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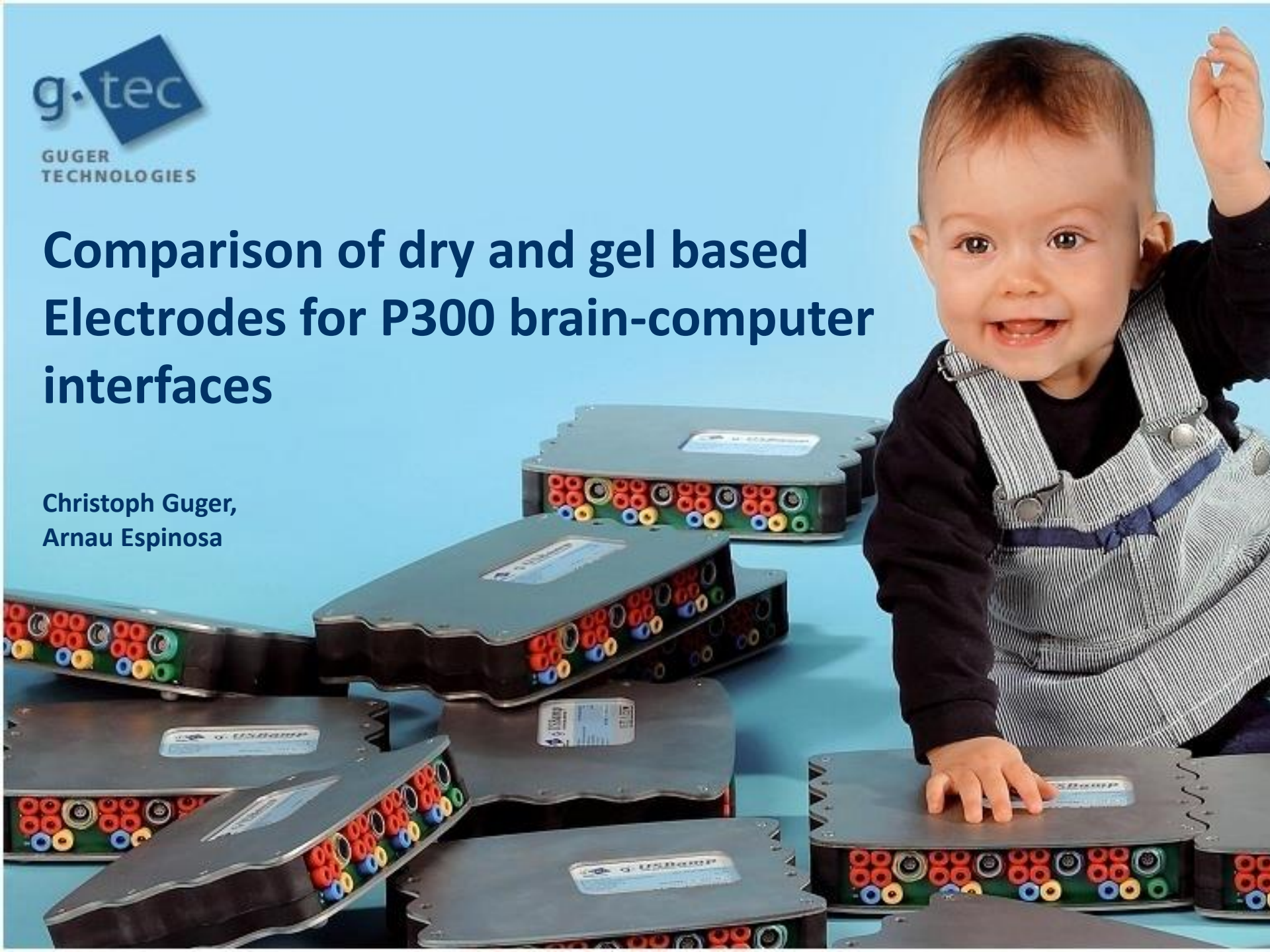
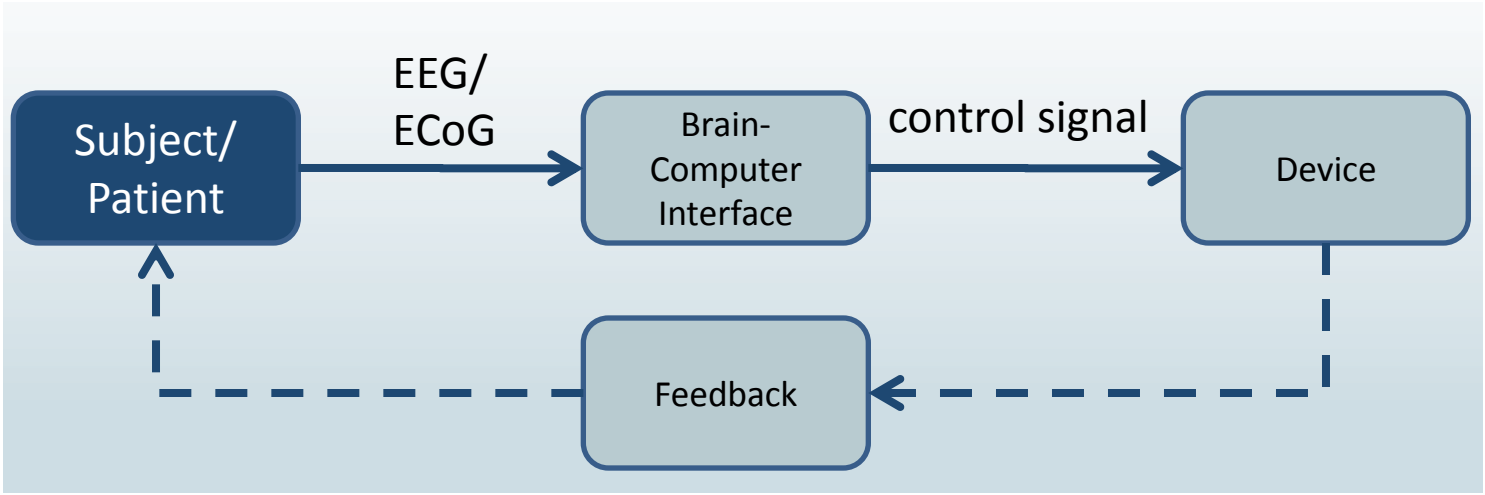
Comparison of dry and gel based Electrodes for P300 brain-computer interfaces

Christoph Guger,
Arnau Espinosa



Brain-Computer Interface (BCI)



"A system for **controlling a device** e.g. computer, wheelchair or a neuroprothesis by human intention which does not depend on the brain's normal output pathways of peripheral nerves and muscles" [Wolpaw et al., 2002].

HCI – Human Computer Interface

DBI – Direct Brain Interface (University of Michigan)

TTD – Thought Translation Device (University of Tübingen)

Some examples of BCI applications

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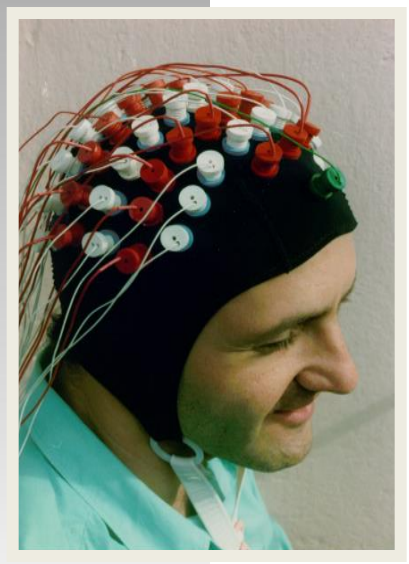
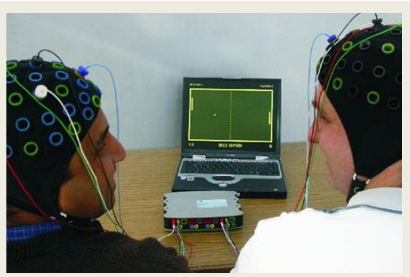
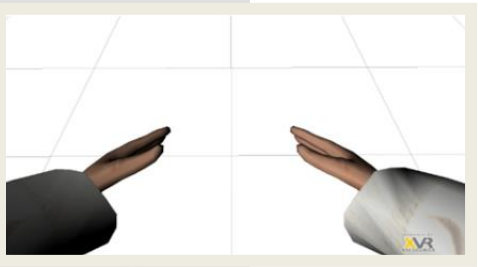


BCI





Changes of brain electrical activity and mental strategies

- Slow cortical potentials (anticipation tasks)

  DC-derivation, artifact problem, difficult strategy, feedback method

- Steady-State Evoked potentials (SSVEP, SSSEP)

  Flickering light with specific frequency

- Event-related, non-phase-locked changes of oscillatory activity ERD/ERS (motor imagery tasks)

  Changes of mu-rhythm, alpha activity and beta activity over sensorimotor areas; imagination of hand- ,foot-, tongue- movements

- Evoked potentials (focus on attention task)

  Thalamic gating, various methods of stimulation (visual, tactile, electrical, auditory, ...), P300

Comparison of gel and dry electrodes

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Normally, EEG is recorded with gel based electrodes

Low electrode-skin impedance important

Passive electrodes: skin must be abraded to reduce the impedance

Active electrodes: electrode gel is injected between the electrode material and the skin

Main disadvantages of gel based systems are:

•the long montage time

•the need to wash the user's hair after the recording

Dry EEG electrode concept

The g.SAHARA electrode system consists of an 8 pin electrode made of a special golden alloy

Pins have sufficient length to reach through the hair to the skin

Golden alloy and the 8 pins reduce the electrode-skin impedance

Electrode itself can be connected with a clip to the active electrode system on top of it

Positioning of dry electrodes

EEG recordings are performed at frontal, central, parietal and occipital regions of the head

Mechanical system is required that holds the electrode to the skin with a constant pressure at every possible recording location

EEG electrodes are typically positioned according to the International 10/20 System

Cap with a total of 160 positions according to an extended 10/20 system, to allow a very flexible electrode montage

Electrode Montage

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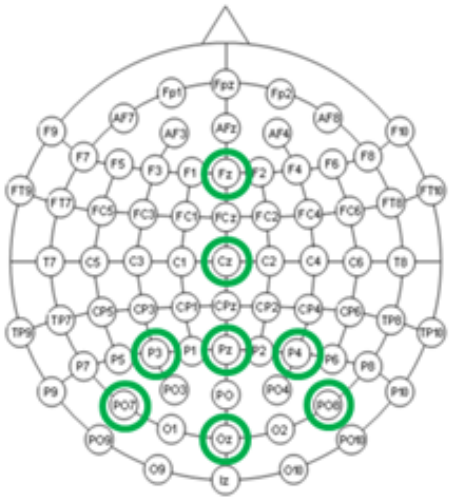
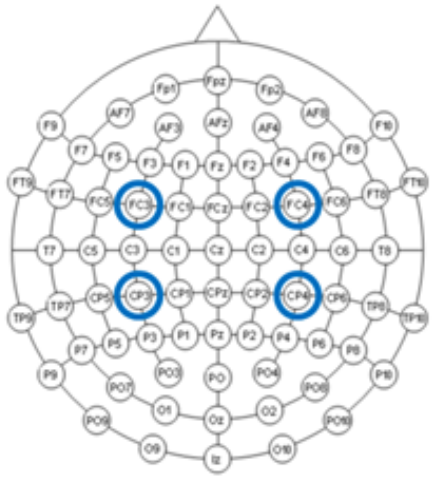
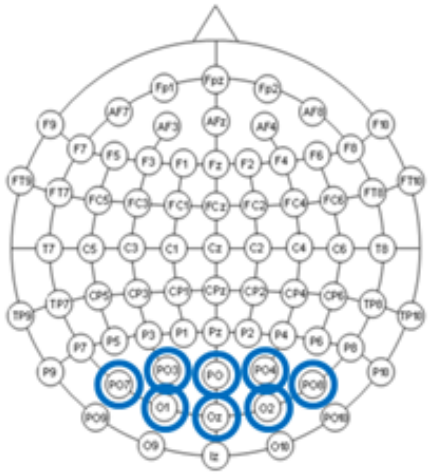
P300



Motor imagery



SSVEP



[Video1]

[Video 2]

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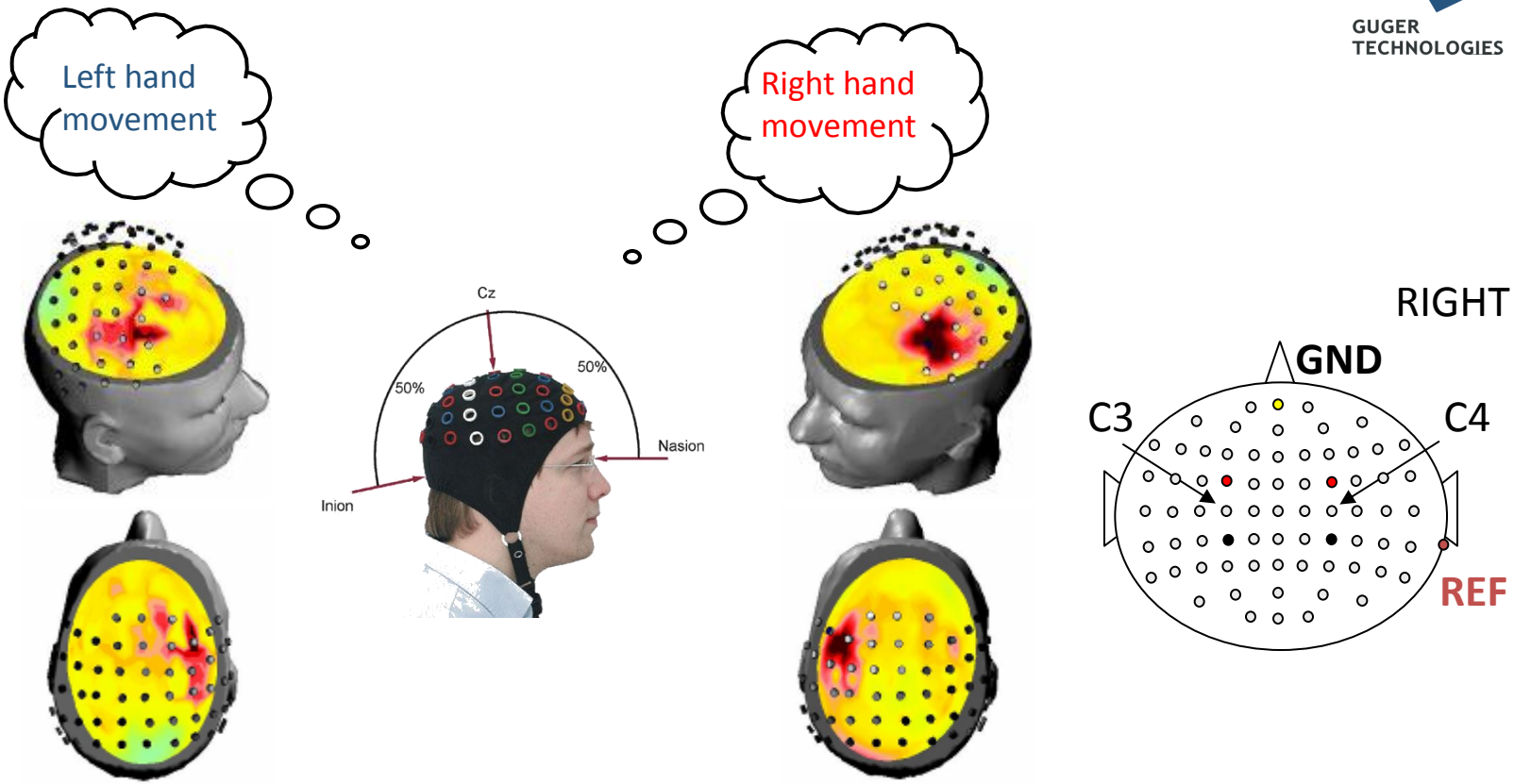
Physiological Background

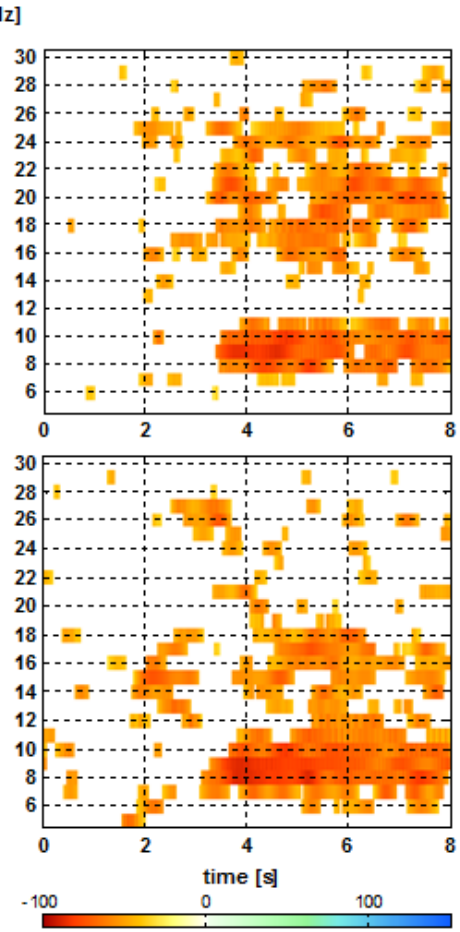


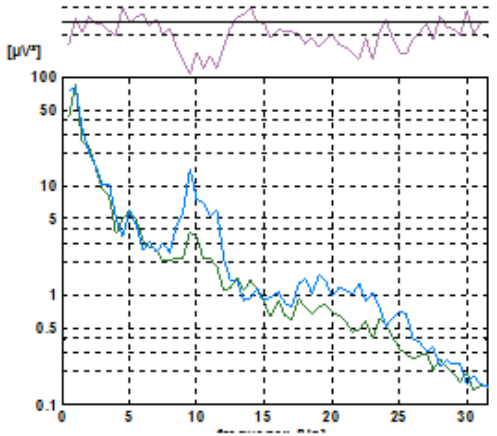
Imagination of hand movement causes an ERD which is used to classify the side of movement. The desynchronization occurs in motor and related areas of the brain.

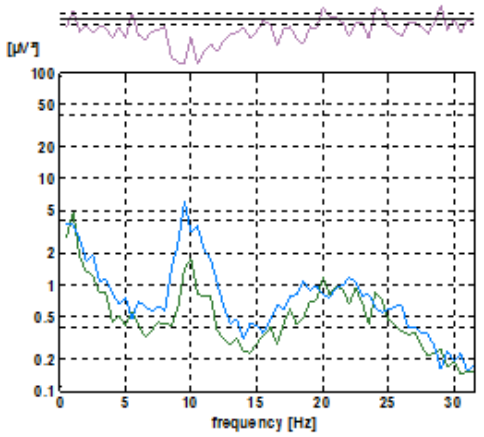
Motor imagery – ERDmaps of C3 and right hand movement

Dry

Gel



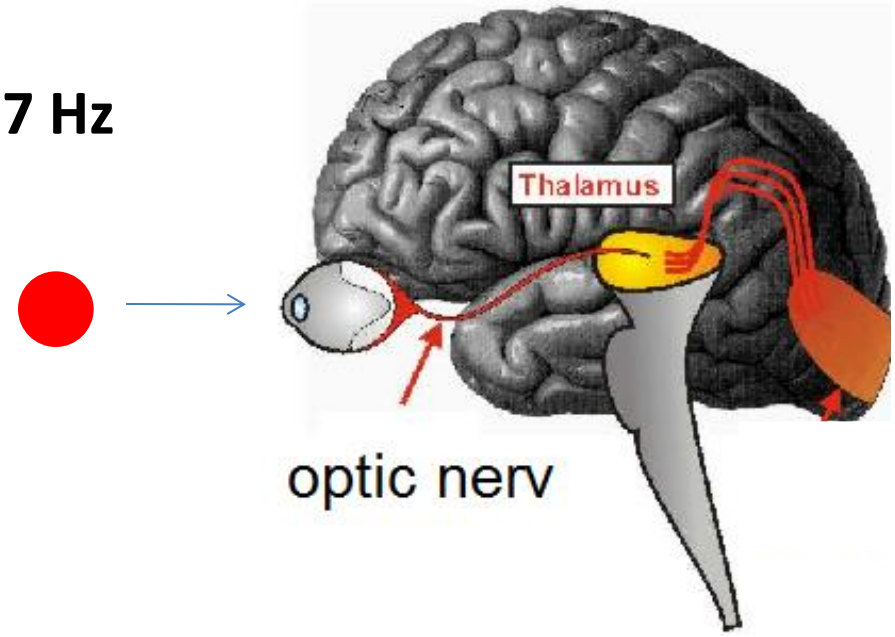




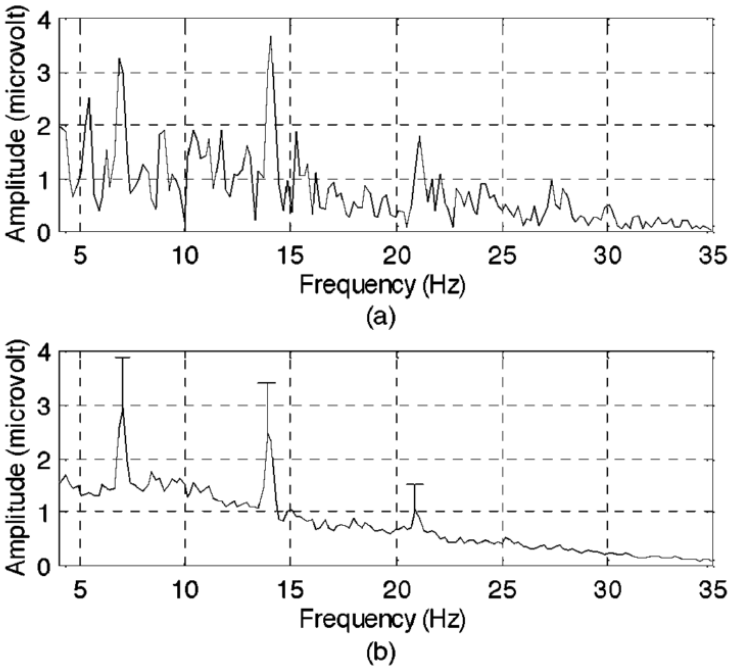
Methodology

Steady State Visually Evoked Potentials (SSVEP)

7 Hz

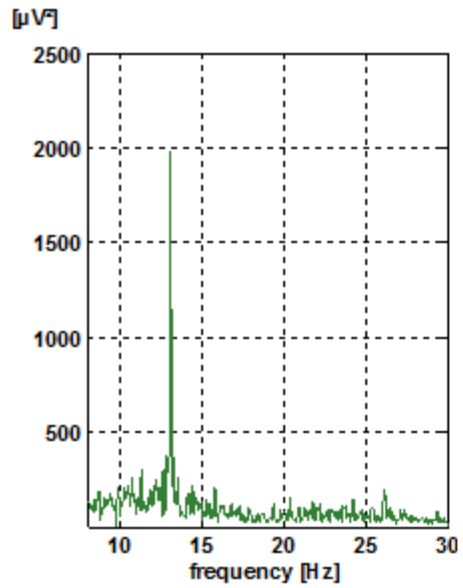


SSVEP

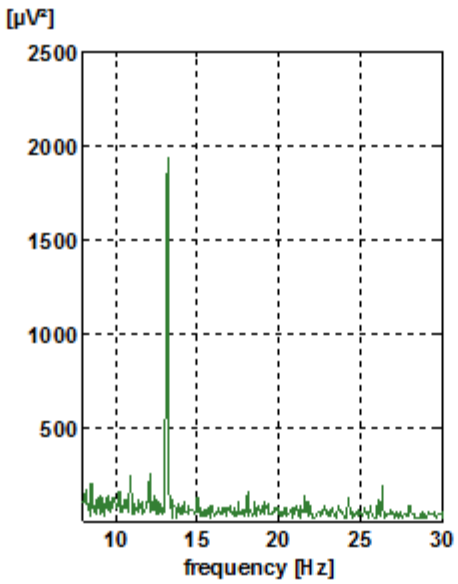


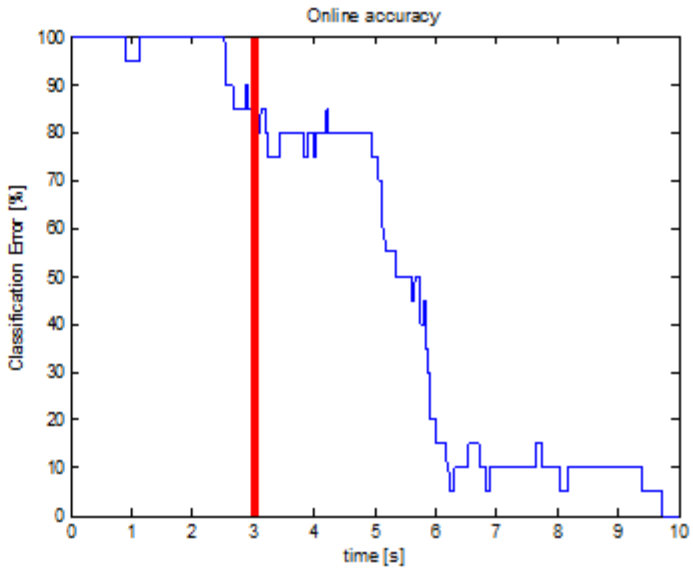
SSVEP - Power Spectrum of Oz stimulated with 13 Hz and accuracy

Dry



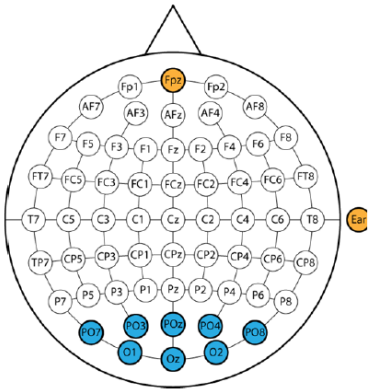
Gel





SSVEP group study accuracy

Accuracy (%)	Number of subjects performing at specified accuracy				Percentage of people after training
	Run 1	Run 2	Run 3	Run 4	
100	22	25	27	27	50.9
90-99	14	19	19	19	35.8
80-89	7	4	5	5	9.4
70-79	2	1	0	1	1.9
60-69	1	2	1	1	1.9
50-59	4	1	0	0	0.0
40-49	3	0	1	0	0.0
0-39	0	1	0	0	0.0
Mean Accuracy	87.9	92.9	95.0	95.5	
	N=53	N=53 with 14 new	N=53 with 7 new	N=53 with 2 new	



Poor performance in SSVEP BCIs: Are worse subjects just slower?

frontiers IN NEUROPROSTHETICS

How many people could use an SSVEP BCI?, Christoph Guger, Brendan Z Allison, Bernhard Grosswindhager, Robert Prückl, Christoph Hintermüller, Christoph, Kapeller, Markus Bruckner, Gunther Krausz and Guenter Edlinger, Frontiers in Neuroprosthetics, 2012.

P300 based speller video

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Evoked Potential: P300 response of copy spelling with 5 characters

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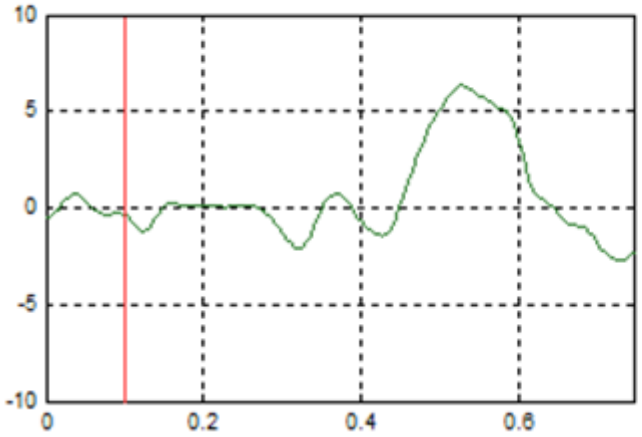
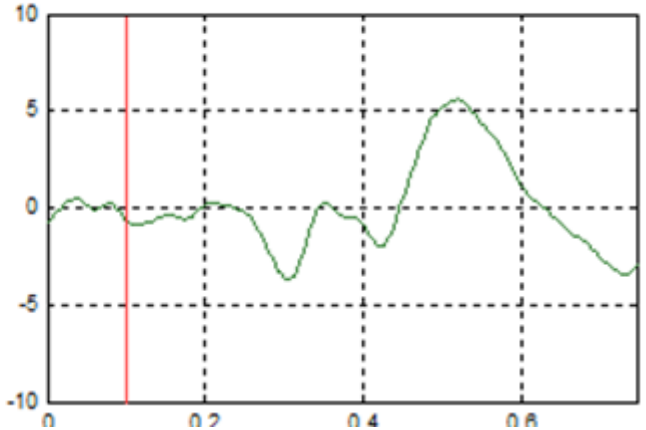
Dry Electrode Cz

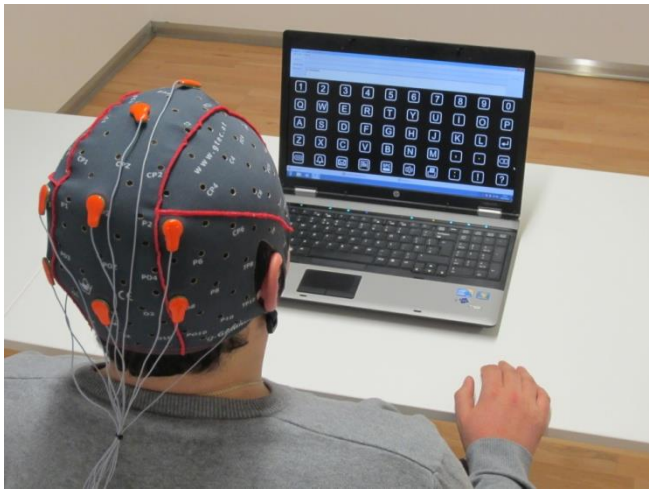


Gel Electrode Cz



P300 group study results

Row-Column Speller Classification Accuracy in %	Gel electrodes (N=81) [Guger 2009]	Dry electrodes (N=23)
100	72.8	69.6
80-100	88.9	87.0
60-79	6.2	8.7
40-59	3.7	4.4
20-39	0.0	0
0-19	1.2	0
Average Accuracy of all subjects	91.0±18.5	90.4 ±17.2



Frontiers 2012, Comparison of dry and gel based electrodes for P300 brain-computer interfaces

Discussion

Dry electrode system that works for motor imagery, SSVEP and P300

Whole frequency range available: 0.1-40 Hz

Dry electrode system that covers extended 10/20 system on frontal, central, parietal and occipital sites

More low frequency components in the EEG spectrum below 3 Hz

Careful montage required and more sensitive to surrounding noise

Very useful e.g. for stroke rehabilitation applications


The Annual BCI Research Award 2012
FOR THE WORLD'S MOST INNOVATIVE BRAIN-COMPUTER INTERFACE PROJECT
this year awarded by the
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(Washington University School of Medicine, St. Louis)
at the
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Leigh Hochberg, Gert Pfurtscheller, Gerwin Schalk
and Junichi Ushiba
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