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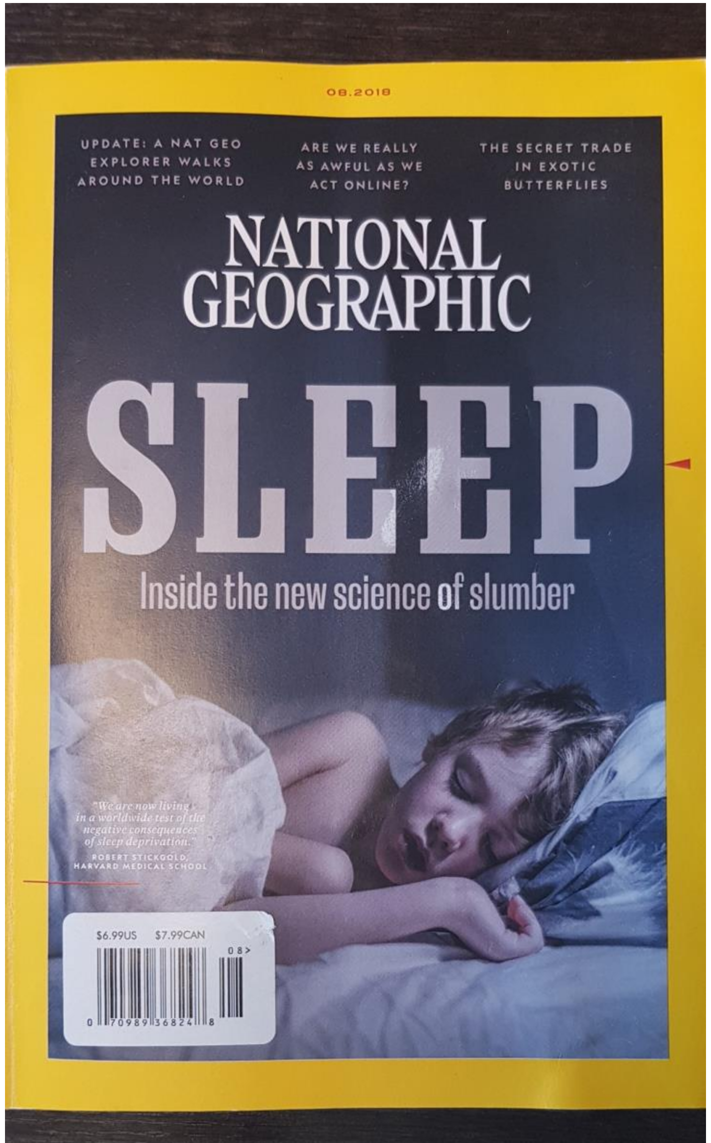
MÓTUM FRAMTÍÐINA SAMAN

Framtíðaráskoranir

Harpa 7. nóv 2018

Pétur Már Halldórsson
Nox Medical

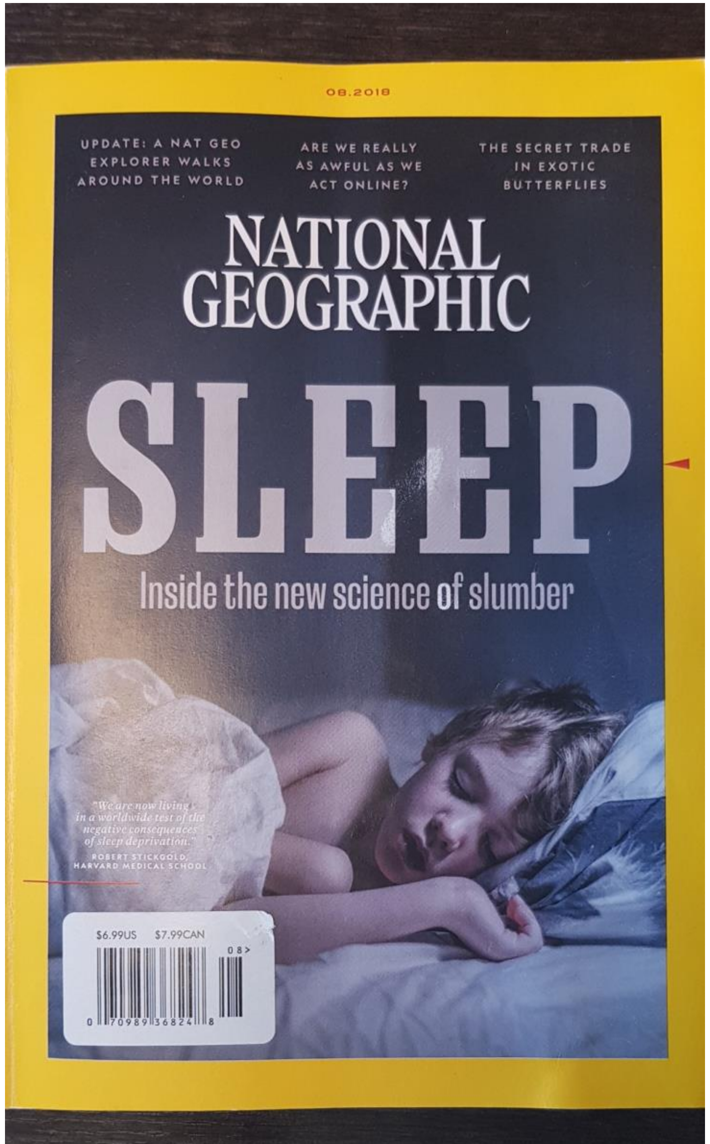
National Geographic (August issue 2018)



„We are now living in a worldwide test of the negative consequences of sleep deprivation“

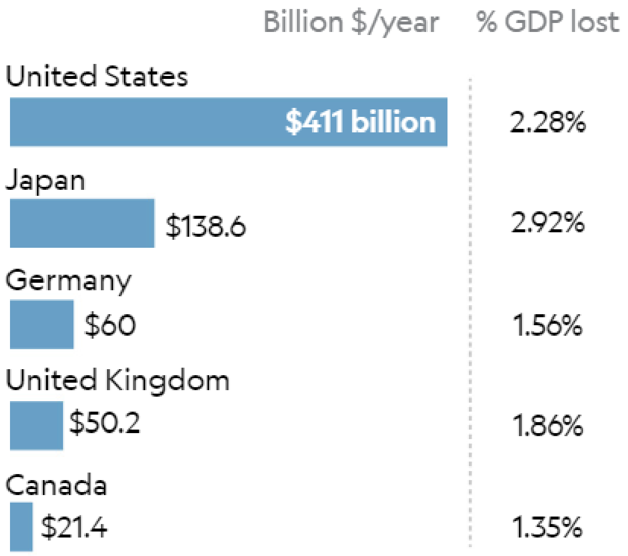
Robert Stickgold, Harvard Medical School

National Geographic (August issue 2018) USA CDC



THE COST OF SLEEPLESSNESS

A 2017 Rand study found that lack of sleep can result in reduced productivity as well as more work absences, industrial and road accidents, health care expenses, and medical errors.



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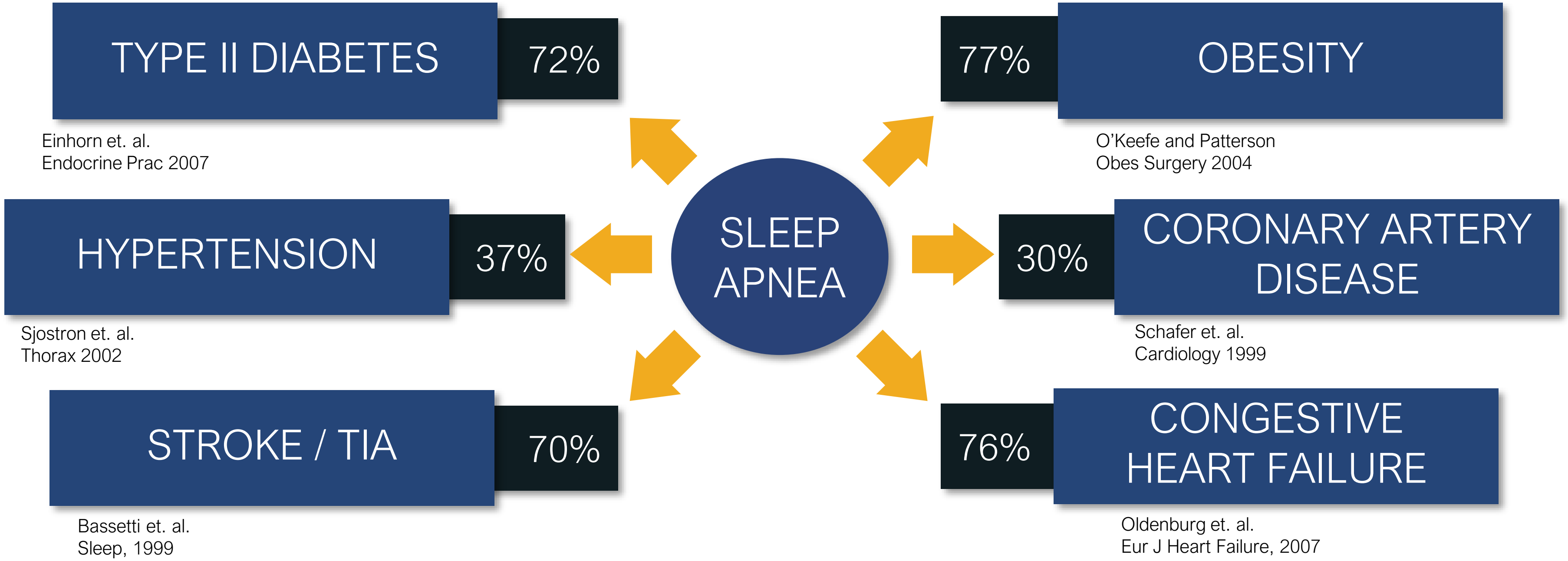
Sleep Apnea – The Silent Killer

Obstructive Sleep Apnea (OSA)

Public Health Problem of Epidemic Proportions



OSA and Sleep Related Chronic Diseases (SRCD)

Cost $1 Trillion Annually - OSA Alone Accounts for $165B

The Nox entrepreneur's

Our People

- More than 50 employees
- Expertise and experience in medical engineering and software development
- High level of domain knowledge
- Tight knit group with a diverse set of qualifications and skills

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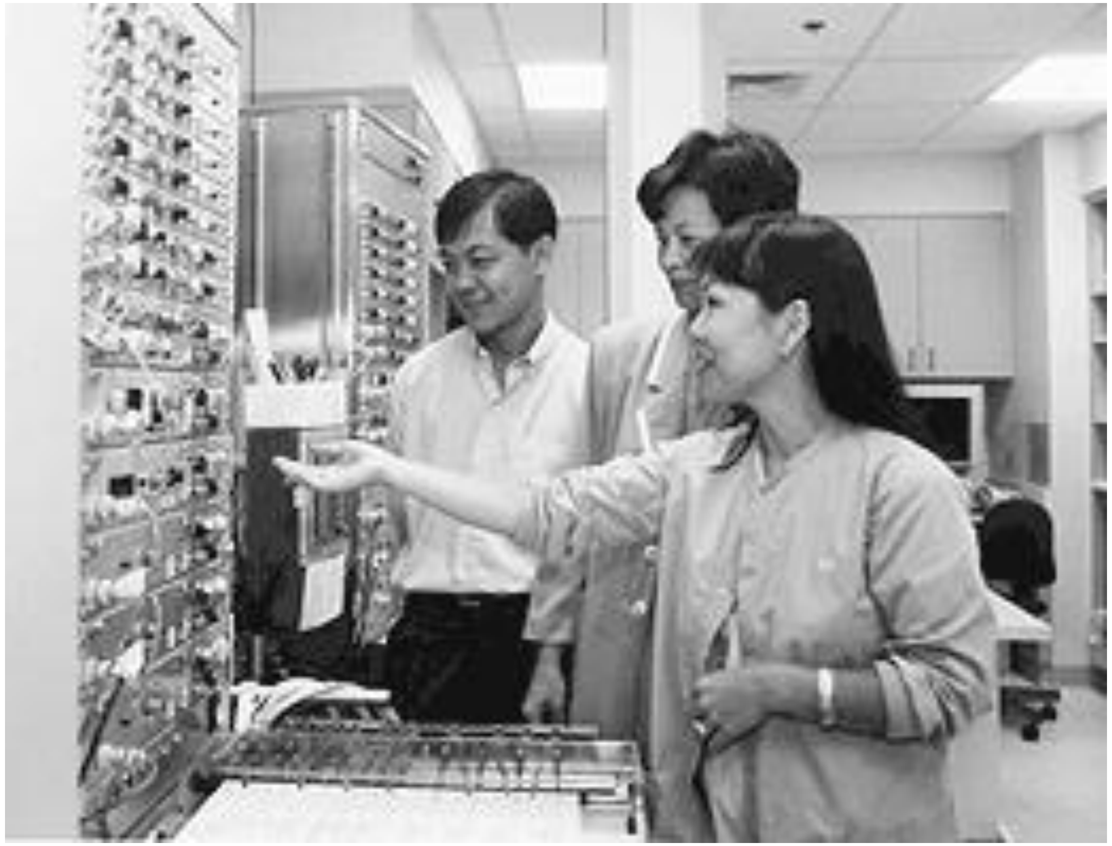
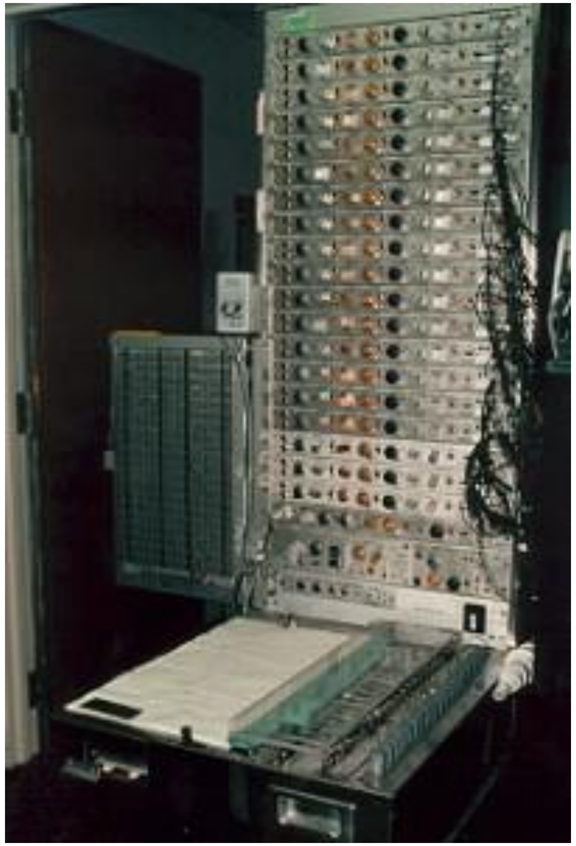
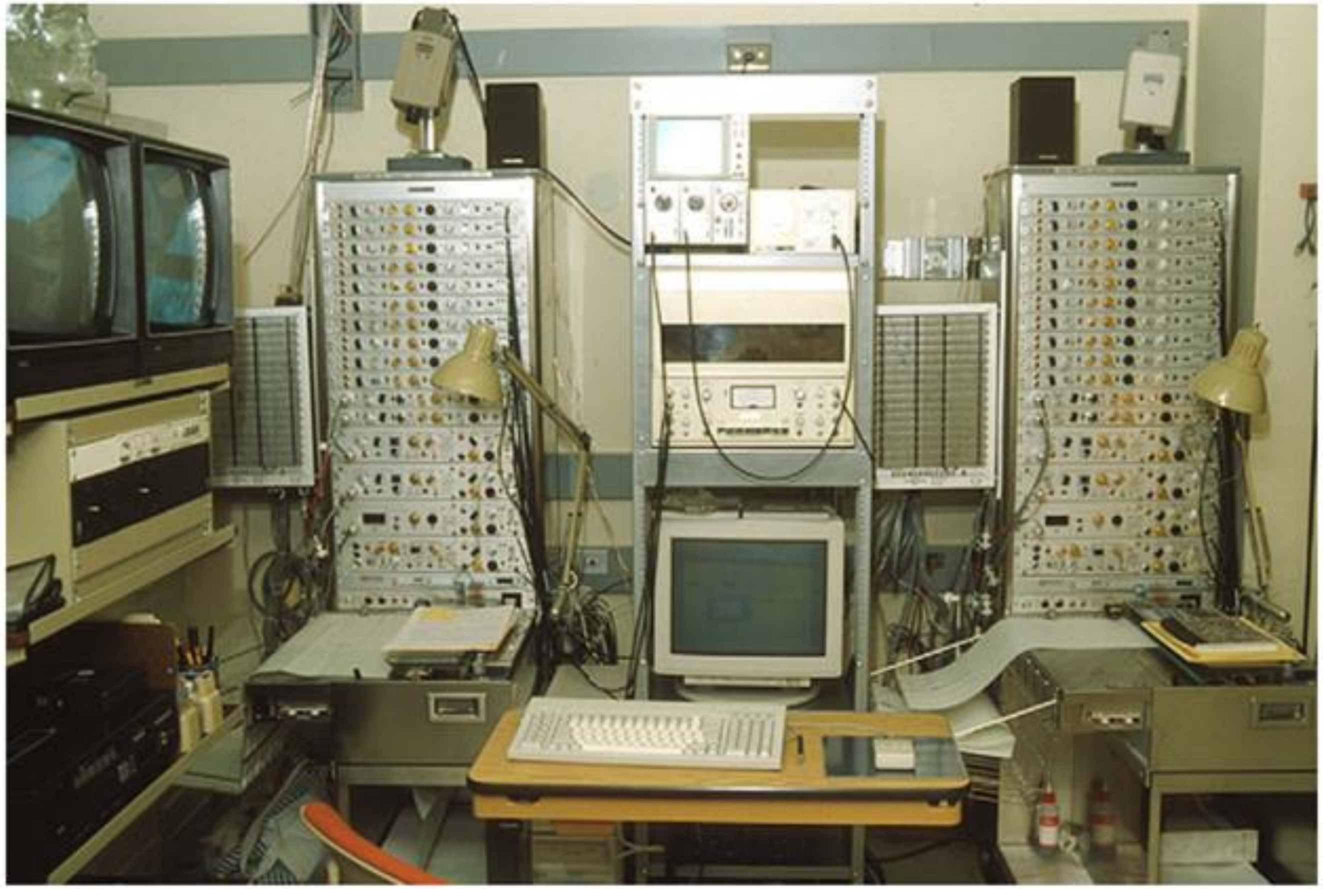
This is not from ancient times





The early days



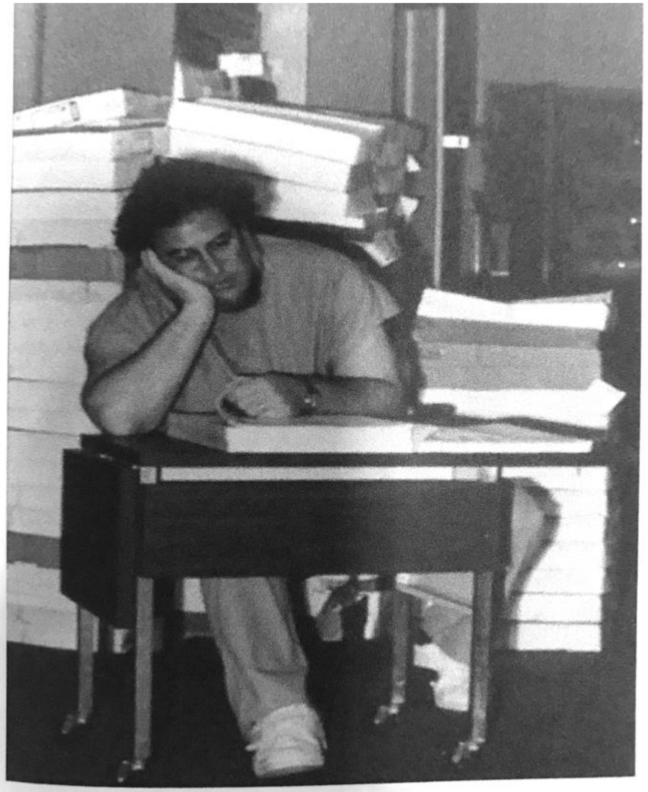


Fig. 4. Author surrounded by a sea of paper polysomnograms.

Fig. 5. Analog sleep system. Two-bed sleep laboratory at the University of Wisconsin, 1988. (*Courtesy of* S. Weber, Madison, WI.)

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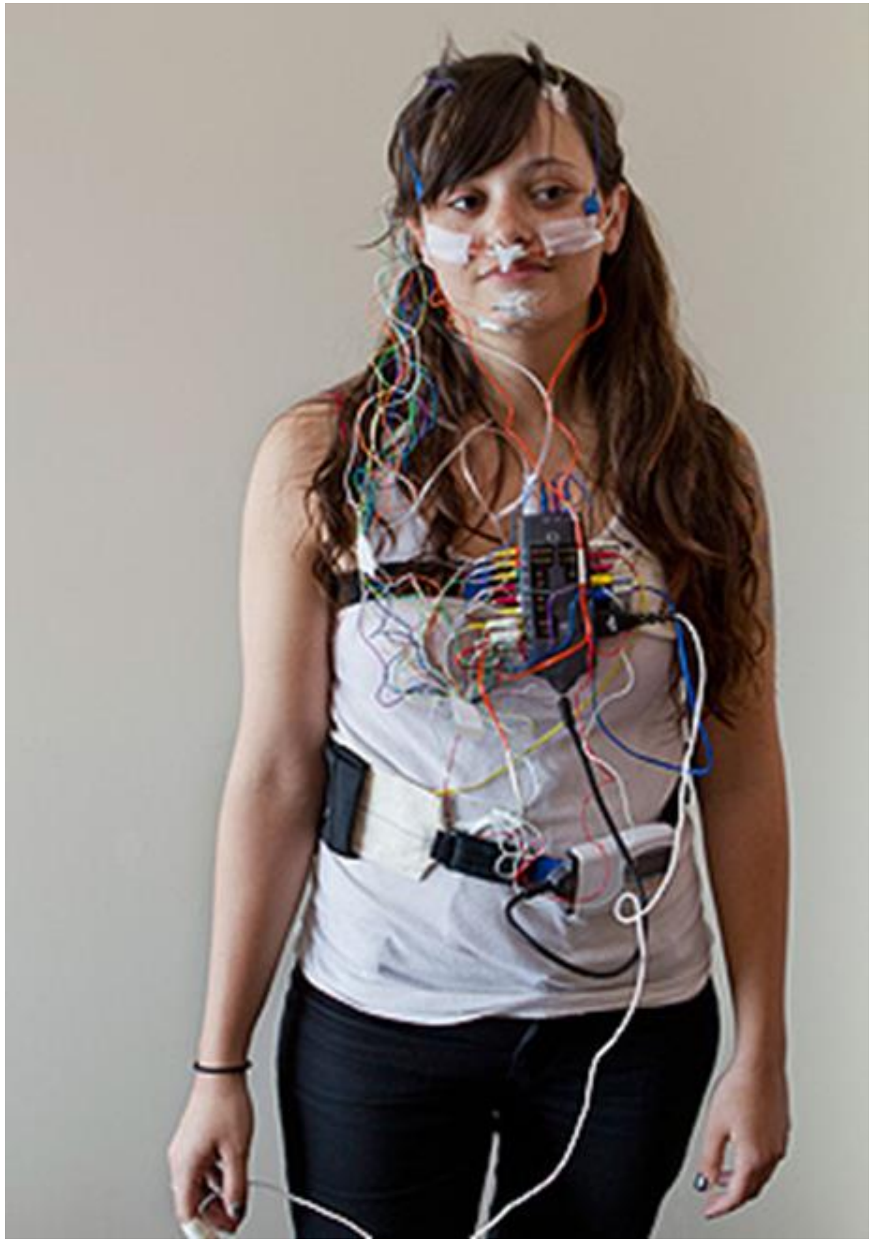

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up until 2018

5 Million lives

Affected with Nox Medical technology world wide

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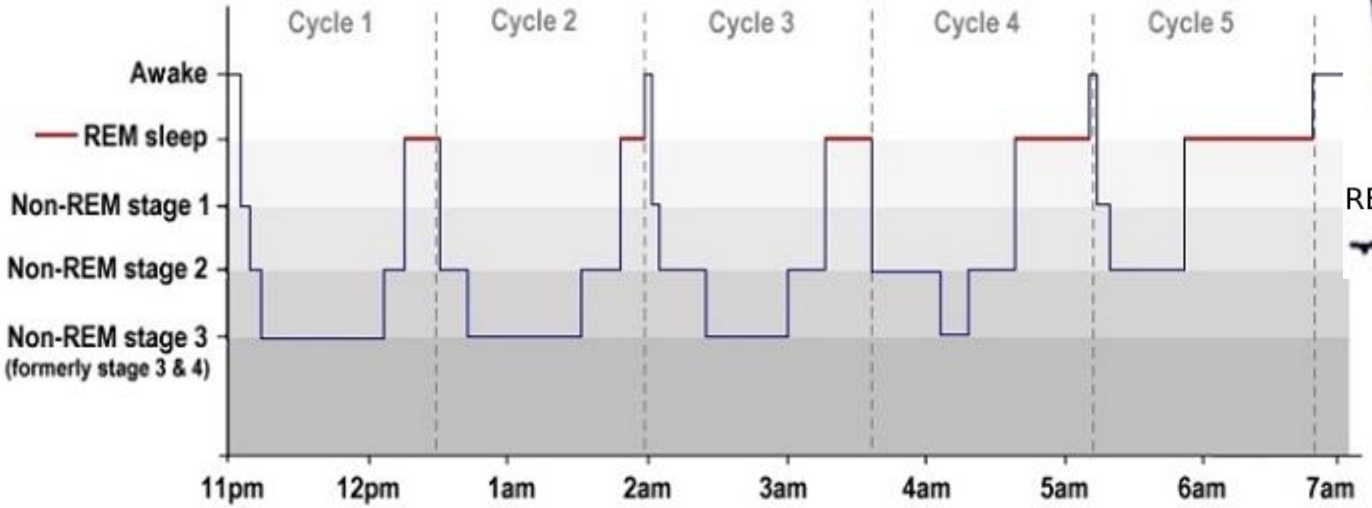
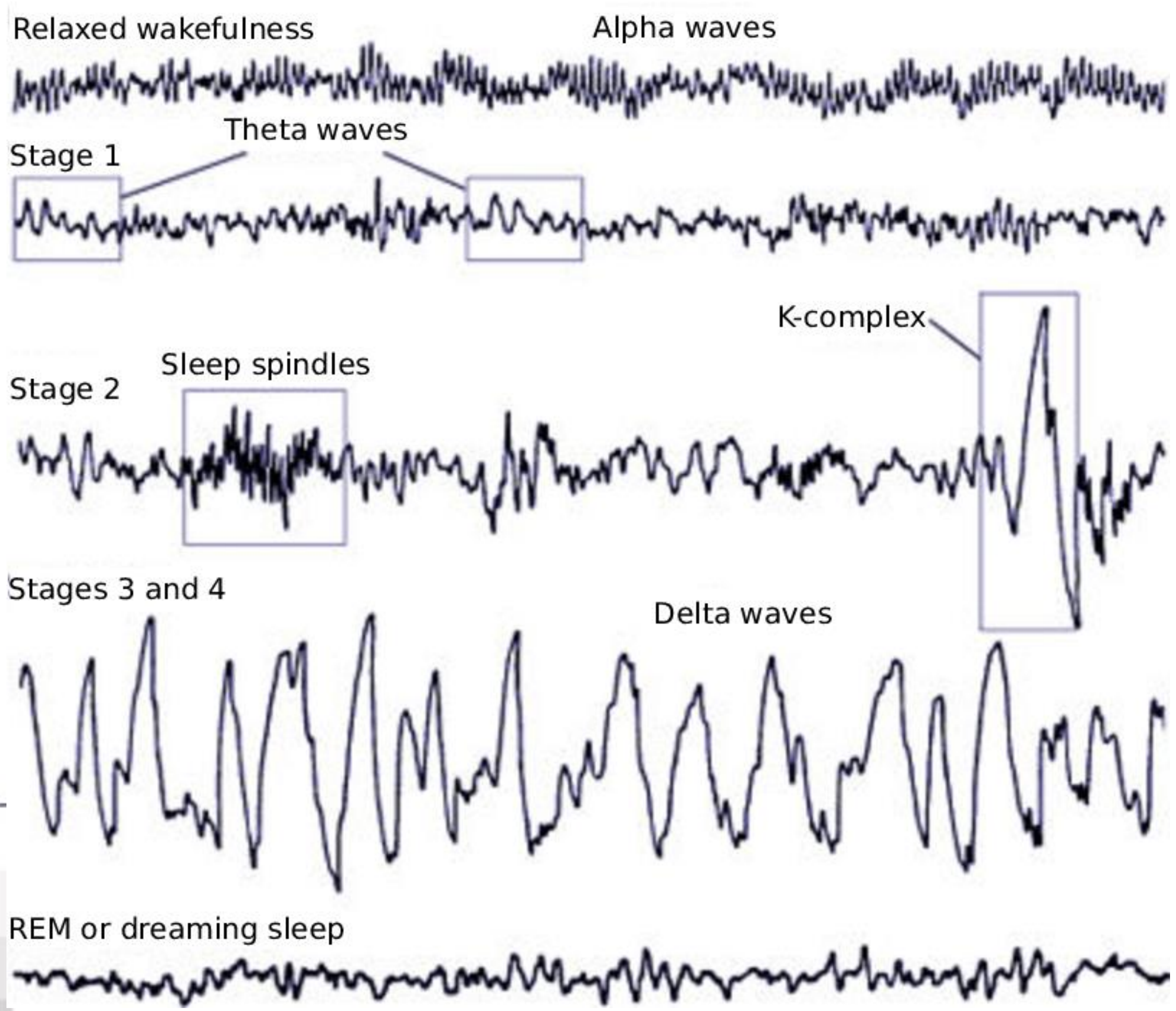
AI and 4th industrial revolutin in HealthCare

Sleep stages

Classify every 30 seconds
5 Sleep stages
Classification rules
Human experts agree





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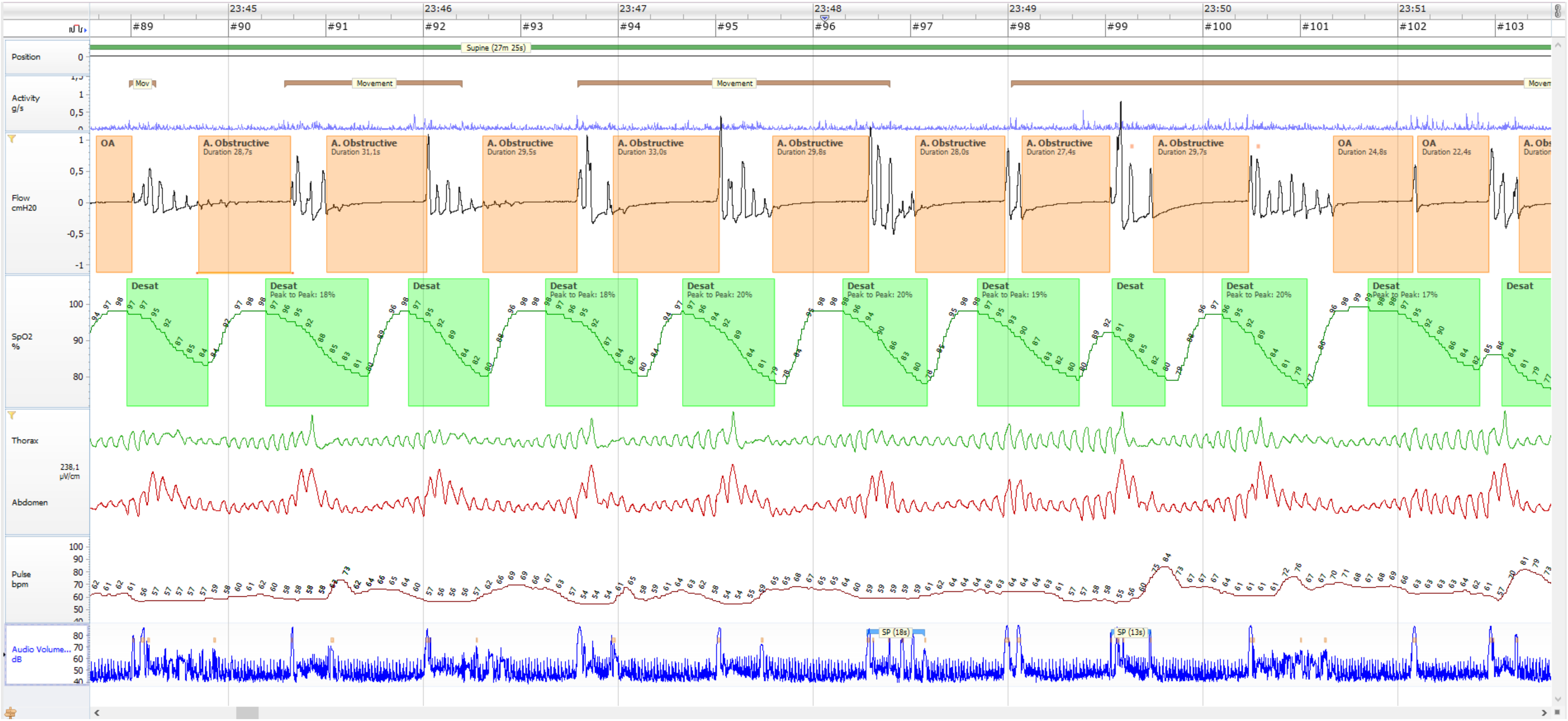
23:45
23:46
23:47
23:48
23:49
23:50
23:51
#89 #90 #91 #92 #93 #94 #95 #96 #97 #98 #99 #100 #101 #102 #103
Position
Supine (27m 25s)
Activity g/s
Movement
Flow cmH20
OA
A. Obstructive
Duration 28,7s
Duration 31,1s
Duration 29,5s
Duration 33,0s
Duration 29,8s
Duration 28,0s
Duration 27,4s
Duration 29,7s
Duration 24,8s
Duration 22,4s
SpO2 %
Desat
Peak to Peak: 18%
Peak to Peak: 20%
Peak to Peak: 19%
Peak to Peak: 17%
Thorax
238,1 µV/cm
Abdomen
Pulse bpm
Audio Volume... dB
SP (18s)
SP (13s)

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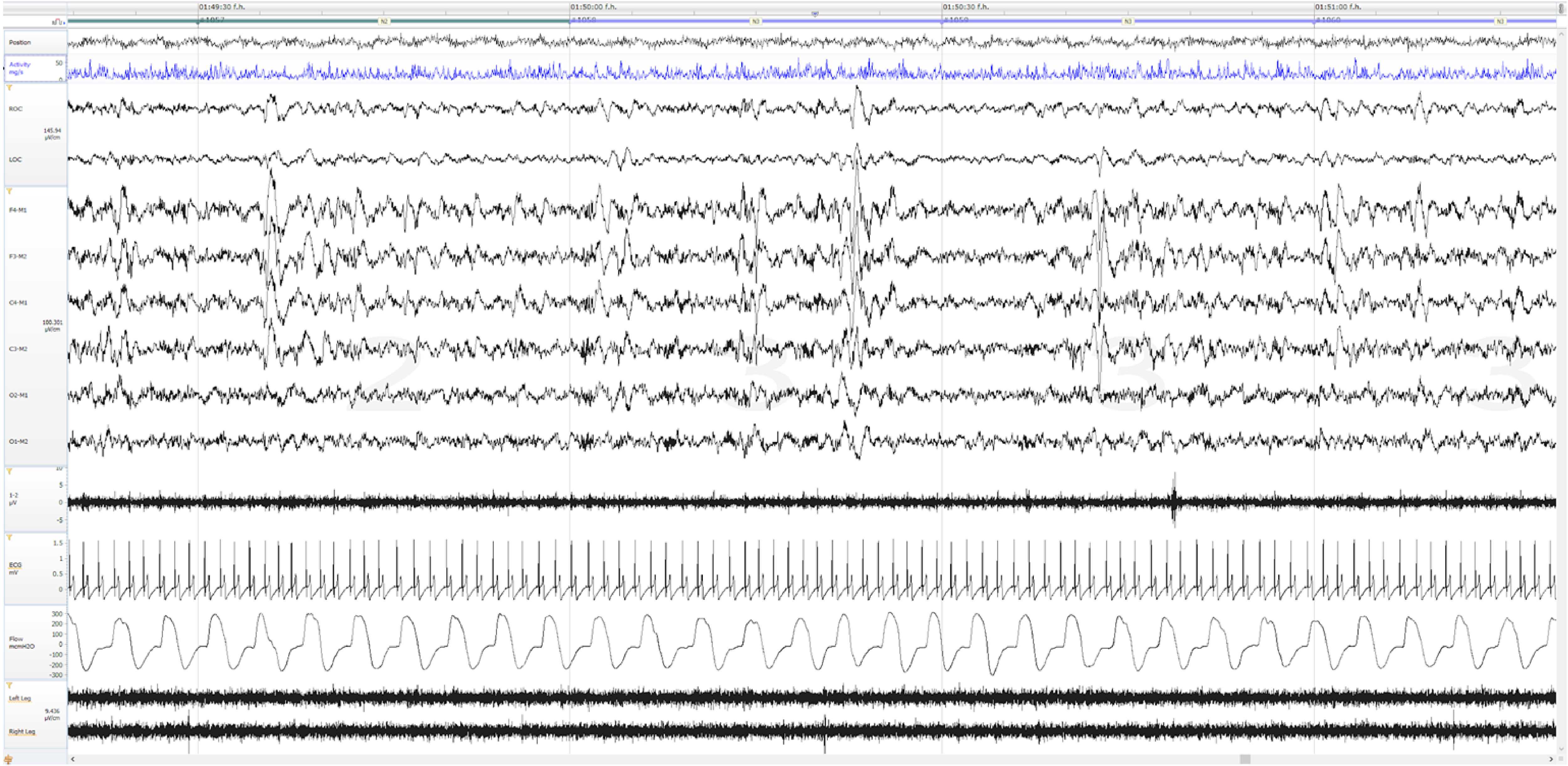
01:49:30 f.h.
01:50:00 f.h.
01:50:30 f.h.
01:51:00 f.h.
N2
N3
Position
Activity
mg/s
ROC
LOC
F4-M1
F3-M2
C4-M1
C3-M2
O2-M1
O1-M2
ECG
mV
Flow
Left Leg
Right Leg

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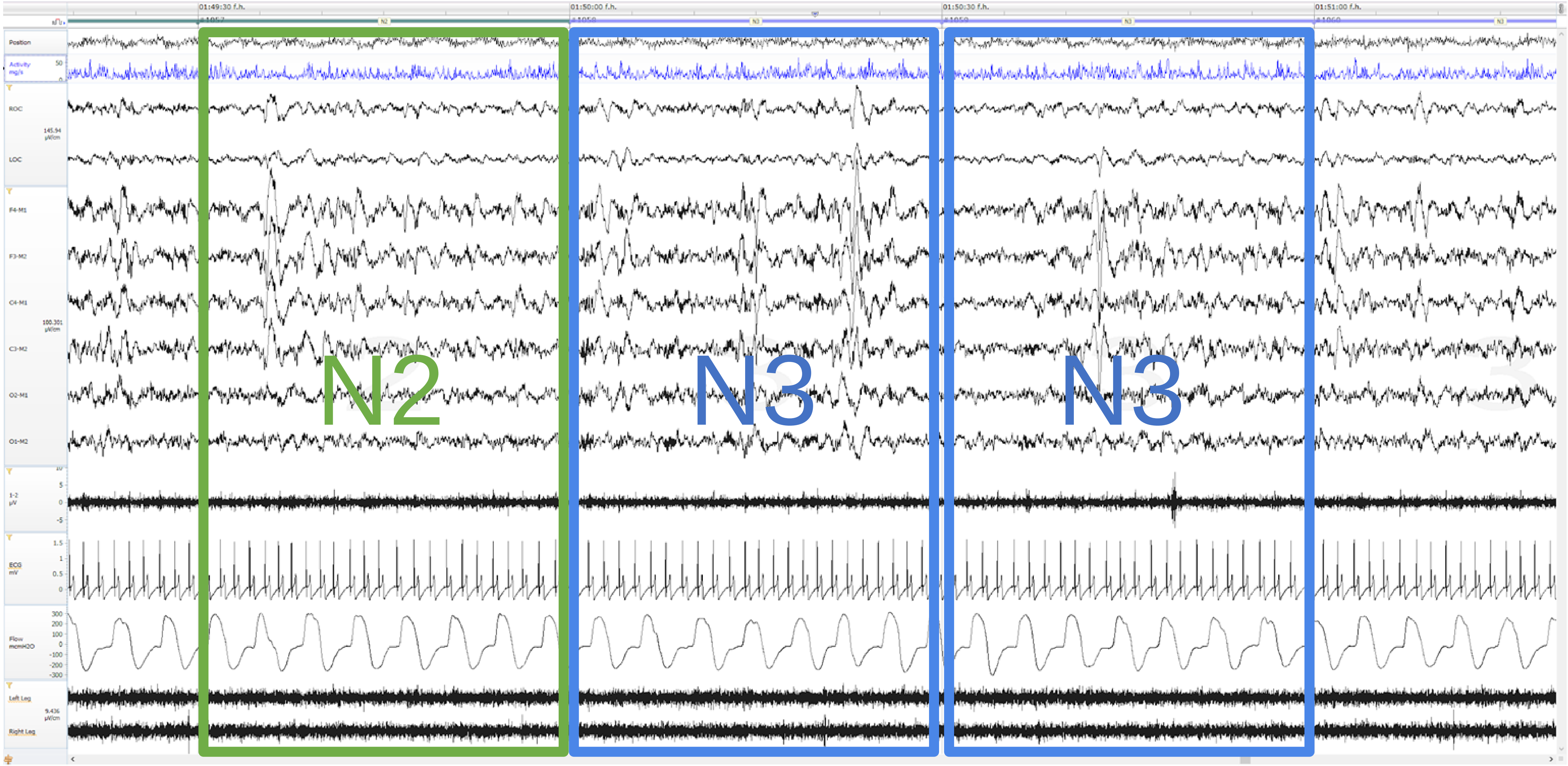
01:49:30 f.h.
01:50:00 f.h.
01:50:30 f.h.
01:51:00 f.h.
Position
Activity mg/s
ROC
LOC
F4-M1
F3-M2
C4-M1
C3-M2
O2-M1
O1-M2
ECG mV
Flow mcmH2O
Left Leg
Right Leg
N2
N3
N3

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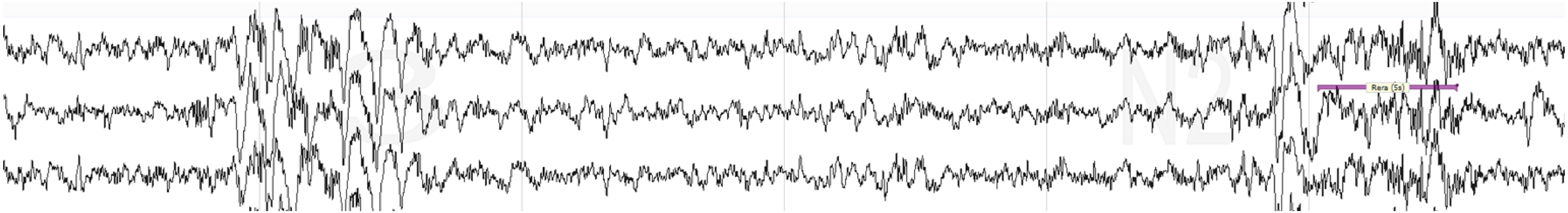
Arousal detection



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Nox Research

Team of scientists
- Self funded
- External collaborations
- Internal projects

Mission
- Automation
- Enabling Research

Ambition
- Convert data to information
- Improve patient health

European Commission | Horizon 2020 European Union funding for Research & Innovation

Tækniþróunarsjóður

eurostars™ dical

Big Data → Big Dating

Yale University School of Medicine

FusionHealth

HARVARD UNIVERSITY

Stanford University

Penn UNIVERSITY of PENNSYLVANIA

BRIGHAM HEALTH

BWH BRIGHAM AND WOMEN'S HOSPITAL

BRIGHAM RESEARCH INSTITUTE

THE UNIVERSITY OF SYDNEY

LANDSPÍTALI UNIVERSITY HOSPITAL

JOHNS HOPKINS MEDICINE

THE JOHNS HOPKINS HOSPITAL

The Icelandic Institute for Intelligent Machines

THE UNIVERSITY OF CHICAGO

AMGEN®

HÁSKÓLINN Í REYKJAVÍK
REYKJAVIK UNIVERSITY

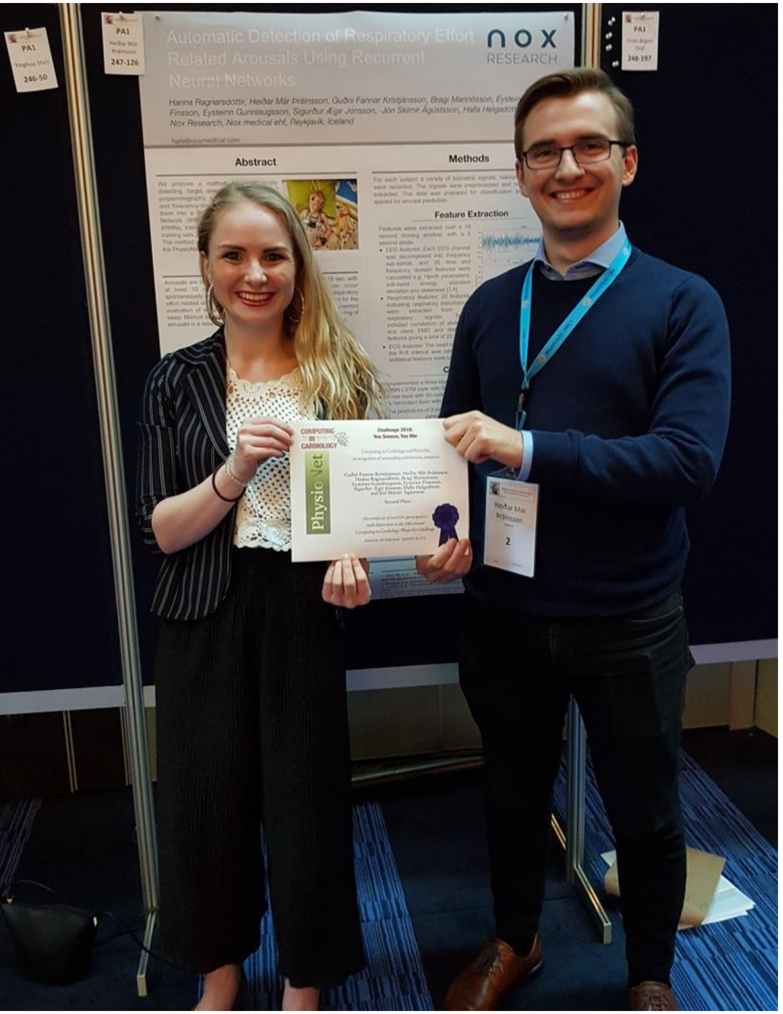
COLUMBIA UNIVERSITY

deCODE genetics

REMOTE A SmartECG

Imperial College London

PhysioNet
the research resource for
complex physiologic signals



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Automatic Detection of Respiratory Effort Related Arousals Using Recurrent Neural Networks

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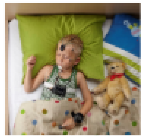
Nox Research, Nox medical ehf, Reykjavík, Iceland

Abstract

We propose a method for automatically detecting target sleep arousal regions of PNG signals by extracting time- and frequency-domain features and feeding them into a Bidirectional Recurrent Neural Network (BRNN). The predictions of five BRNNs, trained using different features and training sets, were averaged for each subject. The method was developed and validated on the PhysioNet 2018 Challenge database.



Objectives

Arousals are defined as an abrupt shift of EEG frequency of 3-15 sec. with at least 10 sec. of previous stable sleep [1]. Arousals can occur spontaneously or as a result of various sleep-disorders, such as respiratory effort related arousals [2]. The identification of arousals is important for the evaluation of sleep continuity, as repeated arousals result in fragmented sleep. Manual scoring of arousals is costly and difficult. Automatic scoring of arousals is a recurring problem, to which we propose a method to solve.

Results

The performance of our method was evaluated using a five-fold cross-validation on the training set of the PhysioNet 2018 Challenge database.

The final ensemble model performs excellently, with AUPRC-score (area-under precision recall curve) of 0.45 and AUROC-score (area under receiver operating characteristic curve) of 0.9.

Model	AUPRC score	AUROC score
Model 1 (BRNN)	0.432	0.893
Model 2 (BRNN)	0.429	0.893
Model 3 (BRNN)	0.428	0.891
Model 4 (BRNN)	0.430	0.893
Model 5 (BRNN)	0.428	0.895
Ensemble model	**0.452**	**0.901**

Discussions

Automatic detection of arousals is an important task but not a trivial one. The main challenges include imbalanced and poorly labelled data and variance between patients. Despite the challenges, our method for automatically classifying target arousal regions, shows encouraging results.

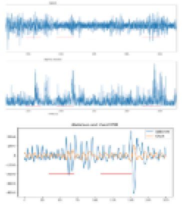
Methods

For each subject a variety of biometric signals, relevant to sleep studies, were recorded. The signals were then preprocessed and meaningful features extracted. The data was prepared for classification and finally deep learning applied to predict arousals.

Feature Extraction

Features were extracted over a 10 second moving window, with a 5 second stride.

- *EEG features*: Each EEG channel was decomposed into frequency sub-bands, and various time and frequency domain features calculated e.g. Hjorth parameters, Sub-band energy, standard deviation and skewness [3,4].
- *Respiratory features*: Features indicating respiratory disturbance, were extracted from the respiratory signals. These included correlation of abdomen and chest EMG and statistical features



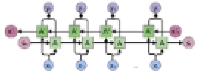
- *ECG features*: The heart beats were located using an R-peak finder and the R-R interval was calculated. Frequency domain features and statistical features were calculated from the interpolated R-R interval [5].

Classification

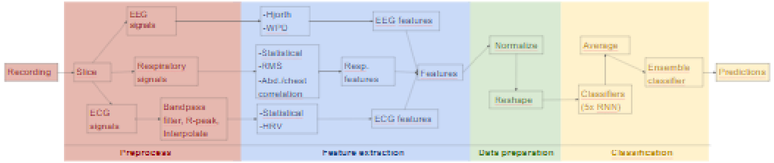
We implemented a three-layer neural network with the following layers:

- BRNN-LSTM layer with 50 LSTM hiddden blocks.
- Dense layer with 50 nodes, using Relu activation function.
- Dense-output layer with 2 nodes, using Softmax activation function

→ The predictions of 5 neural networks were averaged per subject.



Before training a classifier, the input data was normalized and reshaped for the recurrent layer. A more balanced training dataset was further created.



Acknowledgement

This work was supported by the Icelandic Centre for Research under the Icelandic Student Innovation Fund and the Horizon 2020 SME Instrument number 733461.

References

1. Berry RB et al., *The AASM Manual for the Scoring of Sleep and Associated Events; Rules Terminology and technical specifications* (2016)
2. Bonnet M et al., *EEG arousals: Scoring rules and examples* (1992)
3. Faust O et al., Wavelet-based EEG processing for computer-aided seizure detection and epilepsy diagnosis (2015)
4. Hjorth B, *EEG analysis based on time domain properties* (1970)
5. Shaffer F & Ginsberg JP, An overview of heart rate variability metrics and norms (2014)

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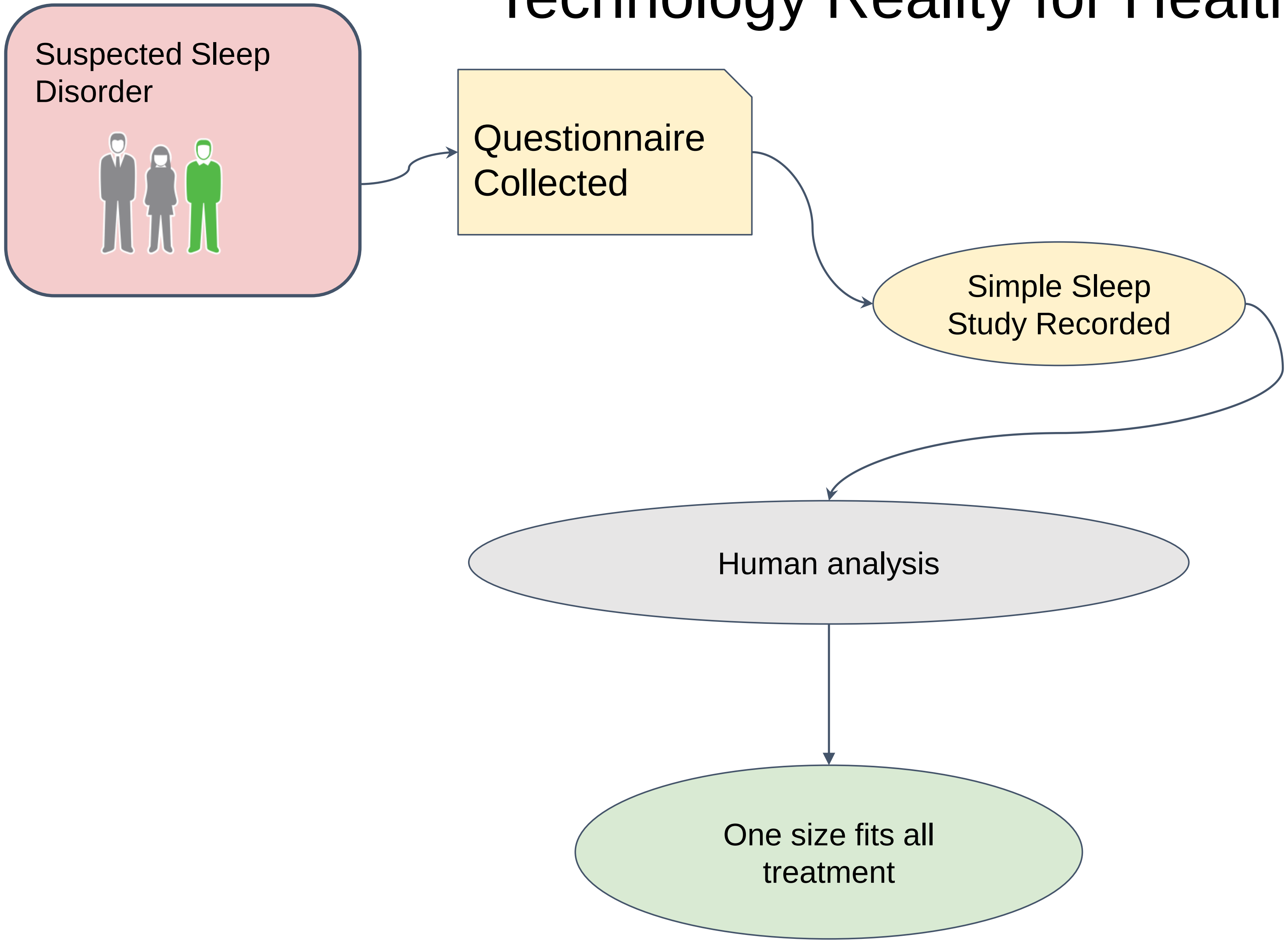
Technology Reality for Health



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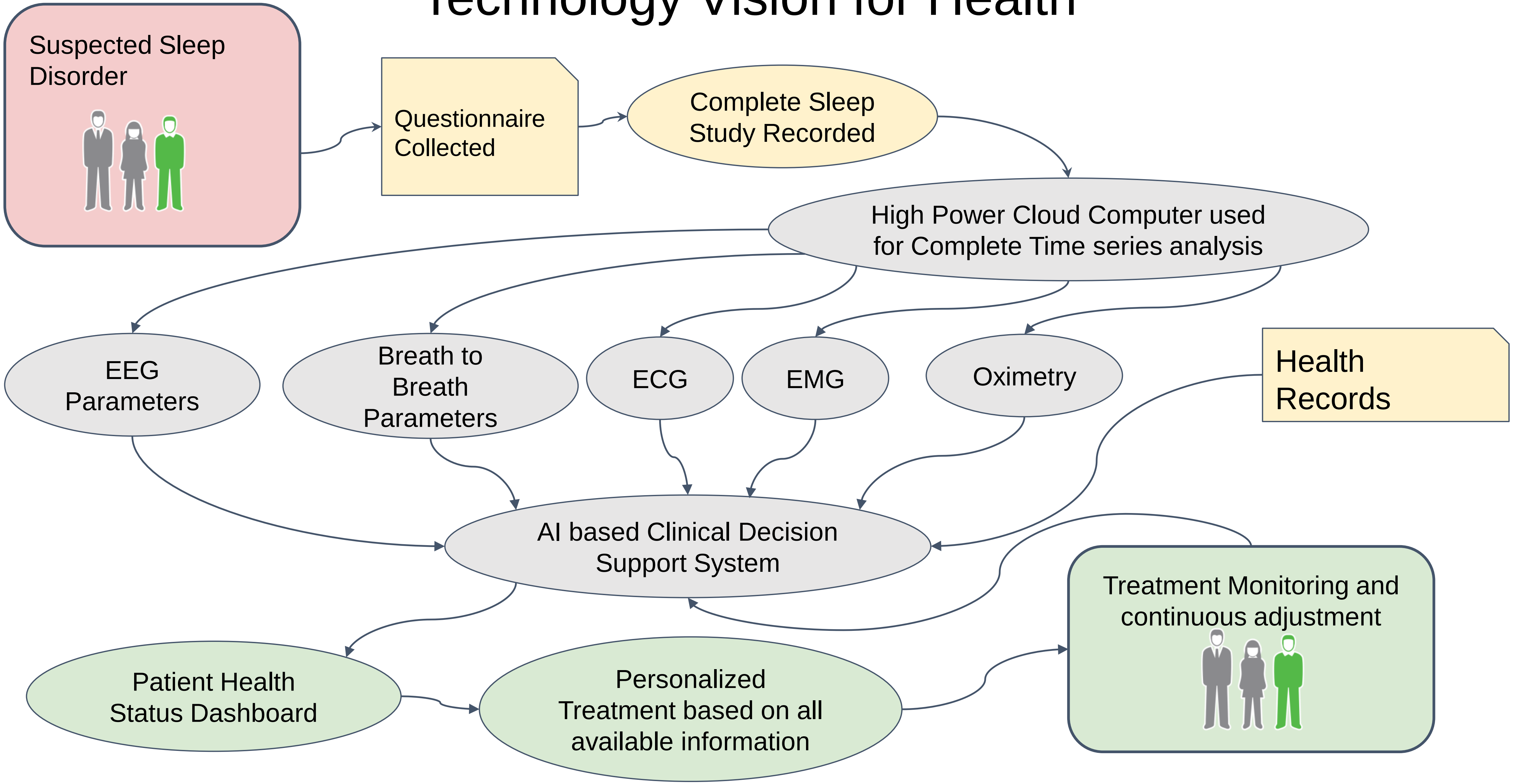
Technology Vision for Health



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