CEBE Project P4: Evaluation of mental disorders using EEG analyser

Hiie Hinrikus
Department of Biomedical Engineering
Technomedicum of Tallinn University of Technology

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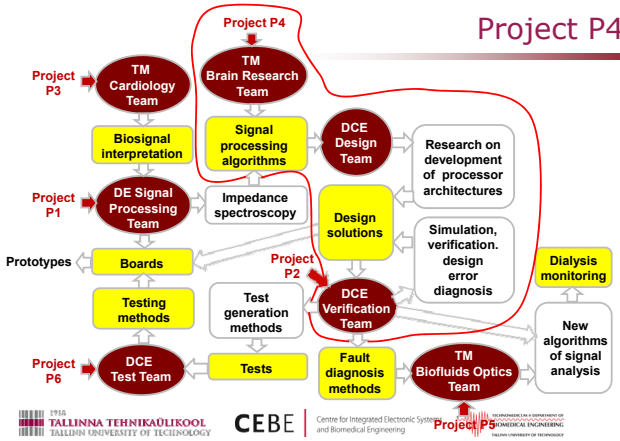
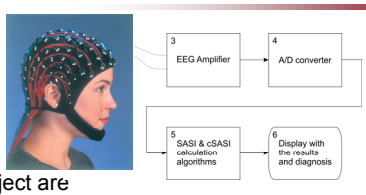
Project P4



Goal



The goals of the project are

- ✓ elaboration and modification of EEG algorithms for detection of mental disorders;
- ✓ electronic implementation of the algorithms as a specific signal processor;
- ✓ development of portable device based on EEG analysis targeted at evaluation of mental disorders.

Cooperative partners

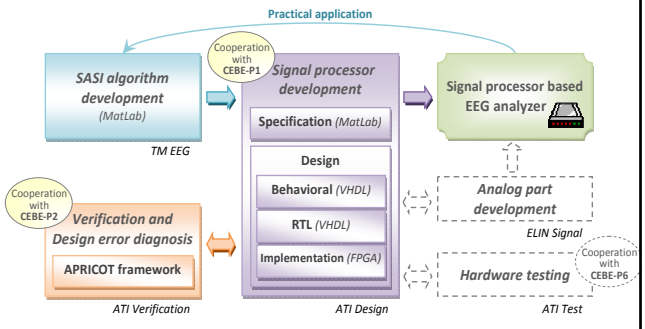
TM Brain Research Group *Leader*: H. Hinrikus; *Team*: J.Lass, M.Bachmann, H.Lurje, A.Suhhova, V. Tuulik,

DCE Design Group *Leader*: P. Ellervee; *Team*: M.Gorev, V.Pesonen, D.Mihhailov, A.Batanov

DCE Verification and Diagnosis Group *Leader*: J.Raik; *Team*: M.Jenihhin, A.Chepurov, U.Repinski

Consultants: P.Annus (DE), A.Sudnitsõn (DCE) Practical application

Cooperation scheme



Brain research group

Department of Biomedical Engineering, Technomedicum of TTU

- ✓ Hiie Hinrikus, DSc, Prof., Leading research fellow,
- ✓ Maie Bachmann, PhD, Senior researh fellow,
- ✓ Jaanus Lass, PhD, Senior researh fellow,
- ✓ Viiu Tuulik, PhD, DMed, Senior researh fellow
- ✓ Anna Suhhova, PhD student at TTU
- ✓ Hanno Lurje, MSc student at TTU

Cooperation

Psychiatry Clinic, North Estonia Medical Centre

- ✓ Kaire Aadamsoo, D Med, Head of the Clinic,
- ✓ Ülle Võhma, D Med,

Brain research group

Research areas
- ✓ effect of weak physical stressors (EM radiation) on EEG rhythms;
- ✓ effect of noise in information processing in the brain.

Methods
- ✓ EEG analysis
- ✓ psychological tests

Cooperation
Psychiatry Clinic, North Estonia Medical Centre

Exciting finding reported by Rohan et al., 2004. Low-field magnetic stimulation in bipolar depression using an MRI-based stimulator. Am J Psychiatry;
Idea: to apply modulated microwave radiation for depression stimulation; as a measure parallel to BAS spectral asymmetry (SA) was used
Unecpected result: not so strong effect of radiation, but remarkable difference in SA between depressive and healthy subjects

Background

Depression and other mental disorders are more and more frequent. About 340 million people (6 per cent of total population of the world) suffer from deep depression. According to study performed by NIH, USA, during last 10 years the number of diagnosed depression increased about 40 times.

The physiological mechanisms of these are not finally clear yet. As a cause of depression, biochemical changes in brain can be considered as disturbance of the function of catecholamines and serotonin in the brain. According to another theory, depression is related to the imbalance of neurotransmitters in the brain.

Diagnosis of depression

The diagnosis for depression is traditionally based on evaluation of the intensity of subjective and clinical symptoms by psychiatrists (M.I.N.I. interview, Hamiltoni test). Distinguishing reactions to somatic diseases from depressive disorders requiring treatment is very complicated in psychiatric diagnostics. Therefore, there is a great need for methods for determining depression based on objective symptoms.

There is a **further need for objective monitoring** of possible appearance of depressive conditions or other mental disorders of high-risk or high-stress workers such as military personnel, police, rescue workers.

Without doubt, mental disorders are related to **changes in physiological state of the brain and EEG** and EEG analysis can provide objective information.

SASI method

The method utilizes a calculation algorithm for **spectral asymmetry index (SASI)** based on the balance between the powers of two special EEG frequency bands selected lower and higher of the EEG spectrum maximum and excluding the central frequency band round the maximum from calculations. The polarity of the index value is the main indicator of the depressive (or other) mental disorder.

The SASI was compared to the EEG inter-hemispheric asymmetry and coherence and showed much better distinguishing between depressive and healthy subjects. Hinrikus et al., Med Biol Eng Comp, 2009.

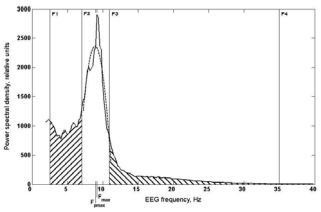
Calculation algorithm

$$SASI = \frac{\int_{f_3}^{f_4} X(f)\,df - \int_{f_1}^{f_2} X(f)\,df}{\int_{f_3}^{f_4} X(f)\,df + \int_{f_1}^{f_2} X(f)\,df}$$

where X(f) is power spectrum of the EEG signal;
frequency band f3 to f4 is selected higher (beta band B);
frequency band f1 to f2 is selected lower (theta band T) than the EEG spectrum maximum.
An important feature defining the B and T bands is excluding central frequency band around spectral maximum (alpha band A) from the analysis.
Therefore, limiting frequencies are related to the spectrum maximum.

Selection of frequency bands

1. the frequency with the maximum spectral power *fmax* was estimated;
2. the parabolic approximation was applied to the spectrum of the EEG central frequency band (*fmax* ± *B*) Hz, where *B* was half-width of the band;
3. the maximum point of the fitted parabola *fc* was taken as a centre of the central band;
4. limiting frequencies are determined as:
   f1 = *fc* - 6Hz,
   f2 = *fc* - 2Hz,
   f3 = *fc* + 2Hz,
   f4 = *fc* + 26Hz.



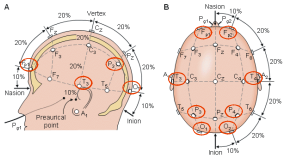
Experimental study

Experiments were performed to define
- optimal EEG channels;
- length of the EEG signal for analysis

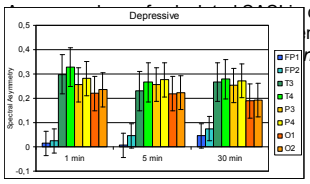
Subjects: two groups of 18 female volunteers: a group of patients with major depressive disorder: Hamilton Depression Rating Scale average score 21, SD 3.3, without antidepressant treatment and control group.

Resting eyes closed EEG was recorded during 30 min. using 19 electrodes, placed according to the international 10-20-electrode position system

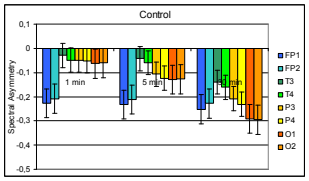
EEG channels for analysis: frontal FP1, FP2, temporal T3, T4, parietal P3, P4, occipital O1 O2



Results: length of signal



different EEG channels at 1, 5 and 30 nts for depressive and control group =18).



Results: length of signal

Bonferroni corrected *p*-values for differences in spectral asymmetry between d 18) in different EEG channels at signal segments *t*.

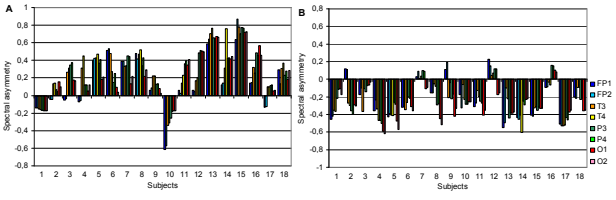
EEG channel	*t*=1 min	*t*=5 min	*t*=30 min
FP1	**0,007**	**0,007**	**0,005**
FP2	**0,005**	**0,008**	**0,004**
T3	**0,004**	**0,017**	**2E-04**
T4	**0,019**	**0,012**	**1E-04**
P3	**0,004**	**0,001**	**3E-05**
P4	**0,001**	**3E-04**	**7E-05**
O1	**0,006**	**0,001**	**2E-05**
O2	**0,004**	**0,001**	**2E-05**

Results: correlation

Correlation coefficients between SASI values in different EEG channels as well as Hamilton Depression Rating Scale score for a group

	FP1	FP2	T3	T4	P3	P4	O1	O2
FP1								
FP2	0,974							
T3	0,817	0,875						
T4	0,709	0,751	0,935					
P3	0,658	0,727	0,876	0,873				
P4	0,666	0,729	0,884	0,867	0,993			
O1	0,542	0,605	0,772	0,793	0,947	0,931		
O2	0,596	0,651	0,777	0,796	0,956	0,949	0,982	
HAM-D	0,534	0,566	0,591	0,625	0,697	0,673	0,725	0,708

Results: individual subjects



Calculated SASI values for individual subjects in A. depressive group and B. control group in different EEG channels at 30-minute length of the EEG signal.

Conclusions from experiments

- ✓ The results showed positive average SASI values for depressive and negative SASI values for healthy group at all brain regions and for majority of individual subjects.
- ✓ Calculated SASI values behave similarly in all EEG channels and both hemispheres
- ✓ SASI values are well correlated in different EEG channels and with Hamilton Depression Rating Scale score
- ✓ SASI distinguish significantly between depressive and healthy groups in the case of 1, 5 and 30 min EEG signal lengths
- ✓ Distinguishing of SASI between depressive and healthy subjects increases with the length of the EEG signal.

Easy to implement
- one EEG channel
- 10-20 min EEG recording

Future

Hypothesis:

SASI reveals disturbed state of the brain

Increases in the EEG beta power caused by alcohol, EMF, anxiety disorder have been reported in publications.

Investigation of SASI for

- ✓depression – larger databases
- ✓other mental diseases
- ✓different external stressors (alcohol, EMF, noise etc)
- ✓correction of algorithm

Application of separate portable device for SASI measurements is very important in further research.