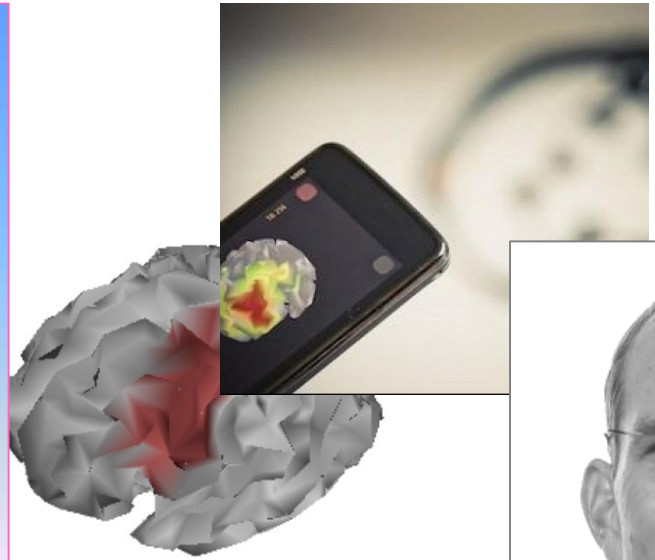
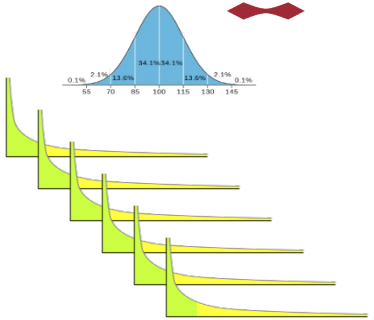
Neuroscience in the wild

- or wild neuroscience in DK?



Innovation Fund DK 24/7 neurotechnology project

Why? Personalized services require access to private data….



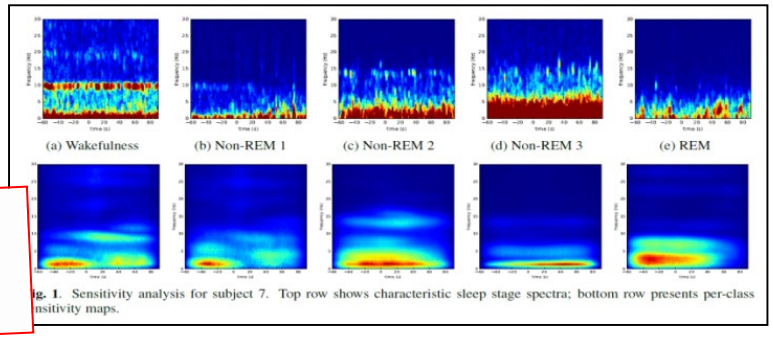
Human variability … can only be handled by individualised models

- Powerlaws of behavior (Song et al., 2010. *Limits of predictability in human mobility,* Science)
- Learning: *The Power law of practise* (Newell, A. and Rosenbloom, P.S., 1981. *Cognitive skills and their acquisition*, *1*:1-55)
- Standard medical solutions based on population effects

Need for a *science of the individual* to predict and act personally

Most behavioral information is ”hidden” (incl. for owner) => neurotechnology

- Brain: Motivation, vigilance, attention
- History: Knowledge graphs, experience
- Social dimensions: Network, sentiments



ig. 1. Sensitivity analysis for subject 7. Top row shows characteristic sleep stage spectra; bottom row presents per-class nsitivity maps.

2017 IEEE INTERNATIONAL WORKSHOP ON MACHINE LEARNING FOR SIGNAL PROCESSING, SEPT. 25–28, 2017, TOKYO, JAPAN

DEEP CONVOLUTIONAL NEURAL NETWORKS FOR INTERPRETABLE ANALYSIS OF EEG SLEEP STAGE SCORING

Albert Vilamala[1], *Kristoffer H. Madsen*[1,2] *and Lars K. Hansen*[1]

Research Articles, Behavioral/Cog

Baseline Levels of Rapid-Eye-Movement Sleep May Protect Against Excessive Activity in Fear-Related Neural Circuitry

Itamar Lerner, Shira M. Lupkin, Neha Sinha, Alan Tsai, and Mark A. Gluck

Journal of Neuroscience 23 October 2017, 0578-17; DOI: https://doi.org/10.1523/JNEUROSCI.0578-17.2017

How? Intelligent systems... ≠ data science

Intelligent systems have senses

- Seek relevant data(1).. causal discovery, embodied
- Attention

Intelligent systems are learning systems

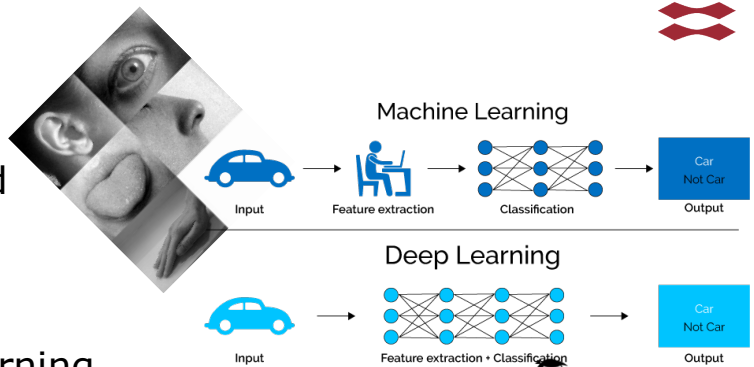
- Machine learning … semi-supervised, transfer learning
- Active learning … ask questions, intervention

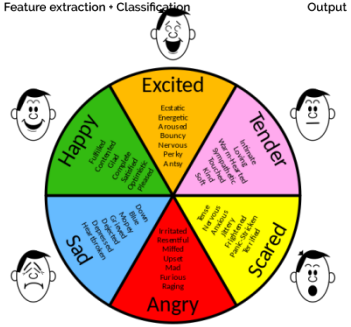
Intelligent systems have social competences

- Communication, own limitations
- Emotion

Intelligente systems perform ”live”

- Global coordination – level C1 conscious (2)
- Real-time operation -action perception (3)





(1) Bajcsy, R., 1988. Active perception. Proceedings of the IEEE, 76(8), pp.966-1005.
(2) Dehaene, S., Lau, H. and Kouider, S., 2017. What is consciousness, and could machines have it?. *Science*, *358*(6362), pp.486-492.
(3) Little, D.Y.J. and Sommer, F.T., 2013. Learning and exploration in action-perception loops. *Frontiers in neural circuits*, *7*, p.37.

Safe AI - Cognitive Systems platform at DTU Compute

Research areas

Machine learning

- Probabilistic ML, deep learning systems, networks, geometry, +1000 eng. students/year

Cognition

- Wikipedia /knowledge graphs, Neurotechnology, Prof Sid Kouider (ENS),

Computational social science

- Sensible DTU, leader/follower dynamics, SODAS (KU, Social Science)

Excellence measured in top venue papers 2015-19 NIPS, AISTATS, ICLR, ICML,…
Co-author network 2015-19: TU Berlin, Stanford, MIT, UCLA, UC London, ENS Paris,…
=> Top rated by three consecutive international review panels (2009/2014/2018)

Societal impact

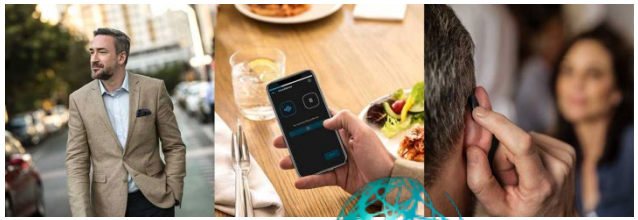
Hearing Systems' high AI acceptance

Audio ML, Personalization, neurotechnology

DABAI open source ML workflows + Language / Danish resources

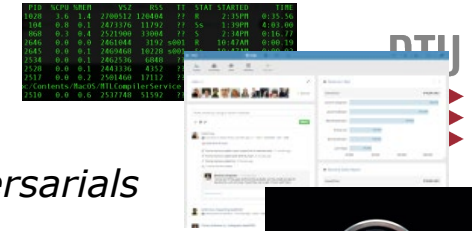
Start-ups: Peergrade, Spektral Experience, Corti,

New AI BSc education – started September 2018



DABAI

Wild neuroscience requires *Safe AI*



Safe AI = secure – test & verified software and hardware, adversarials

Safe AI = open source – methods, code, hardware, check and evolution

Safe AI = self-conscious – understands own role

Safe AI = can keep a secret – privacy by design

Safe AI = has calibrated values – debug for stereotypes, biases

Safe AI = is accountable - transparent, communicating, "right to explanation"

Safe AI = understands social relations – understands user's knowledge graph

Safe AI = understands power – digital self-defense

Safe AI = generates trust

Privacy for Personal Neuroinformatics
Arkadiusz Stopczynski[1,2], Dazza Greenwood[2], Lars Kai Hansen[1], Alex Sandy Pentland[2]
1 Technical University of Denmark
2 MIT Media Lab
arks@dtu.dk, dazza@civics.com, lkai@dtu.dk, sandy@media.mit.edu

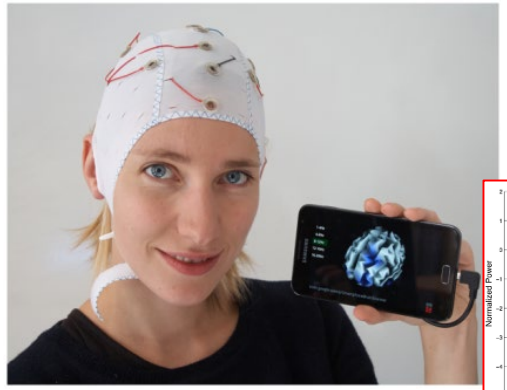
engineering in progress...

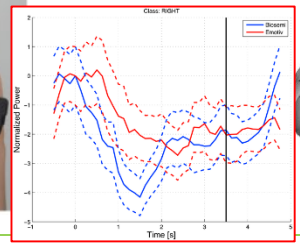
Wild, Wilder, Wildest?

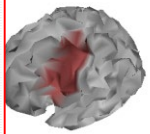
The smartphone brain scanner
- LMIC epilepsy project

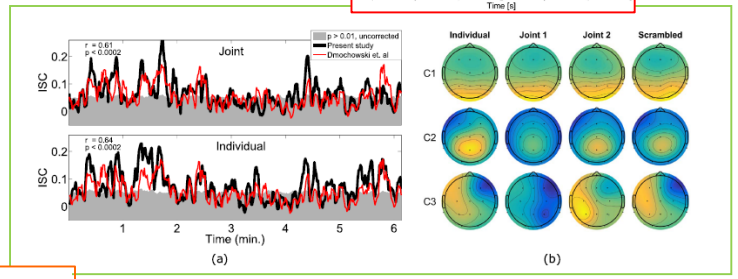
Measuring attention
in the classroom

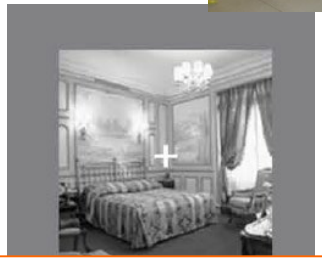
Controlling attention

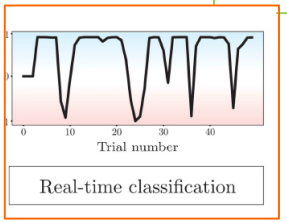












A. Stopczynski et al. *Smartphones as pocketable labs: Visions for mobile brain imaging and neurofeed-back.* International Journal of Psychophysiology, (2014).
A. Stopczynski, et al. *The Smartphone Brain Scanner: A Portable Real-Time Neuroimaging System.* PloS one 9 (2), e86733, (2014)
JP. Dmochowski et al, "Audience preferences are predicted by temporal reliability of neural processing", Nature Communications 5: 4567, July 2014.
S Kamronn et al Multiview Bayesian correlated component analysis. Neural computation. 2015.
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UN WHO - Epilepsy treatment gap

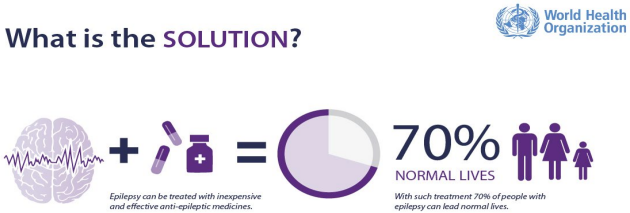
Huge epilepsy treatment gap in low and middle income countries (LMIC).

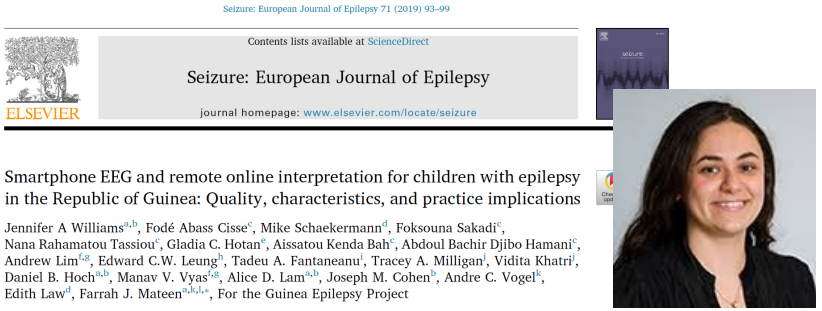
WHO estimate: $30 \cdot 10^6$ million people with undiagnosed epilepsy in LMIC,

Annually 2 million new undiagnosed cases

WHO estimate: 70% can be treated with inexpensive medication if diagnosed…

The main diagnostic tool is EEG





LMIC's limited access to EEG

✓ *Braincapture low cost caps*

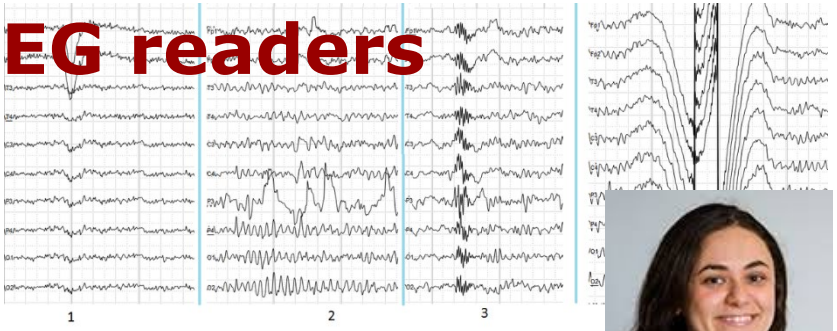
LMIC missing expert "readers"

Cloud of volunteer readers

+ DTU AI

WHO: https://youtu.be/SshVn6MUGxA

Braincapture - cloud of EEG readers

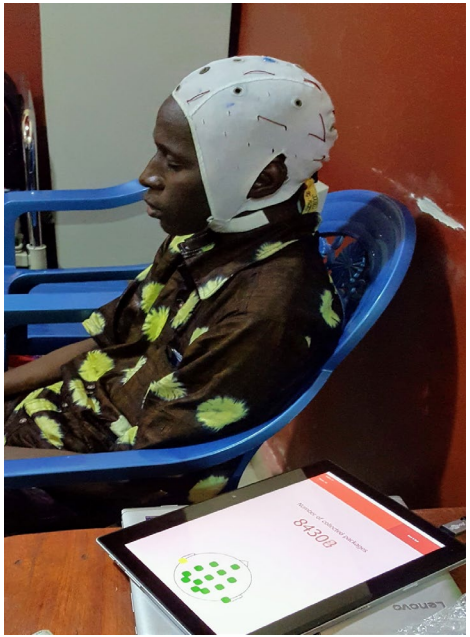


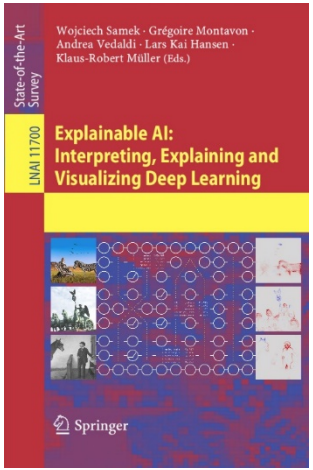
Two levels of AI support

- On-site, real-time quality control
  - novelty detection
  - user feedback
- Of-line analyses, denoising

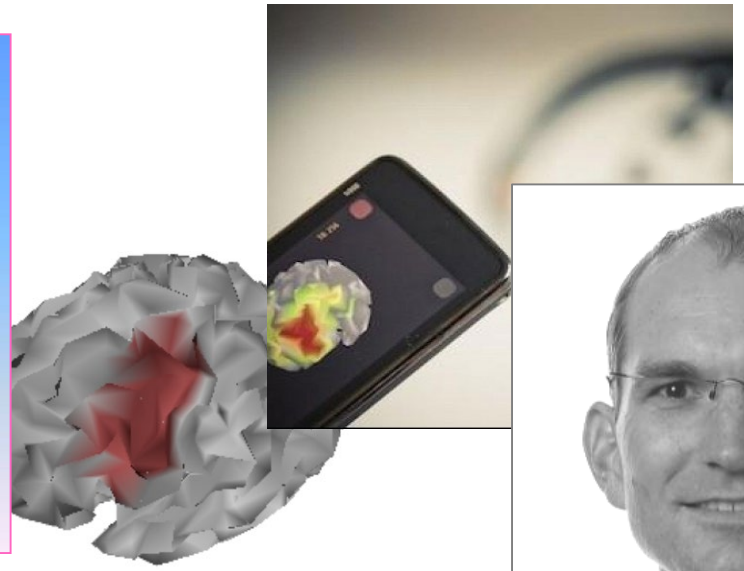
AI / deep learning challenges

- EEG = extremely noisy, non-stationary data,
  - Data augmentation + interpretability
- Embedding using generative model
  - w/ large databases, transfer learning
- Explainability / Interaction design





Looking very much forward to collaborating with the Center for Ear-EEG *– let's go wild!*



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