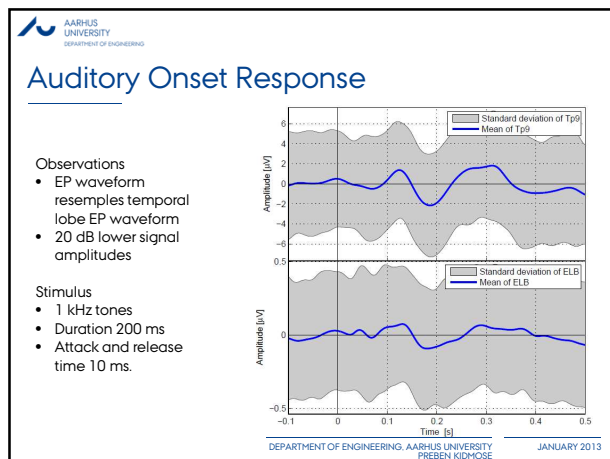
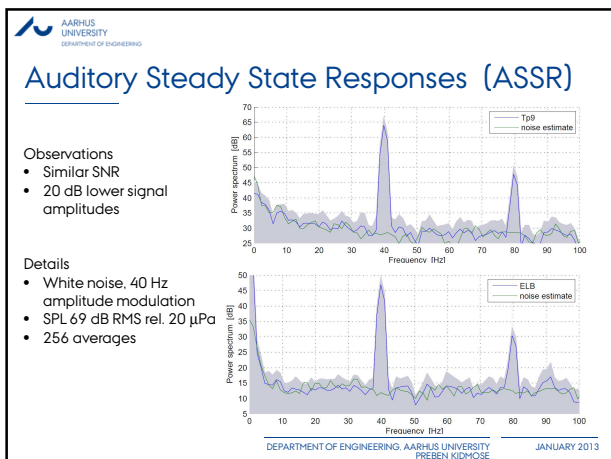
**FIGURE 9.1.** Procedures for recording of cochlear potentials. (A) Transtympanic electrode placed on the promontory. (B) extratympanic electrode placed on the tympanic membrane, here combined with an insert earphone. (Part A reprinted with permission from Eggermont JJ, Odenthal DW, Schmidt PH, Spoor A. Electrocochleography: Basic principles and clinical application. Acta Otolaryngol 1974 (Suppl)3:10:1-84. Part B reprinted with permission from Ferraro JA, Blackwell WL, Medavilla SJ, Thedinger BS. Normal summating potential to tone bursts recorded from the tympanic membrane in humans. J Am Acad Audiol 1994;5:17-23.)

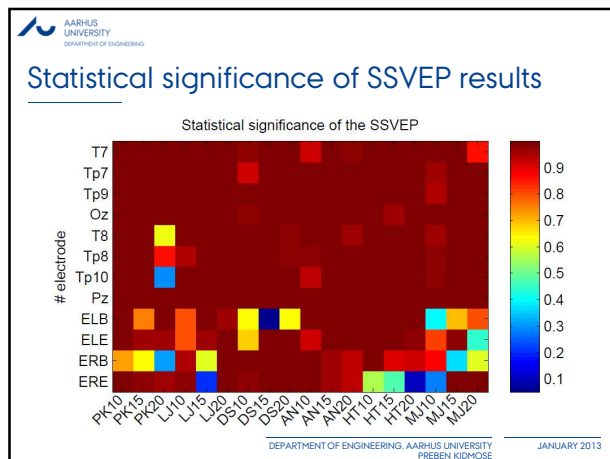
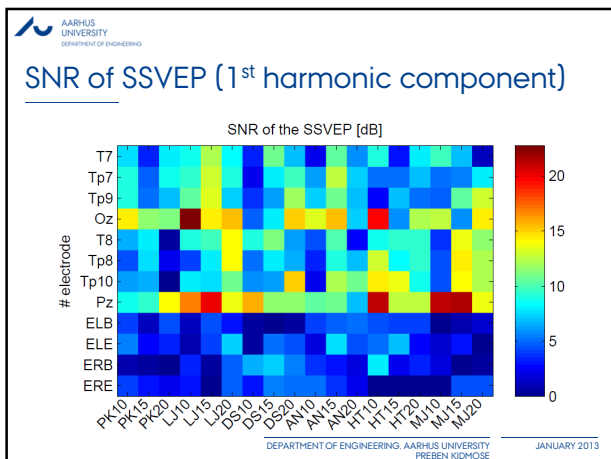
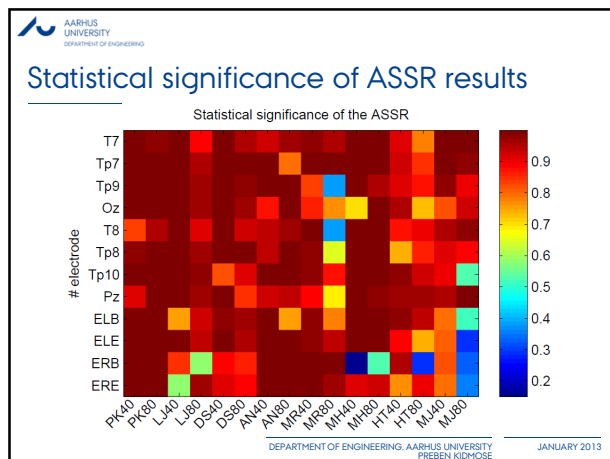
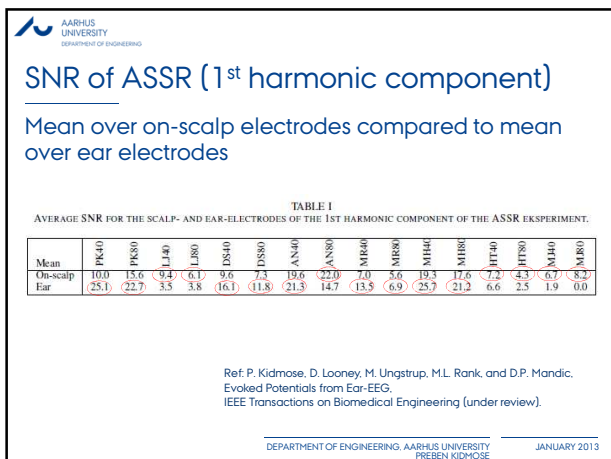
**Cochleography**  
Burkard, Robert Francis, Manuel Don, and Jos J. Eggermont.  
Auditory evoked potentials: Basic principles and clinical application.  
Lippincott Williams & Wilkins, 2006.

**Device for monitoring EEG**  
Patent: US2007/0112277  
Fischer et. al.

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE

JANUARY 2013

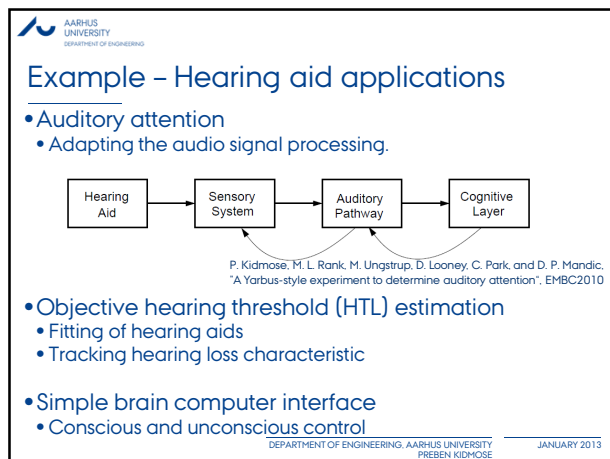




### Ear-EEG advantages and applicability

- **User-friendly**
  - The user can put on and take off the device themselves without the need of assistance from others.
- **Unobtrusive**
  - Small device and no loose wires connecting the electrodes.
  - (the device is not occluding the ear).
- **Discreet in use**
  - Virtually invisible electrodes/device.
- **Robust recordings**
  - Same electrode placement every time (high reproducibility).
  - Diminished motion and EMG artifacts.
  - The ear-canal provides shielding against electrical fields.
- **Limitations**
  - Limited spatial resolution.

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE  
JANUARY 2013



AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Example – Hypoglycemia detection

- Hypoglycemia is a common complication to glycemic control in type 1 diabetes patients.
- Hypoglycemia is a state caused by a low level of blood glucose.
- Symptoms can range from a vague feeling of discomfort to more serious conditions such as angina attacks and unconsciousness.

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Ear-EEG activities

Ongoing activities:

- Characterizing ear-EEG and comparative studies.
- Development of a wearable version.
- Development of a dry-electrode platform.
- Auditory Brain Computer Interface (BCI).
- Fatigue and sleep studies (in collaboration with Imperial College London).

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## Applications and Research Perspectives

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE JANUARY 2013

AARHUS UNIVERSITY  
DEPARTMENT OF ENGINEERING

## References

1. D. Looney, C. Park, P. Kidmose, M. L. Rank, M. Ungstrup, K. Rosenkranz, and D. P. Mandic, "An in-the-ear platform for recording electroencephalogram," EMBC 2011.
2. P. Kidmose, D. Looney, and D. P. Mandic, "Auditory evoked responses from ear-EEG recordings", EMBC 2012.
3. D. Looney, P. Kidmose, C. Park, M. Ungstrup, M. Rank, K. Rosenkranz, and D. Mandic, "The in-the-ear recording concept," IEEE Pulse Nov/Dec 2012.
4. P. Kidmose, D. Looney, M. Ungstrup, M.L. Rank, and D.P. Mandic, "Evoked Potentials from Ear-EEG", submitted to IEEE Transactions on Biomedical Engineering.
5. P. Kidmose, M. L. Rank, M. Ungstrup, D. Looney, C. Park, and D. P. Mandic, "A Yabus-style experiment to determine auditory attention", EMBC2010

DEPARTMENT OF ENGINEERING, AARHUS UNIVERSITY  
PREBEN KIDMOSE JANUARY 2013