Convenient and Portable Subcutaneous EEG Monitor for Ultra-Long Term Out-Patient Use

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Background

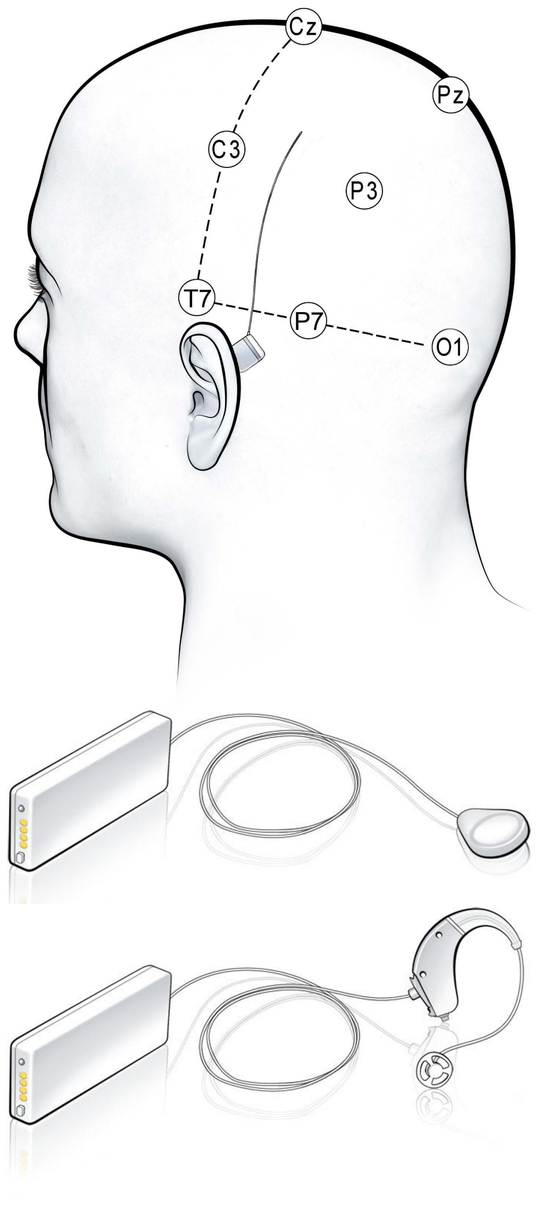
Recent years have shown an increasing need for ambulatory monitoring of epilepsy patients. This has required a technological development of convenient and portable systems for ultra-long term EEG recording. We present a discreet device that can continuously record high quality, two channel, subcutaneous EEG for years.

Methods

12 patients were monitored continuously night and day for more than a month. Visual as well as power and spectral analysis in standard frequency bands were analyzed as evidence of signal quality.

For overview of entire study period, the signal power in the α-band (8-13Hz) was extracted.

Figure 1 (right): The system consists of an implantable and an external device connected via an inductive link. The external device (measuring 9x4x1.5 cm) powers the implantable device (10 cm long wire with a disc-shaped housing of approximately 2 cm in diameter) and receives the EEG signal through the link. This means that the subcutaneous device can stay implanted for years without being serviced. Three measuring points are available with an inter-electrode distance of 3.5 cm.



Usage

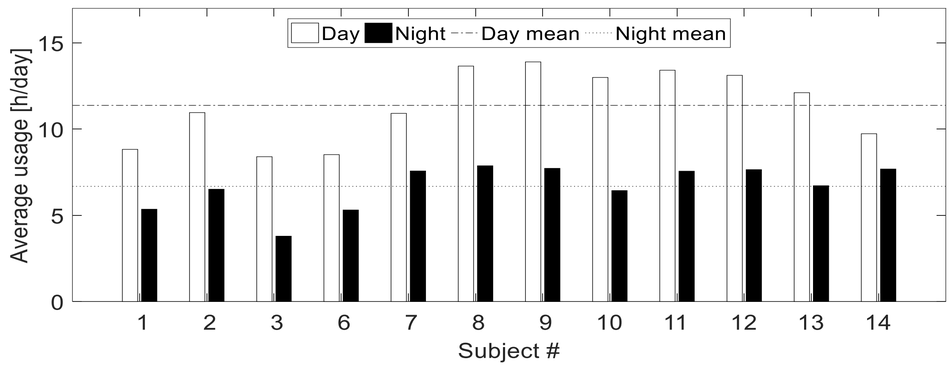


Figure 2: Five week average usage by 12 healthy subjects. After subject 6, an improved attachment system was introduced leading to higher average usage. The average overall usage was above 18 hours/day and almost 20 hours/day with the new attachment system.

EEG morphology

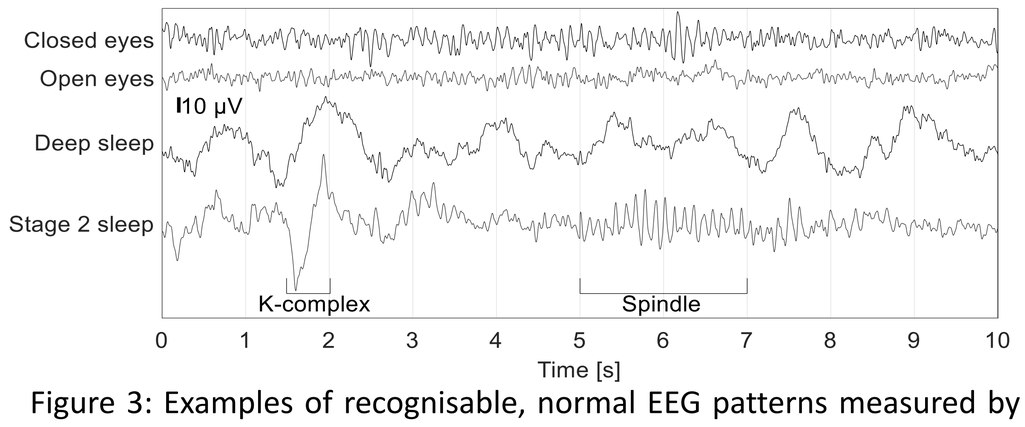


Figure 3: Examples of recognisable, normal EEG patterns measured by the subcutaneous system. A visual comparison of standard scalp EEG and the subcutaneous EEG by two board certified neurophysiologists showed that the signal quality was comparable (Duun-Henriksen et al., 2015).

One week of data

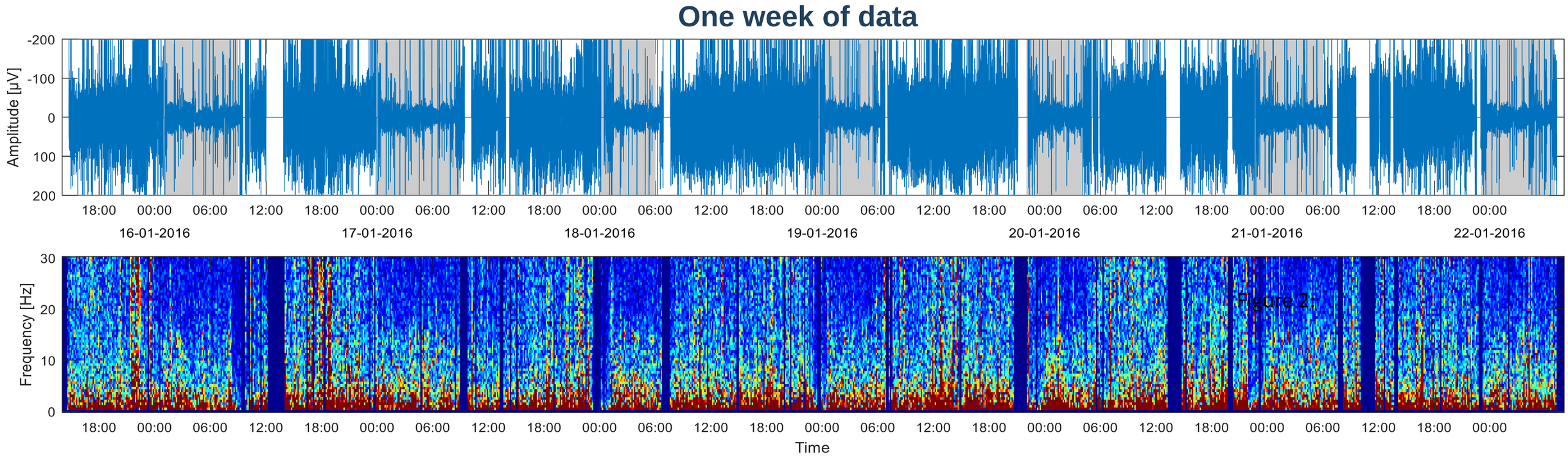


Figure 4: Seven days of continuous recording. The gray shaded areas are night recordings. Only few short periods without data are seen. Except for periods of eating, the percentage of good EEG was constantly high. During nights almost no artifacts were present.

42 days of data

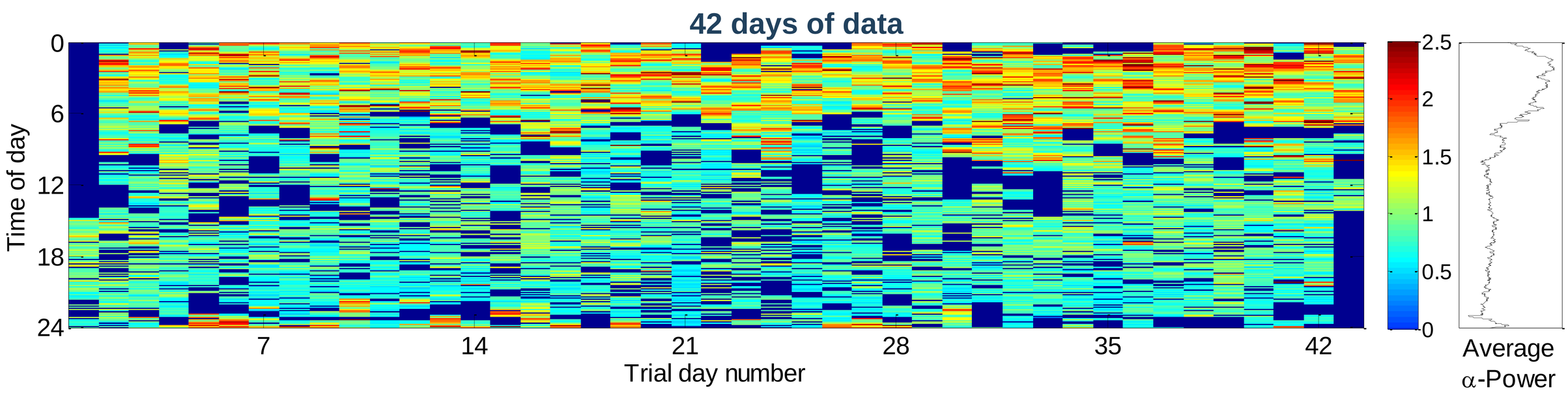


Figure 5: The signal power in the α-band (8-13 Hz) during the entire recording period for a single patient (subject 9). Dark blue signifies no data recorded. Only few short periods without data are seen. During all nights, cycles of deep sleep are evident.

Conclusion

Well-described normal EEG patterns were easily recognizable in the measurements. A high average usage time as well as a high signal quality lead us to conclude that the subcutaneous EEG monitoring system provides a convenient and unobtrusive method of ultra-long term EEG recording when a small number of EEG electrodes are sufficient.

We have recently initiated a study describing the uses of subcutaneous EEG in multiple aspects of epilepsy and associated problems in subjects with probable or definite mesial temporal lobe epilepsy. This study will serve as a proof-of-concept for the use of the device for epilepsy studies.

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Declaration of interest: Jonas Duun-Henriksen, Sirin W Gangstad and Lykke Blaabjerg are all full time employed at Hypo-Safe A/S developing and producing devices for unobtrusive subcutaneous EEG monitoring.

References: Duun-Henriksen et al., "EEG Signal Quality of a Subcutaneous Recording System Compared to Standard Surface Electrodes," Journal of Sensors, 2015.

Elsborg et al., " Detecting Hypoglycemia by Using the Brain as a Biosensor", Biosensors for Health, Environment and Biosecurity, 2011