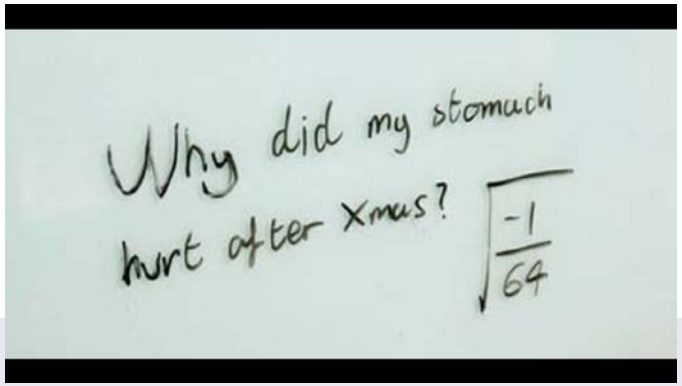
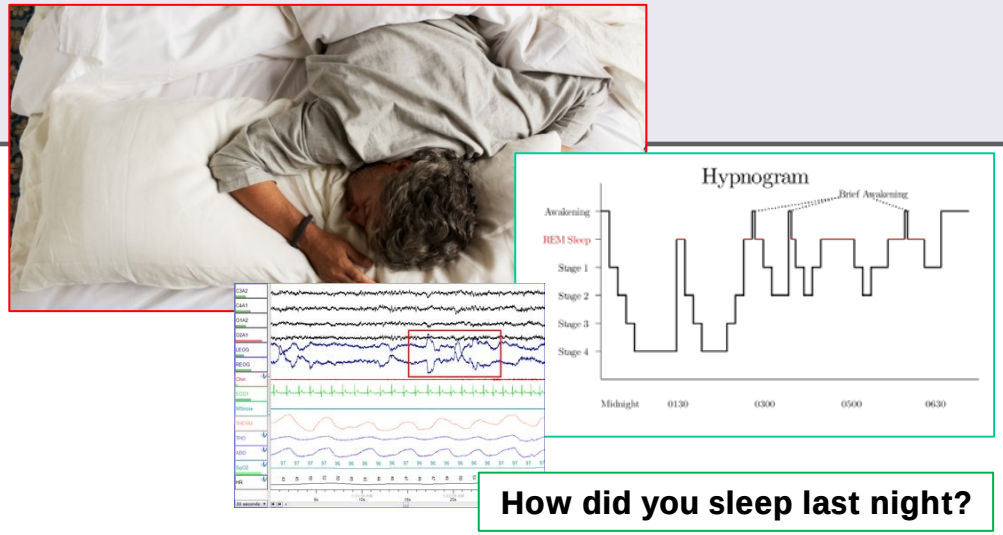
Quantified human behavior

"... obvious business potential"



Lars Kai Hansen – lkai@dtu.dk
Technical University of Denmark

Happy New Year!



How did you sleep last night?

Human behavior as a ressource

- What are the signals?
- .. and the challenges?

5 minute business bs

- AI = Augmented intelligence
- Prepare for IQ=1000
- Why connected brains?

Mind reading internet

- Shift the focus from individual to social
- Internet of brains
- IoB v1.0: Connected hearing aids
- Brain state monitoring - where are we?

More direct access to our state of mind will revolutionize the ways we understand and interact with ourselves, our collaborators and our computers

Mobile brain scanning can be used to read wishes and plans, to improve diagnosis, medication, and rehabilitation

At DTU Compute we have build the first truly mobile brain scanner. The scan is a 3D image of the instantaneous brain activity.

My aim is to give everybody realtime access to their brains.

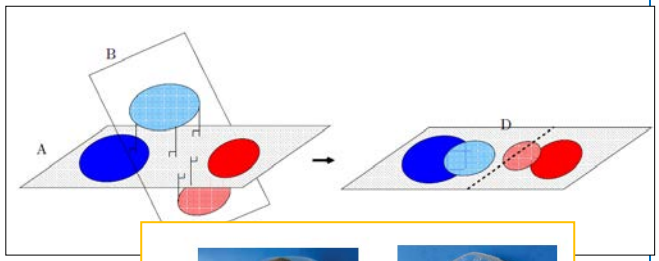
Lars Kai Hansen – lkai@dtu.dk
Technical University of Denmark

Quick intro

Early work in machine learning introduced the **ensemble method** (IEEE PAMI 1990).

Since mid-90s work on systems neuroscience /neuroimaging: **first papers on mind reading** (PET, 1994) and (fMRI, 1997)

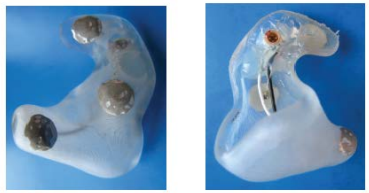
More recent work in ML on "**Variance inflation**"
kPCA (JMLR, 2011) and SVMs (PRL, 2013)
Recovering from undersampling biases for small samples in high-dimensional spaces



AISTATS 2016: *"Dreaming more data… "*
On deep learning with limited sample sizes

Active in the community for "mobile EEG":

The Smartphone Brain Scanner.
New Scientist Nov 2011: "Now you can hold your brain in the palm of your hand"



(a) An earplug with electrodes ERA, ERB and ERH visible.

(b) An earplug with electrodes and connector (opposite view of Figure 1(a)). Electrode ERE is visible.

) Right ear with earplug.

(d) Side view of test subject showing the recording setup.

View of a right ear earplug and the Ear-EEG recording setup.

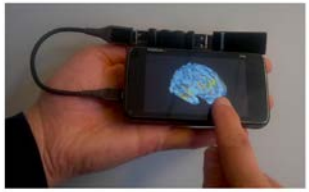
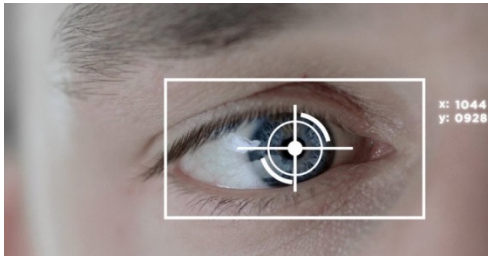


Fig. 3. A user interacting with a 3D model of the brain using the handheld brain scanner device with touch-based interaction.

Human behavior - what are the signals?

Single subject measures

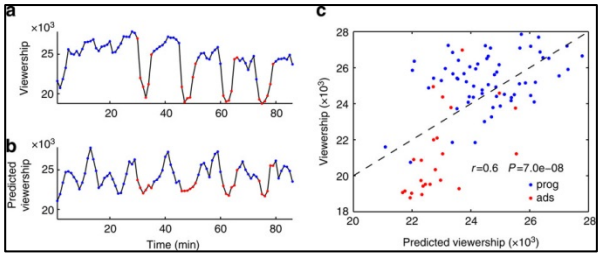
- Smartphones, watches: Mobility/GPS/Wifi triangulation, speech, eye-track, face recognition
- Quantified self devices: Fitbit, Jawbone,
- Medical devices – hearables, Cure4You,



Oculus acquires eye-tracking startup The Eye Tribe

*"**Oticon Tego** is directed by the DecisionMaker system, driven by (AI) Artificial Intelligence that processes sound intelligently. This super advanced form of computer processing. Artificial Intelligence is the process of performing logical operations enthused by the human brain.*

The difference between AI-based and conventional instruments is distinct: AI-based instruments constantly adapt to particular situation where conventional instruments provide only a fixed response to selected types of sounds. AI-based, Oticon Tego evaluates the different sound processing options and selects the one guaranteed to give the clearest sound quality. "



Digital & Social media

- Deep decoding: Emotional states
- Media attention, shared attention in twitter
- Social patterns: Sensible DTU / Copenhagen network study

Life-logging for evidence based living

MyLifeBits a Microsoft Research project. (ca 2001-05)

Inspired by Vannevar Bush's hypothetical Memex computer system.

http://www.theatlantic.com/magazine/archive/1945/07/as-we-may-think/303881/

The project included full-text search, text and audio annotations, and hyperlinks. The "experimental subject" of the project was computer scientist Gordon Bell, and the project aimed at collecting a lifetime of storage on and about Bell.

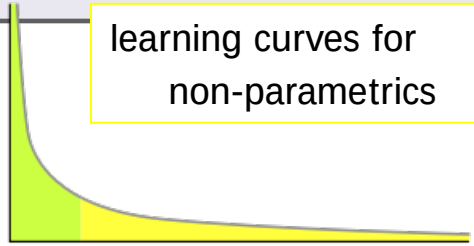
Jim Gemmell of Microsoft Research and Roger Lueder were the architects and creators of the system and its software.

http://research.microsoft.com/en-us/projects/mylifebits/default.aspx

Gordon Bell

Quantified Self
self knowledge through numbers

Human behavior – modeling challenges



learning curves for
non-parametrics ~ log(N)/N

Human variability => Individualization

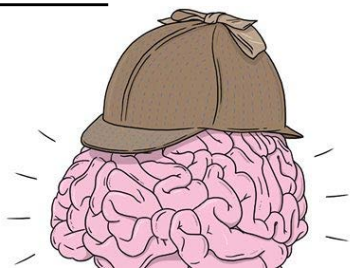
- Power laws of human behavior (Song et al., 2010. *Limits of predictability in human mobility,* Science)
- Learning: The Power law of practise (Newell, A. and Rosenbloom, P.S., 1981. *Cognitive skills and their acquisition*, *1*:1-55)
- Population measures have vanishing effect sizes..

"Replication crisis in psychology" -> Need a science of the individual based on the signals

"Principia project"

Important information is in "hidden variables" => neurotech

- Brain state: Motivation, vigilance, attention
- History: Individual conceptual spaces, experiences,
- Social dimensions - sensible DTU



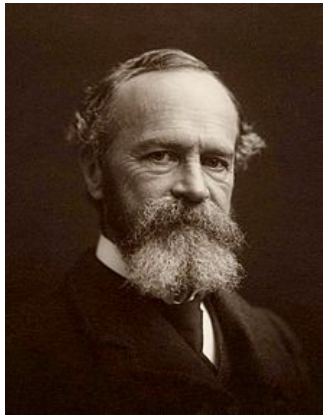
"It is a capital mistake to theorize before one has data"

William James, The Principles of Psychology (1890)

CHAPTER IV "Habit"

"When we look at living creatures from an outward point of view, one of the first things that strike us is that they are bundles of habits."

"In wild animals, the usual round of daily behavior seems a necessity implanted at birth; in animals domesticated, and especially in man, it seems, to a great extent, to be the result of education. The habits to which there is an innate tendency are called instincts; some of those due to education would by most persons be called acts of reason."



"It thus appears that habit covers a very large part of life, and that one engaged in studying the objective manifestations of mind is bound at the very outset to define clearly just what its limits are."

Limits of Predictability in Human Mobility

19 FEBRUARY 2010 VOL 327 SCIENCE

Chaoming Song,[1,2] Zehui Qu,[1,2,3] Nicholas Blumm,[1,2] Albert-László Barabási[1,2]*

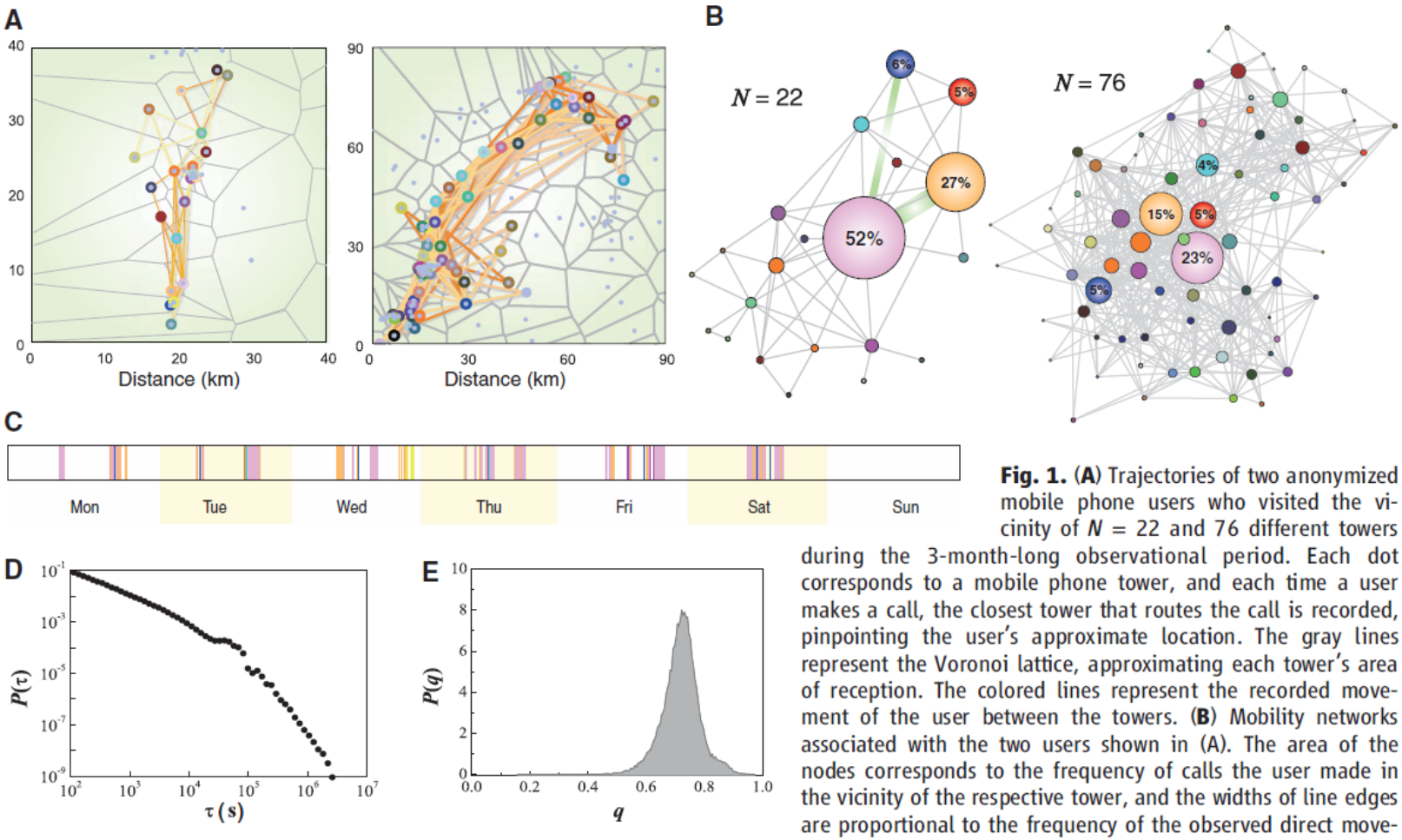
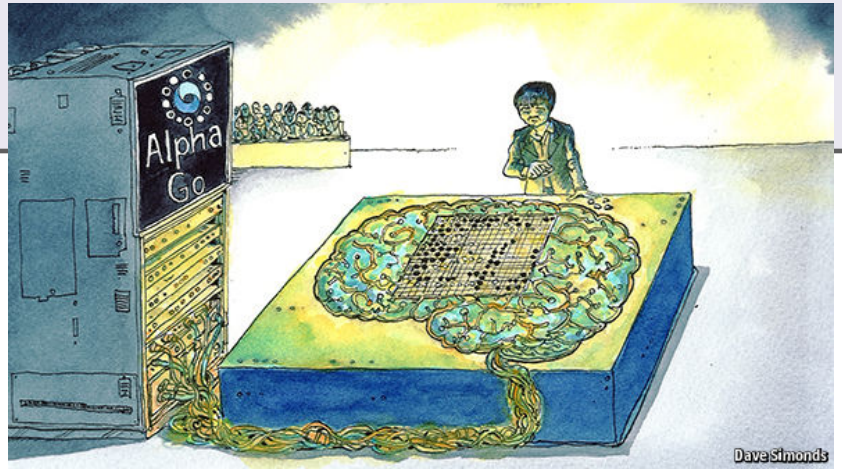


Fig. 1. (**A**) Trajectories of two anonymized mobile phone users who visited the vicinity of N = 22 and 76 different towers during the 3-month-long observational period. Each dot corresponds to a mobile phone tower, and each time a user makes a call, the closest tower that routes the call is recorded, pinpointing the user's approximate location. The gray lines represent the Voronoi lattice, approximating each tower's area of reception. The colored lines represent the recorded movement of the user between the towers. (**B**) Mobility networks associated with the two users shown in (A). The area of the nodes corresponds to the frequency of calls the user made in the vicinity of the respective tower, and the widths of line edges are proportional to the frequency of the observed direct movement between two towers. (**C**) A week-long call pattern that captures the time-dependent location of the user with N = 22. Each vertical line corresponds to a call, and its color matches the tower from where the call was placed. This sequence of locations serves as the basis of our mobility prediction. (**D**) The distribution of the time intervals between consecutive calls, τ, across the whole user population, documenting the nature of the call pattern as coming in bursts (*11*). (**E**) The distribution of the fraction of unknown locations, q, representing the hourly intervals when the user did not make a call, and thus his or her location remains unknown to us.

Outline



AlphaGo - Lee Sedol
3 - 1

Human behavior as a ressource

- What are the signals?
- What are the challenges?

5 minute business bs

- AI = Augmented intelligence
- Prepare for IQ=1000
- Why connected brains?

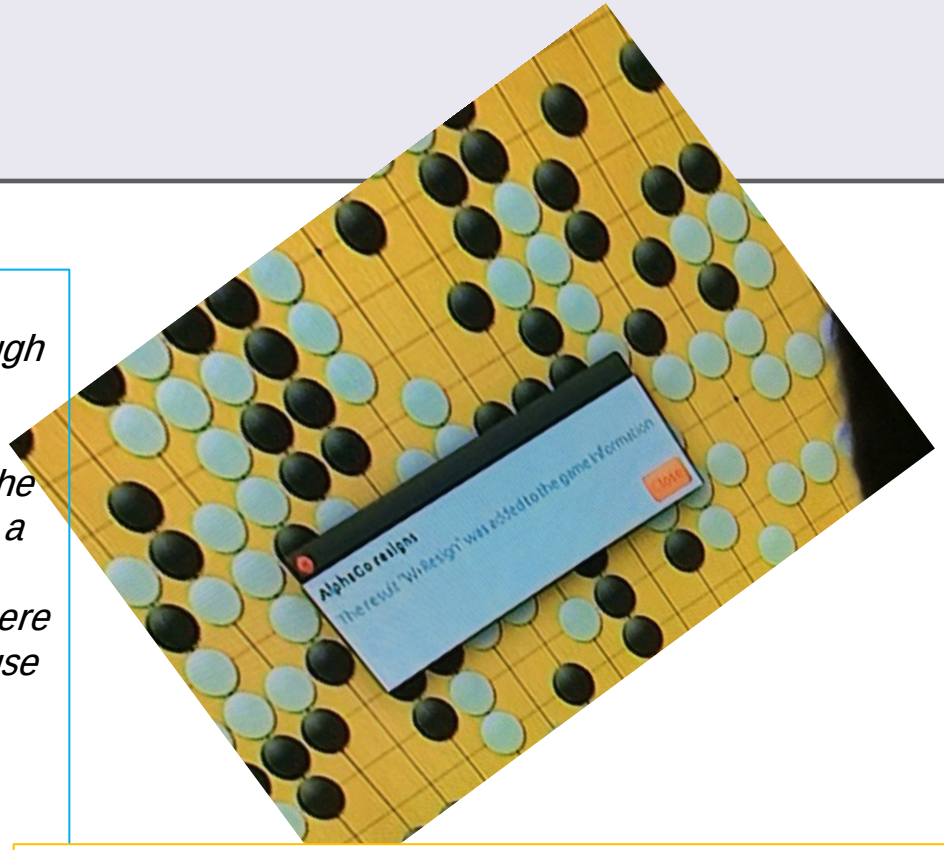
Mind reading internet

- Shift the focus from individual to social - Internet of brains
- IoB v1.0: Connected hearing aids
- Brain state monitoring - where are we?

How big is AlphaGo?

"So far, machine learning is missing its separate condenser moment. So is AlphaGo a breakthrough on the path to emulating human intelligence? I think of it more as a trig point. It's certainly an important intermediate goal, a chance to map the landscape and take the odd photo, but it is just a stage on the journey and one that we already knew we would reach. We have however got there quicker than expected, and that is a natural cause for celebration."

Neil Lawrence, Guardian Jan 28, 2016



#AlphaGo It is Lee vs 1,920 CPUs and 280 GPUs @ 3-4000 times the power consumed?... biology still rules
http://www.economist.com/news/science-and-technology/21694540-win-or-lose-best-five-battle-contest-another-milestone ...

We find out by understanding from top players whether alphago has a style of its own, whether its coming up with something creative, and that's after all why we've chosen to play with lee sedol, because we need someone who can really push alphago and try something different every day and really try and stretch him, stretch alphago to its limits to see how it will respond in all these different situations asnd so I don't know what alphago will do. we create it but we just have to stand back and watch it like everyone else.

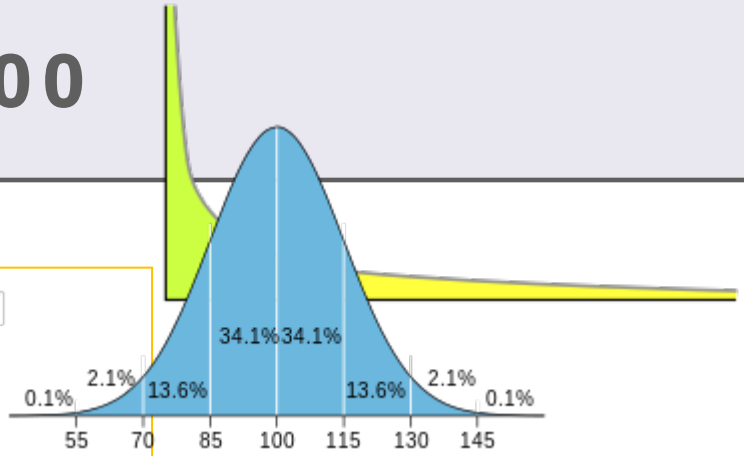
AI = Augmented Intelligence

…Fan Hui once sat in much the same place. As we talk after the match, he clearly feels an enormous empathy for Lee Sedol, complaining about the online critics who have lambasted the Korean's play. "Be gentle with Lee Sedol," he says. "Be gentle." But as hard as it was for Fan Hui to lose back in October and have the loss reported across the globe—and as hard as it has been to watch Lee Sedol's struggles—his primary emotion isn't sadness.

As he played match after match with AlphaGo over the past five months, he watched the machine improve. But he also watched himself improve. The experience has, quite literally, changed the way he views the game. When he first played the Google machine, he was ranked 633rd in the world. Now, he is up into the 300s. In the months since October, AlphaGo has taught him, a human, to be a better player. He sees things he didn't see before. And that makes him happy. "So beautiful," he says. "So beautiful."

Wired, March 2016

Prepare for ~~IQ~~ AIQ=1000



Status on human vs. machines

POSTED ON MARCH 15, 2015 UPDATED ON NOVEMBER 21, 2016

Are computers beating humans. In mere simple number crunching yes, but also in more complex tasks.

Year	Domain	Description
2016	Lipreading	Lip Reading Sentences in the Wild writes "… we demonstrate lip reading performance that beats a professional lip reader on videos from BBC television."
2016	Conversational speech recognition	Microsoft Research reports past human performance on benchmark datasets in Achieving human parity in conversational speech recognition
2016	Geoguessing	Google's PlaNet: "In total, PlaNet won 28 of the 50 rounds with a median localization error of 1131.7 km, while the median human localization error was 2320.75 km" according to Google Unveils Neural Network with "Superhuman" Ability to Determine the Location of Almost Any Image
2016	Go	DeepMind's AlphaGo beats best European Go player reported in January Mastering the game of Go with deep neural networks and tree search
		ImageNet classification by Microsoft Research researchers with deep neural network, see Delving Deep into Rectifiers:

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"Overzealous business types"?

Guess which occupation is NOT the most frequent among persons from the Panama Papers

The Wikidata scholarly profile page

So what can we use Wikicite for?

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"Overzealous b… on Metallica fan Milena Penkowa r…

Finn Årup Nielsen on Simplest sentiment analysis in…

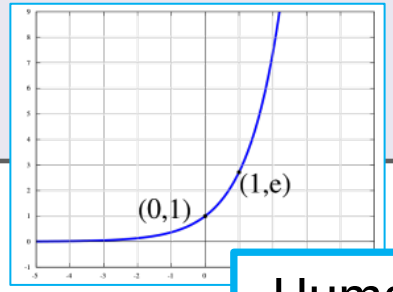
Prayson Daniel on Simplest

IQ(woman + computer) > IQ(computer)

Lars Kai Hansen – lkai@dtu.dk
Technical University of Denmark

Connected brains means business

Lars Kai Hansen – lkai@dtu.dk
Technical University of Denmark



Why?

Human progress and growth is driven by *division of labour* and *specialization* made possible by *communication*

Limiting factors to human progress and growth:

- *Intelligence:* our capacity for *deep specialization*
- *Communication:* our ability to *share*

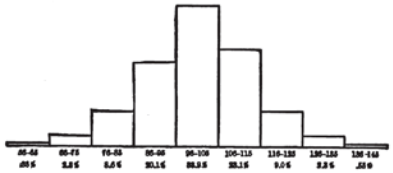


FIG. 8. DISTRIBUTION OF I Q'S OF 905 UNSELECTED CHILDREN, 5-14 YEARS OF AGE

Solutions for human progress and growth:

- *AI Augmented Intelligence*
- *B2B direct communication*
- A vision for *the effective society*

the effective ~~market~~ society:

actionable access to any open information from all brains to all brains

Support productivity and well-being

Respect democratic living and privacy

”Obvious business potential”

Human senses & brains are not optimal …

Ambiguity effect	The tendency to avoid options for which missing information makes the probability seem "unknown."[8]
Anchoring or focalism	The tendency to rely too heavily, or "anchor," on one trait or piece of information when making decisions (usually the first piece of information that we acquire on that subject)[9][10]
Attentional bias	The tendency of our perception to be affected by our recurring thoughts.[11]
Availability heuristic	The tendency to overestimate the likelihood of events with greater "availability" in memory, which can be influenced by how recent the memories are or how unusual or emotionally charged they may be.[12]
Availability cascade	A self-reinforcing process in which a collective belief gains more and more plausibility through its increasing repetition in public discourse (or "repeat something long enough and it will become true").[13]
Backfire effect	When people react to disconfirming evidence by strengthening their beliefs.[14]
Bandwagon effect	The tendency to do (or believe) things because many other people do (or believe) the same. Related to groupthink and herd behavior.[15]
Base rate fallacy or base rate neglect	The tendency to ignore base rate information (generic, general information) and focus on specific information (information only pertaining to a certain case).[16]
Belief bias	An effect where someone's evaluation of the logical strength of an argument is biased by the believability of the conclusion.[17]
Bias blind spot	The tendency to see oneself as less biased than other people, or to be able to identify more cognitive biases in others than in oneself.[18]
Cheerleader effect	The tendency for people to appear more attractive in a group than in isolation.[19]

list of cognitive biases in Wikipedia

http://en.wikipedia.org/wiki/List_of_cognitive_biases

DTU mobility projects

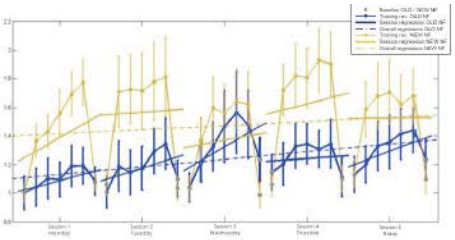
Social EEG-
- -Leaders and followers
- -Joint attention

Mobile real-time EEG Imaging
- -Neurofeedback
- -Digital media & emotion
- -Bhutan Epilepsy Project

Ivana Konvalinka

Simon Kamronn

Andreas Trier Poulsen



Camilla Falk

Farrah J. Mateen, Massachusetts General Hospital

Outline

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- What are the signals?
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5 minute business bs

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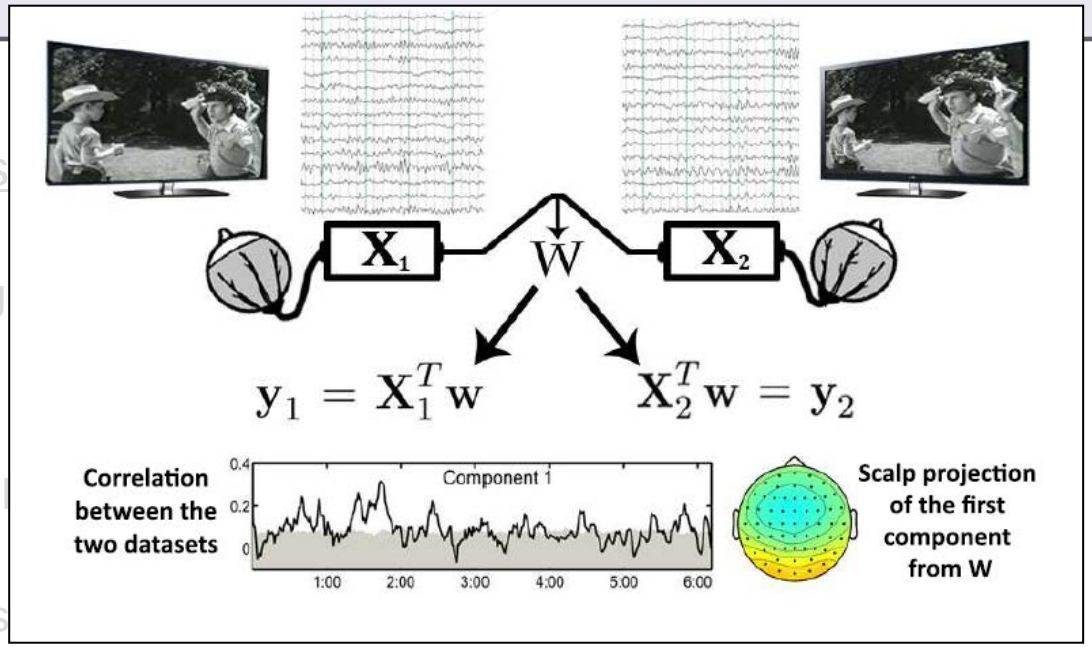
- Why connected brains



Mind reading internet

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Smartphone brain scanner

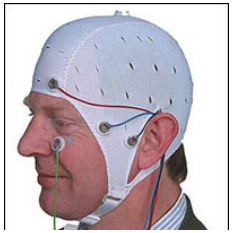
https://www.youtube.com/watch?v=i_66KAOzXhU

Bhutan epilepsy project

https://www.youtube.com/watch?v=Qkno9a0J9nM

Smartphone Brain Scanner

Based on the Emotiv wireless transmission mechanism w/ the EPOC head set or modified EasyCaps (Stefan Debener, Oldenburg)



Version SBS2.0 for generic Android platforms (Tested in Galaxy Note, Nexus 7,...)

https://github.com/SmartphoneBrainScanner

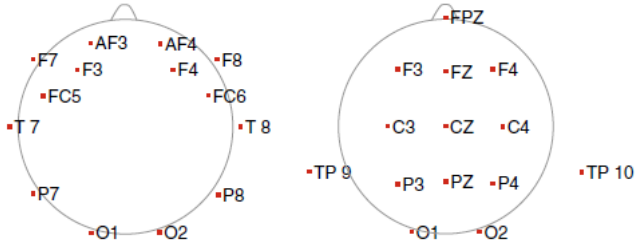
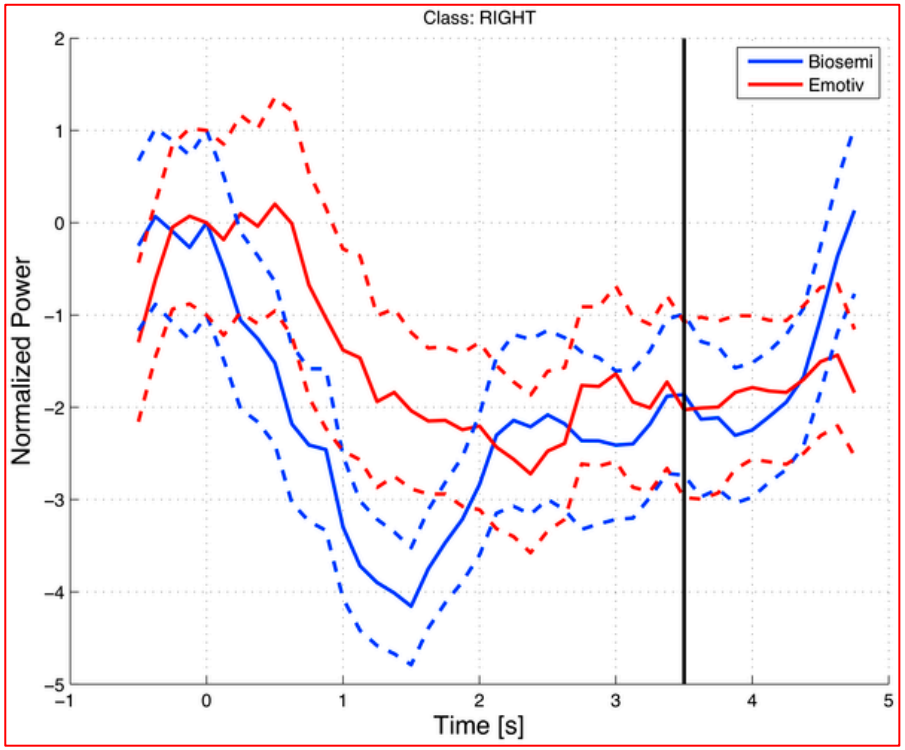


Fig. 5. Electrode locations for two mobile 16 channel EEG setups; the Emotiv neuroheadset using saline sensors positioned laterally (left), versus a standard gel-based Easycap EEG montage including central and midline positions (right).

A. Stopczynski, C. Stahlhut, M.K. Petersen, J.E. Larsen, C.F. Jensen, M.G. Ivanova, T.S. Andersen, L.K. Hansen. *Smartphones as pocketable labs: Visions for mobile brain imaging and neurofeed-back.* Int J. of Psychophysiology, (2014).

A. Stopczynski, C. Stahlhut, J.E. Larsen, M.K. Petersen, L.K. Hansen. *The Smartphone Brain Scanner: A Portable Real-Time Neuroimaging System.* PloS one 9 (2), e86733, (2014)

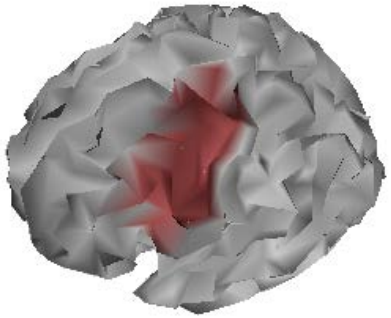
Do we get meaningful 3D images?

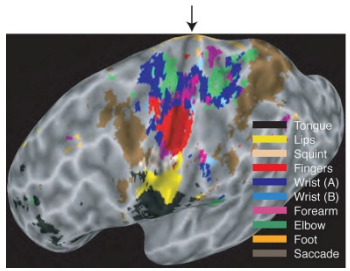


Imagined finger tapping

Left or <u>right</u> cued (at t=0)

Signal collected from an AAL region (n=80)





Meier, Jeffrey D., Tyson N. Aflalo, Sabine Kastner, and Michael SA Graziano. Complex organization of human primary motor cortex: a high-resolution fMRI study.Journal of neurophysiology 100(4) :800-1812 (2008).

A. Stopczynski, C. Stahlhut, M.K. Petersen, J.E. Larsen, C.F. Jensen, M.G. Ivanova, T.S. Andersen, L.K. Hansen. *Smartphones as pocketable labs: Visions for mobile brain imaging and neurofeedback.* International Journal of Psychophysiology, (2014).

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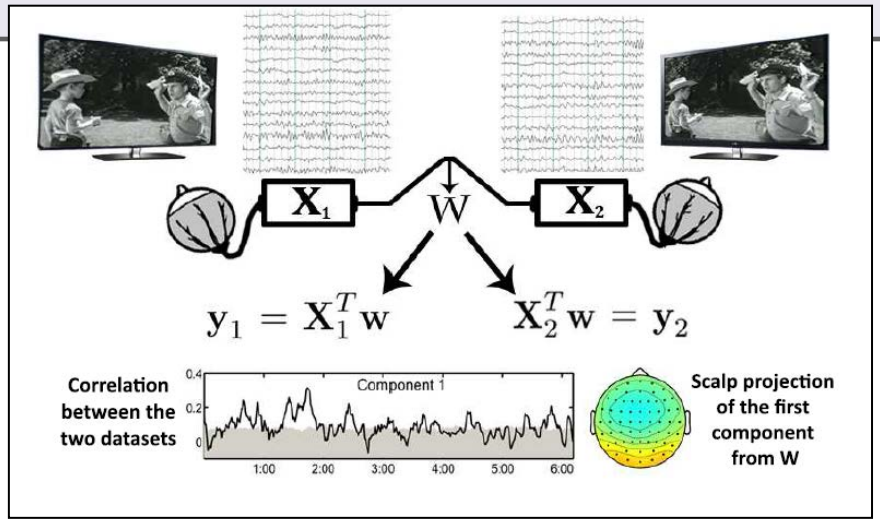
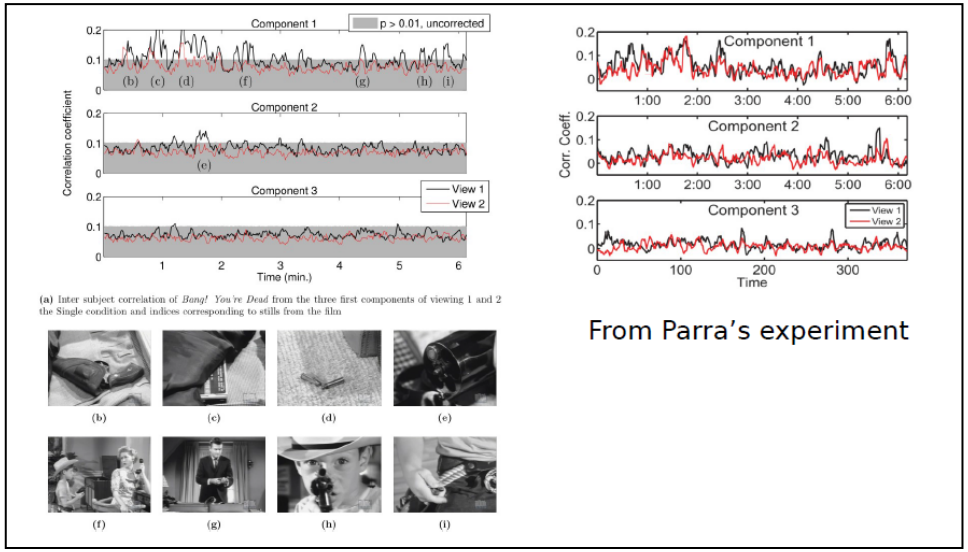
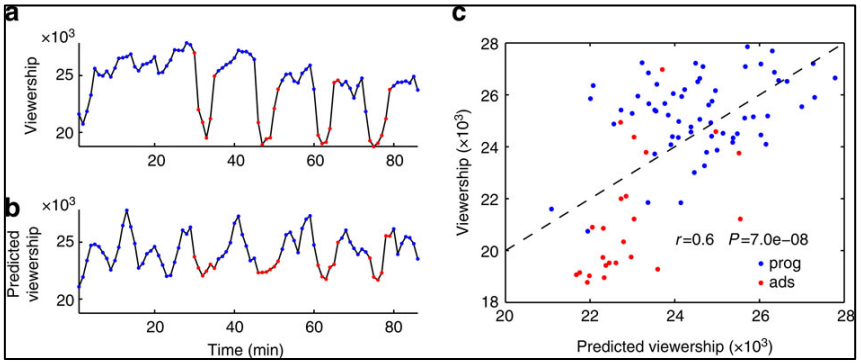
EEG in the classroom





From Parra's experiment



JP. Dmochowski et al, "Correlated components of ongoing EEG point to emotionally laden attention a possible marker of engagement?" Frontiers of Human Neuroscience, 6:112, April 2012.

JP. Dmochowski et al, "Audience preferences are predicted by temporal reliability of neural processing", Nature Communications 5: 4567, 2014.

AP Poulsen et al. "EEG in the classroom: Synchronised neural recordings during a video presentation." arXiv:1604.03019 (2016).

24/7 Neurotechnology - with Aarhus Univ, Roskilde Sygehus, Hyposafe/Widex
Connect lab neuroscience and everyday life

Conventional EEG system

High-performance research and clinical EEG system

Wearable EEG system

Discreet, unobtrusive and user-friendly assistive devices for everyday life

Ear-EEG/Hyposafe device

Smartphone data

Brain state representations connected by machine learning

Neurotech: Ear-EEG

Aim:

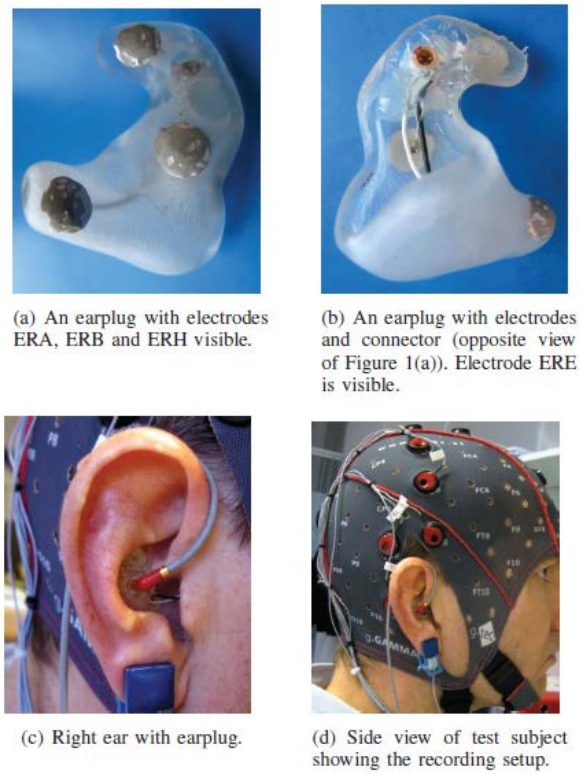
A discreete, non-invasive solution for long time recording in the wild

Status

EarEEG is a well-established technology

Classical EEG reproduced: Sustained and event related responses to audio and visual stimulus

High mutual information between ear and scalp EEG



(a) An earplug with electrodes ERA, ERB and ERH visible.

(b) An earplug with electrodes and connector (opposite view of Figure 1(a)). Electrode ERE is visible.

(c) Right ear with earplug.

(d) Side view of test subject showing the recording setup.

Fig. 1. View of a right ear earplug and the Ear-EEG recording setup.

Kidmose, P, et al. "Ear-EEG from generic earpieces: A feasibility study." *Engineering in Medicine and Biology Society (EMBC), 2013 35th Annual International Conference of the IEEE*. IEEE, 2013.

Hyposafe's subcutaneous EEG

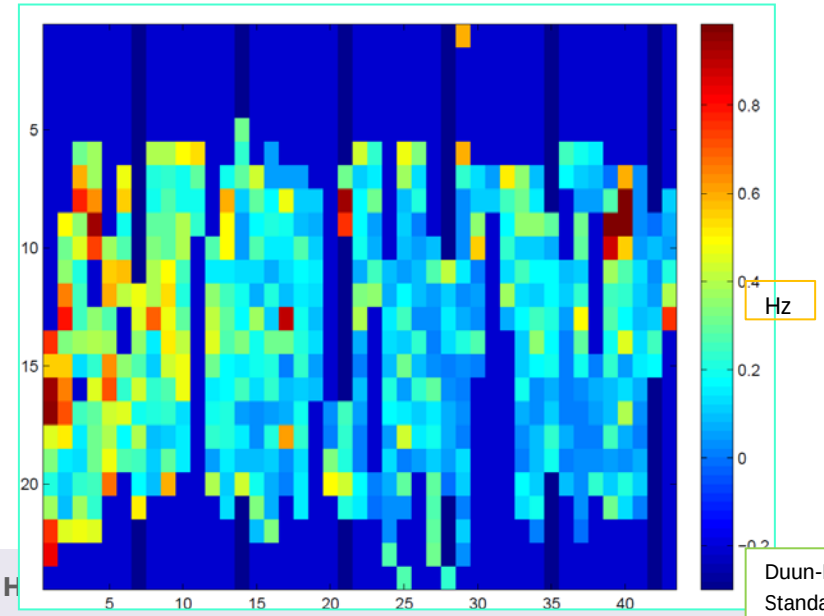
Permanent recording in the wild -
build for decoding hypoglaemia risk

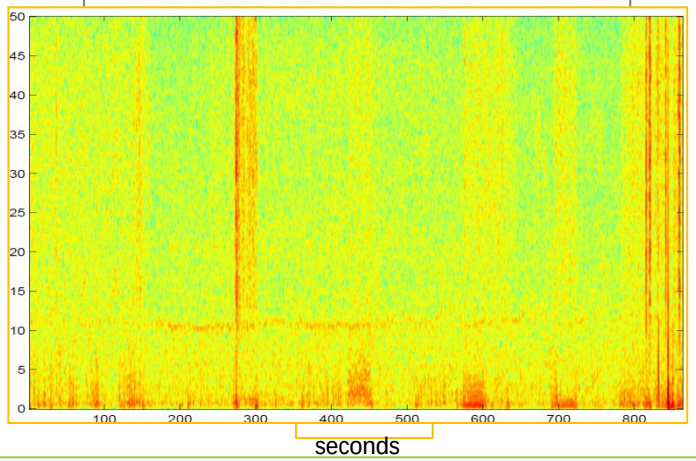
Status

Very stable subcutaneous electrode

Magnetic coupling (signal <-> power) with outside ear piece

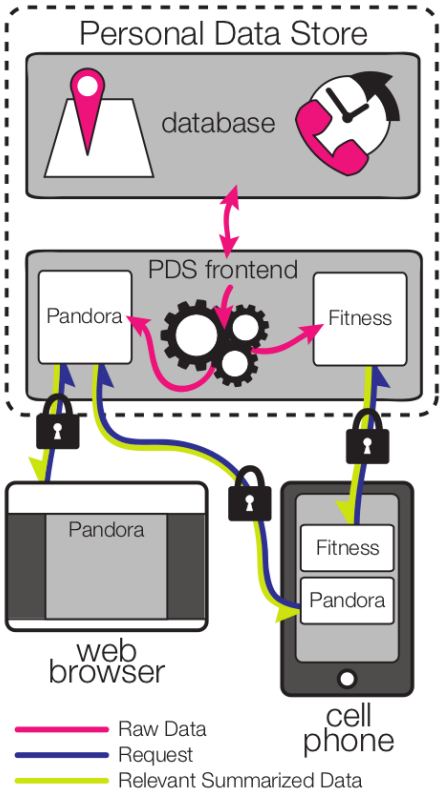
Signal highly correlated with surface electrode in same location.





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

Privacy… it's human to share



Intuitive data

Images, speech, economical, commercial, location, individual thoughts

Non-intuitive data

Health: diet, complete motion patterns

Physiology: heart beat, skin resistance, gaze, brain data, your mind set

Sandy Pentland calls for "**a new deal on data**" with three basic tenets:

1) you have the right to possess your data,
2) to control how it is used,
3) to destroy or distribute it as you see fit.

Privacy for Personal Neuroinformatics

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