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

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Brain-Computer Interface (BCI)

“A system for controlling a device e.g. computer, wheelchair or a neuroprosthesis 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
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

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

P300

Motor imagery

SSVEP
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
Methodology

Steady State Visually Evoked Potentials (SSVEP)

SSVEP

7 Hz
SSVEP - Power Spectrum of Oz stimulated with 13 Hz and accuracy
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     | 0                      | 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 with 14 new

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

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

Spelling with the brain-computer interface
g.tec - Austria

biomedical engineering program
Evoked Potential: P300 response of copy spelling with 5 characters
# P300 group study results

| Row-Column Classification Accuracy in % | Speller Classification Accuracy in % [Guger 2009] | Gel electrodes (N=81) | 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 Center for Innovation in Neuroscience and Technology (Washington University School of Medicine, St. Louis)
at the SfN annual meeting, Neuroscience 2012
Oct. 13 - 17, 2012 in New Orleans, Louisiana, USA

The jury
Eric Leuthardt (chairman), Moritz Grosse-Wentrup, Leigh Hochberg, Gert Pfurtscheller, Gerwin Schalk and Junichi Ushiba

Submission deadline
July 15, 2012

Nominee notification
August 15, 2012

Send your submission to
bciaWARD2012@gtec.at

More details about the BCI Research Award at
www.bci-award.com

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