

Applications of BCIs in Performance Art

Brain Painting, Brain Sculpting and Brain Dancing

Lars Schwabe - May 12, 2020
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ARIC Brown Bag Session

aric-hamburg.de



Lars Schwabe

Director AI, Data Analytics, Blockchain

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Background

Education [TU Berlin](#) (Informatik & Philosophie)

PhD TU Berlin ([Neuroinformatik](#))

Research [MIT](#), [Univ of Utah](#), [EPFL](#), [U Rostock](#)

Industries

Digital & Online Marketing

Aviation & MRO

Energy, Media, Transport & Logistics

Awards

[INNS Young Investigator](#), Best Paper Awards,
DFG Fellowships

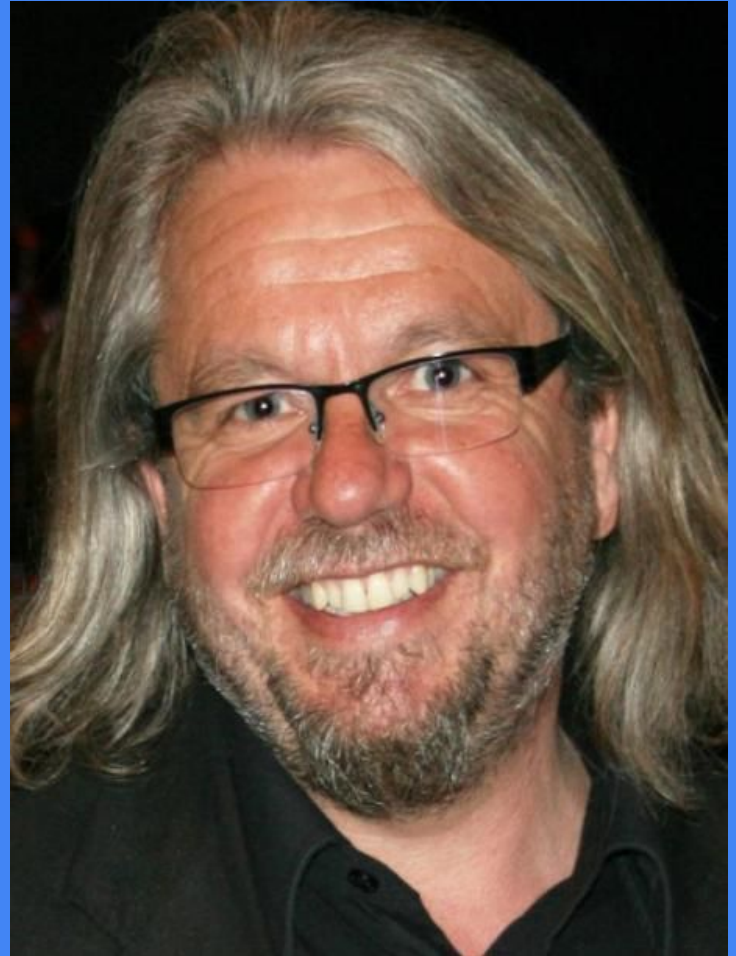
Publications

[Google Scholar](#) (active research until ~2013)



The Artist Behind these Projects

<https://retrogradist.com>
(Adi Hoesle)



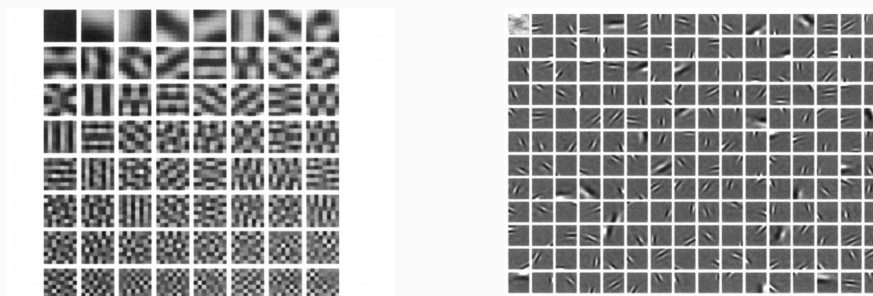
Background: Neuroscience

In neuroscience and neuroscience-inspired machine learning we believe that...

- ...neural activity in sensory systems reflects both i) **representations** and ii) **computations**
- ...the learning of representation is driven by **principles** + **constraints**

Example 1: Sparsity seems to matter

(Model: Olshausen, B., Field, D., Nature 381, 607–609, 1996)



Example 2: Bayesian inference seems to matter

(Many behavioural & imaging studies, models + interpretations)

$$\begin{aligned}\hat{x}_{bimod} &= \operatorname{argmax} P(x|r_{vis}, r_{aud}) \\ &= \frac{1/\sigma_{vis}^2}{1/\sigma_{vis}^2 + 1/\sigma_{aud}^2} \hat{x}_{vis} + \frac{1/\sigma_{aud}^2}{1/\sigma_{vis}^2 + 1/\sigma_{aud}^2} \hat{x}_{aud}\end{aligned}$$

↑ ↑ ↑ ↑
weight for vision visual estimate weight for audition auditory estimate

Consequence for BCIs:

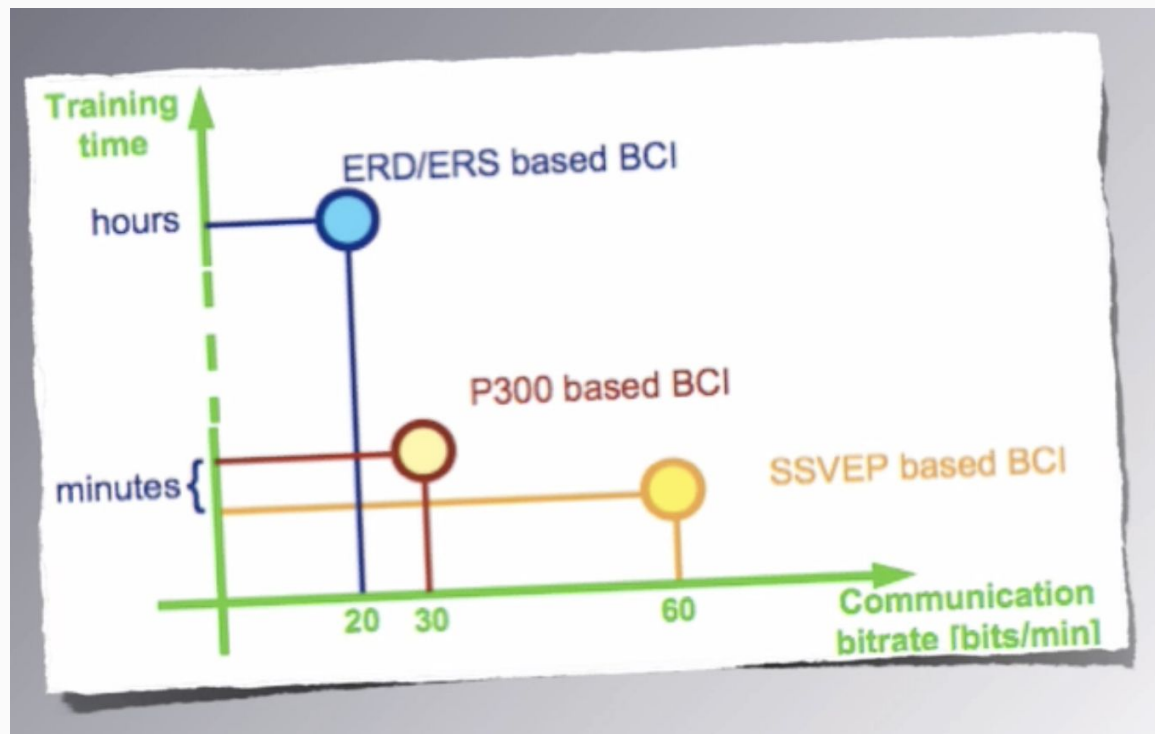
We are decoding brain activity that we currently do not fully understand from a scientific point of view!

Of course, this should not stop us.

Background: EEG-based BCIs

EEG reflects the electrical activity of many neurons in the brain.

We have to develop paradigms and tricks to make EEG-based BCIs work, because there are so many confounding factors and the signals are only macroscopic signals (but with a good temporal resolution).



Example: P300 Spelling

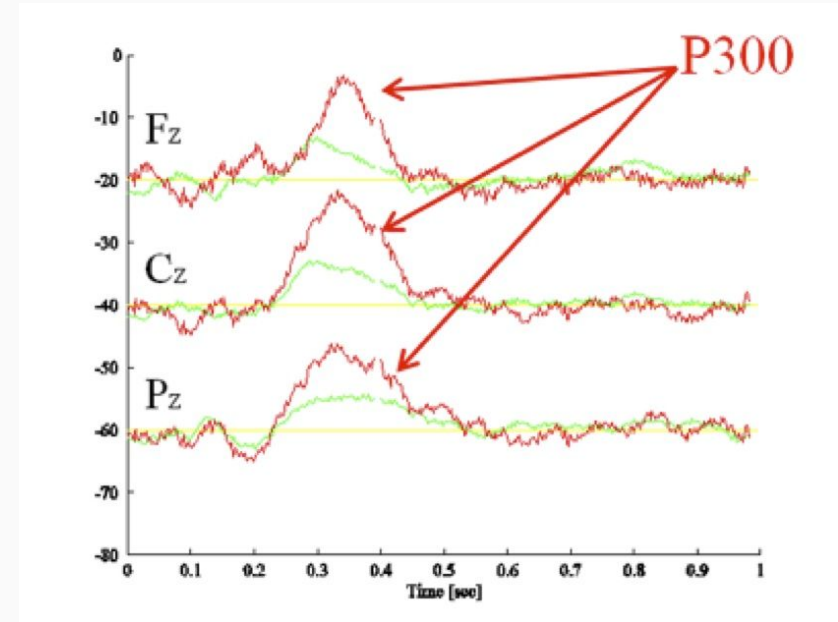



Image Source:

<https://psyenceblog.wordpress.com/2014/11/25/neuroimaging-as-lie-detection-detecting-retrieval-of-individual-memories-using-eeeg-recordings/>

Impressions: pingo-ergo-sum.com (Brain Painting)

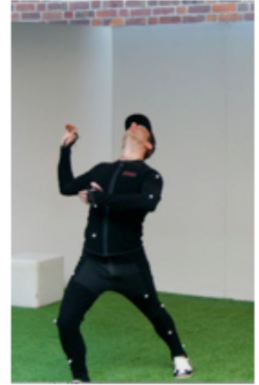


Adi Hoesle

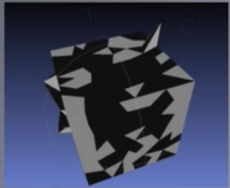
L	Q			75	W		31
					3	7	15
25	50					63	127
	100				255	511	
1	2		M	Z +	Z -		S
4	8		T	H	UD	RD	STOP 















Impressions: pingo-ergo-sum.com (Brain Painting)

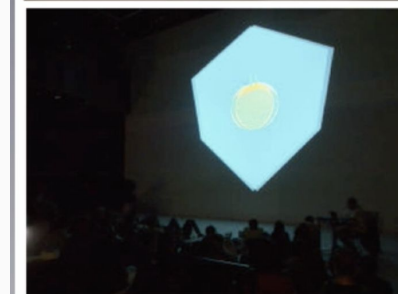


Impressions: Brain Sculpting @ Ars Electronica, 2012



- Plain OpenGL
- Stereo via Quad Buffer
- Bullet Physics Engine

Selector +Z	Rotate -90°	Elevate +22.5°	Enlarge Selector	Selector On	STL	Push 75%	Pull 75%
Selector -X	Rotate -45°	Elevate -22.5°	Shrink Selector	Selector Off	Save	Push 50%	Pull 50%
Selector +X	Rotate -15°			New		Push 25%	Pull 25%
Selector -Y	Rotate +15°						Load
Selector +Y	Rotate +45°						Lock Selector
Selector -Z	Rotate +90°	Undo					Unlock Selector

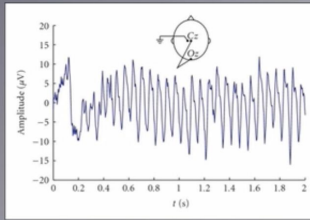
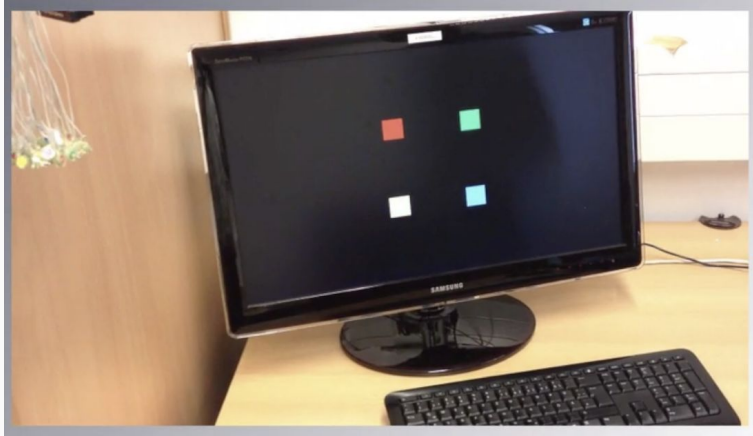


The Brain Dancing Project: Switch on the SSVEP-listening mode with your brain...

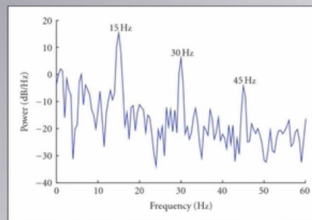
Use global brain state as the
wake-up signal for the SSVEP BCI



The Brain Dancing Project: The Effect of Colors



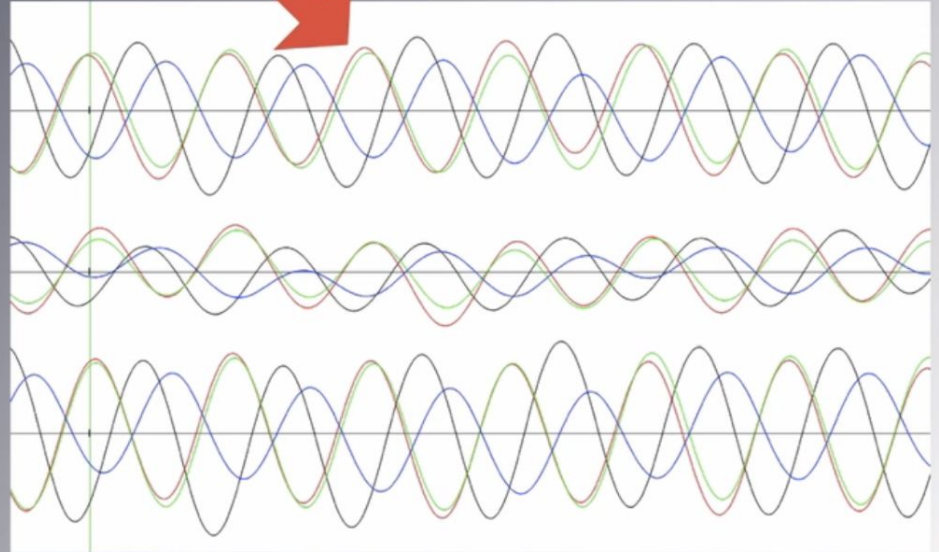
Typical waveform of an EEG signal (Oz-Cz) acquired during visual light stimulation with a frequency of 15 Hz.



Corresponding Powerspectrum.

Choose frequencies, which are NOT harmonics of each other!

Characterizing Color-dependent Delays and Amplitudes for Optimal PTSSVEP Stimulus Design



The Brain Dancing Project: The Final Setup (EU VERE Competition, 2012)



The Brain Dancing Project: Demo



15 Hz flickering, 75% duty cycle, 180 deg phase shift between **red** (right) and **blue** (left)
BioSemi ActiveTwo with only 1 Oz electrode, bandpass 13-17 Hz, decoding via MSE

Summary: BCI is an exciting, promising, but difficult field for AI. It is the next big thing.

Reading thoughts has always been part of the sci-fi literature and deemed not possible. But it is possible!

Research can be pushed -- as it was done for ML in the last decade -- by objective measures and competitions.

Words of caution: Many confounding factors (e.g. artifacts) and wishful thinking in certain communities (e.g. [Niels Birbaumer](#) case).

Current hardware technology is still the major limitation. But Neuralink's work (Mr. Musk) is a good indicator of future advances: We need to push BCI hardware development and go deeper (into the brain)

AI/ML & Neuroscience are ready-to-go once the sensor/actor technology is more mature.

We will be cyborgs...

Thanks for your attention.

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