BRAIN AWARENESS WEEK (BAW)

PROCEEDINGS

Second Conference 2015

Human-Machine Interface

from

Student-to-Student Interface

HMI from SSI

University of Belgrade - School of Electrical Engineering

March 20. 2015, Belgrade, Serbia

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Welcome address

We

- aim to provide a scientific stage with a powerful presenter-audience relationship;
- encourage creative learning and active engagement of students;
- help young persons to reach their potential;
- actively mentor the next generation of students;
- reach out to a diverse student audience;
- are proud to have showcased an array of events over a four-year period;
- look forward to sharing this day with you and welcome all interested parties to attend the second *HMI from SSI* Conference

Yours,
http://bmit.etf.bg.ac.rs/

FOREWORD (2011-2015)

Brain Awareness Week (BAW) is a worldwide campaign supported by Dana Foundation (New York, US). Every March starting from 1996 in the US, and in the form of global campaign since 2000, institutions all over the world are organizing activities and events with the aim to increase public awareness on the benefits and progress of brain research. Each year, over thousand of such events are held in the world.

School of Electrical Engineering at University of Belgrade hosted the First BAW seminar ***Brain Computer Interface from Student-to-Student Interface (BCI from SSI)*** in 2011 as a part of dissemination of the results from EU-funded project "An ambulatory BCI-driven tremor suppression system based on functional electrical stimulation – TREMOR". ***BCI from SSI*** BAW seminars were continued during years 2012 and 2013, organized by the students and professors of the Laboratory for Biomedical Instrumentation and Technologies - BMIT (http://bmit.etf.bg.ac.rs/). In 2014 ***BCI from SSI*** series of seminars advanced and became a Conference. Reviewed extended abstracts were published in the First Annual Proceedings.

This year the Second National Conference with international participation ***Human Machine Interface from Student-to-Student Interface (HMI from SSI'15)*** expanded the scope of interest promoting interdisciplinary research in the area of health sciences. Whole-day program includes invited lectures, poster sessions, interactive presentations and demonstrations. This year's conference continues its tradition of being the forum for presentation of research results and experience reports aimed to motivate students, clinical partners and biomedical companies for technical aspects of neuroscience in particular. Finally, the overall goal is to improve the awareness of science and brain research in society at large.

The conference gathers participants from universities and academic research institutions, and partners from the clinics for neurology and rehabilitation. Attending students are from University of Belgrade: School of Electrical Engineering, Faculty of Philosophy, Faculty of Medicine, Faculty of Dental Medicine, Faculty of Organizational Sciences, Faculty of Sport and Physical Education, and Faculty of Technical Sciences, University of Novi Sad. The aim is to promote research networking and scientific collaborations among the students of engineering, medicine, biology, psychology, with clinicians and biomedical companies.

Fruitfull collaboration between BMIT and the Serbian Student Section for Neuroscienece continues. This year joint program that includes the popular scientific demonstrations will be held at the Serbian Academy of Sciences and Arts. We are particularly delighted to have Pre-Conference Workshop "Current and Future Applications of Non-invasive and Invasive BCIs" organized by g.tec company from Austria on March 19 2015.

Putting together ***HMI from SSI'15*** was a team effort. We first thank the authors for providing the content of the program. We kindly thank our dear colleagues and students for generous help and admirable motivation in organization and preparation of the Conference. We are grateful to the reviewers who worked very hard in reviewing papers and promptly providing feedback for authors. Finally, we thank the Electrical Engineering Students European Association (EEESTEC) who expressed willingness to participate in the conference organisation.

A conference could not be realized without the tremendous and generous support of our friends and collaborators who contributed to making it all happen. A special note of gratitude to Tecnalia Serbia Ltd., Belgrade; National Instruments Inc.; g.tec Medical Engineering GmbH, Austria; Academic Mind, Belgrade; UNO-LUX NS d.o.o., Belgrade; HAPEL, Belgrade; EESTEC LC and Project grant 175016, Ministry of Education, Science, and Technological Development, Serbia.

Official languages are Serbian and English.

Attendance is free of charge.

Thank you for coming.

Editors

Use of Shoulder Elbow Synergies for the Control of a Rehabilitation Exoskeleton

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Abstract—Upper-limb impairment after stroke involves abnormal, stereotyped, and fixed synergies with a disruption of the flexible coordination of the shoulder and elbow joints. Robotic exoskeletons have a potential to specifically rehabilitate inter-joint coordination.

Keywords— rehabilitatio; exoskeleton; upper-limb, synergies

I. SYNERGIES IN HEMIPARETIC STROKE PATIENTS

Synergies combine several elements, which share the same spatio-temporal properties and "work together," and may be combined in a task specific way so that a limited number of synergies can give rise to a continuum of responses. But, there is still no agreement on the space (muscles or joints) in which synergies are organized. For some authors, synergies are organized at the muscle level, for others, at the joint level and are endowed with properties of flexibility and automatic compensation between elements to stabilize the important task variable. The word synergy refers also to the pathological coupling of movements [1]. Kinematic analysis in stroke patients showed a disruption of the relative timing between shoulder and elbow movements during reaching [2], shoulder flexion and elbow extension tend to be reduced and shoulder abduction increased. The neurophysiology mechanisms behind synergies are still poorly understood. One current physiopathological hypothesis is that the abnormal fixed patterns are related to the activity of sub-cortical structures [3].

II. ROBOTIC REHABILITATION

A. Manipulanda

Robotic devices offer promising perspectives in the field of neurorehabilitation by augmenting the effectiveness of manual physical therapy because they afford many more movement repetitions. Recent extensive clinical testing of the InMotion robot has shown significant improvements in arm motor capacity after a robot therapy but the qualitative benefit of robotics over manual therapy has not been proved [4].

B. Perspectives with exoskeletons

The crucial feature of robotic devices is the ability of fine interaction with the whole limb of the patient as in conventional therapy. To that purpose, we developed a series of experiments in order to target neurorehabilitation at the inter-joint level. These experiments and a review of the constraints linked to the interactions between an exoskeleton and human body are detailed in [5].
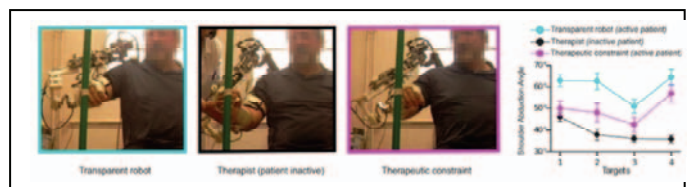
Fig. 1. Example of interactions with an exoskeleton (from [5] see text).

The experiments were performed with the ABLE orthosis (CEA-LIST). We used the formalism of principal component analysis to compute the "natural" shoulder elbow synergy during reaching movement. From this analysis, we compute a viscous constraint in order to modify the inter-joint coordination. This was verified in healthy subjects and a preliminary proof of concept was obtained in a group of hemiparetic patients. The patient illustrated in Fig 1 uses excessive abduction to perform forward reaching movement (left). The objective is indicated by the therapist while the patient remains passive (middle). The active reaching movement of the patient may then be modified thanks to interaction with the therapeutic viscous constraint. The mean results in 5 patients showed a significant decrease of the abduction.

Further studies are needed in both healthy subjects and hemiparetic patients to precise the mechanisms of adaptation to viscous constraints at joint level.

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Portable Brain-Computer Interface for Home-Based Neurorehabilitation

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Abstract—**This study demonstrates a technical solution for a portable Brain Computer Interface system for two applications, BCI controlled functional electrical stimulator and neurofeedback.**

Keywords—Brain computer interface, wireless EEG, functional electrical stimulation, neurofeedback

I. INTRODUCTION

Existing Brain Computer Interface (BCI) solutions for neurorehabilitation typically rely on costly equipment, limiting its application to the hospital environment. Here we propose a portable BCI system consisting of a wireless multichannel headset (Epoch, Emotive, USA) and a tablet for two software applications: neurofeedback treatment of central neuropathic pain and rehabilitation of hand function.

II. METHODS

The wireless connection between the Epoch and a tablet (ASUS Win 8.1) was performed using a proprietary software and Bluetooth technology. EEG data recording, processing, and visualization were performed using a custom made applications developed under Visual Studio C++.

A. BCI-Functional Electrical Stimulation

Six naive healthy participants took part in this study (years, 30.5±5.08) (3M, 3F). Epoch-tablet system was combined with a multichannel functional electrical stimulator FES (Rehastim, Hasomed, Germany) applied to participants' right hand flexor muscles. EEG was recorded from FC3-CP3 channels. A controlled parameter was the relative power of the sensory-motor rhythm (SMR, 8-12 Hz), calculated online by band-pass filtering the signal, squaring, smoothing and averaging over 0.5 s window. The algorithm was based on time-controlled switch algorithm [1] with time set to 1s and SMR threshold set individually. Following a visual cue, participants had 10s to complete the trial (2 sessions of 30 trials in total).

B. BCI neurofeedback

The efficiency of the protocol was previously confirmed on patients [2], using standard laboratory equipment. By using novel measurement configuration EEG was recorded from C4. The relative power of SMR, theta and beta (20-30 Hz) were calculated and shown to the user in a form of bars that could change size and color. Participants were trained to upregulate power of SMR and to down regulate power in the theta and beta bands. Bars had green color when power of a chosen frequency band was in the right range and had red color otherwise.

III. RESULTS

Figure 1 shows BCI-tablet-FES system. The average success rate was 76.2% in Session 1 and 85.7% in Session 2, indicating fast improvement in BCI performance in naïve subjects. Figure 2 shows a BCI screen used for neurofeedback training. The central bar represents SMR while left and right bars present theta and beta band power.

IV. DISCUSSION AND CONCLUSIONS

Portable wireless EEG can be used to create an inexpensive BCI neurorehabilitation system. Home-based experiments on patients are planned in the near future.
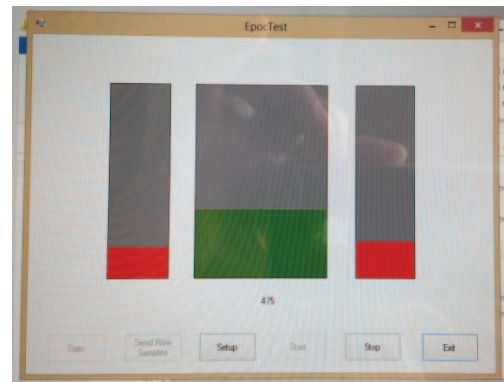

Fig 1. BCI-FES system

Fig 2. BCI-neurofeedback screen

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Combined Measurements:
Tools for Cardiac Related Analysis

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Abstract—**Alternative vibroacoustical cardiac function measurements are becoming popular in automatic estimation of cardiac state. The new methods based on combined measurements have been recently proposed for making step towards standalone heart sound based control and analysis.**

Keywords—*Reference electrocardiogram; phonocardiogram; combined measurements; medical imaging; seismocardiogram*

I. ICT IN HEALTH CARE CHALLENGES AND BEYOND

According to World Health Organization the main challenges are related to providing people-centered and integrated health services dealing with both financial tasks and medical personnel deficiency [1]. It is believed that information and communication technologies (ICT) enable development of novel self-care services, systems for assisting elderly and disabled people, telemedical applications for improved interoperability and new solutions for both operating efficiently and reducing costs. Special attention is given to the use of body area networks in monitoring, assisting in everyday life (movement, senses, cognitive aspects) and (tele-) alarming in the cases of particular signal anomaly pattern detected. Body-device control system goes beyond health services, where a typical example is authentication. In this paper a summary of the results from [2] and [3] is presented for possible phonocardiogram (PCG) based control and similar possibilities which use seismocardiogram (SCG) [4].

I. TOOLS FOR ONE-DIMENSIONAL CARDIAC RELATED ANALYSIS

Besides reference electrocardiogram (ECG), tools for cardiac related analysis can be based on alternative one-dimensional noninvasive approaches, where combined measurements are important for both testing and verification purposes. The interest in acoustical and mechanical methods has been revitalized by the availability of low cost sensors and portable devices [2-4]. Several examples are presented in Fig.1(a)-(c). Synchronously recorded EPCG (Fig.1(a): ECG-PCG) is often used to determine fundamental heart sounds and make a step towards standalone PCG analysis. Even asyncronous measurements of PCG and Echo (Fig.1(b)) may lead to development of PCG-based systems in the case when medical imaging equipment is not available or ECG standalone analysis is not appropriate. PCG-based control possibilities for heart rate calculation and (tele-) alarming are

illustrated in Fig.1(d)-(f), where specific multiscale methodologies are applied on pediatric patients [2-3]. Furthermore, new dataset of combined ECG-breathing-SCG measurement is recently publicly available for heart rate variability testing [4]. In order to obtain higher benefits, combined measurements may provide new information regarding correlation of body (neurobiological-cardiovascular-respiratory) functionalities, where cardiac-related analysis takes an important place.
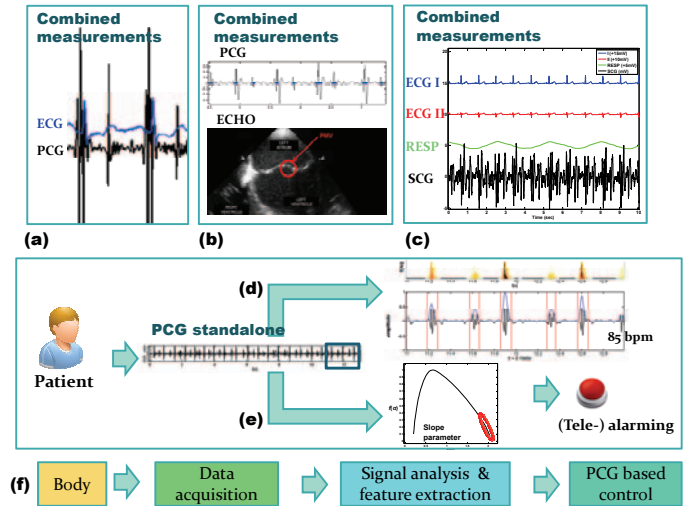
Fig. 1. Examples of combined measurements: (a) EPCG, (b) EchoPCG and (c) Combined ECG, breathing and SCG. (d) Heart rate calculation and (e) (tele-)alarming in the case of (f) PCG based control.

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The Brain and the Hand: Here Comes Writing

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Abstract — **Handwriting is a language modality and it is a highly specific skill. There is a complex set of neural and cognitive underpinnings integrated in handwriting production such as cognitive, visual, and motor.**

Keywords — handwriting; ADHD

I. WHAT IS HANDWRITING?

Handwriting is a cognitive skill and one of the finest outputs of the human brain. Handwriting, as a language production modality, is a means of communication and a necessary life skill. The development of handwriting begins early and it is important for the development of other cognitive skills. From early scribbling, a drawing of shapes, to print letters, handwriting becomes an automatic, cognitive skill around age 8-9 years, which continues to develop during the middle school years [1].

II. NEURO-COGNITIVE UNDERPINNINGS OF HANDWRITING

Various brain regions are involved in handwriting production [2]. Although the whole brain is important, frontal and parietal superior areas appear crucially involved, while fronto-medial, precentral, frontal inferior, temporal posterior, thalamic, and cerebellar regions contribute at different levels from orthographic selection to motor execution (i.e. the writing hand) [2,3]. The brain regions form a complex set of "handwriting networks" that integrate various parts and skills to produce handwriting [4]. Some important parts and skills integrated are the following: cognitive (e.g. attention, memory, reading, speaking), visual perceptual (e.g. visual discrimination, visual memory, visual spatial-relations, visual form constancy, and others), or motor (e.g. motor skills such as laterality, praxis, or fine motor coordination, muscle control such as grasp or motor accuracy, and neuromuscular such as muscle strength).

III. "POOR" HANDWRITING

Any interruption in the above networks may results with "poor" handwriting performance, with the two most important elements affected legibility and speed. Generally speaking, in various neurological, psychiatric, and neuropsychological difficulties, handwriting disability could be classified as dysgraphia or agraphia. Dysgraphia is a deficiency in the ability to write while agraphia is a complete inability to write. There are various forms of dysgraphia/agraphia, such as phonological, special, lexical, and others [5].

IV. WHY STUDYING HANDWRITING IS COMPLEX?

Words handwriting involve many processes such as analysis of the input sensory information (visual or auditory), access to the orthographic representation of the word to be written and its temporary storage into working memory (the graphemic buffer) [6]. These central stage processes are followed by allographic processes, i.e., the specification of the format in which letter series will be produced, including the idiosyncratic way each individual actually produces graphic scripts, and this involves the programming and neuromuscular execution of appropriate motor sequences [2]. Several of these processes are not specific to writing and can also be involved in other tasks such as linguistic or motor. Studies on handwriting should be able to disentangle writing/spelling processes from unrelated input or linguistic processing, or non-specific motor movements. In addition, studies should consider which networks are involved while evaluating handwriting performance.

V. STUDY ON HANDWRITING IN ADHD

Evidence from past studies indicates that children with attention/deficit/hyperactivity disorder (ADHD) might have various handwriting difficulties [7]. As a joint project between Clinic for neurology and psychiatry for children and youth and Laboratory for Biomedical Instrumentation and Technology, School of Electrical Engineering Belgrade University, it is planned a case-control study with the aims to evaluate kinematic parameters of handwriting in children with ADHD using a graphic tablet as a method of the analysis.

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The Changing Brain:
Bidirectional Learning Between Algorithm and User

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Abstract— **In a series of publications our group has developed an MRCP-based BCI intended for neuromodulation. We have (1) the ability to detect movement intent during dynamic tasks; (2) higher detection accuracy than conventional approaches by implementing the locality preserving projection (LPP) approach; (3) the ability to use a single channel for accurate detection; (4) enhanced neuroplasticity by driving a robotic device in an online mode. To realize our final goal of an at home system we have characterized alterations during single session use in our extracted signal when the user is undergoing complex learning or experiencing significant attentional shifts – all seriously affecting the detection of user intend. Learning enhances the variability of MRCP at specific recording sites while attention shifts result in a more global increase in signal variability. With the results presented we are working towards an adaptive brain–computer interface where bidirectional learning (either user or algorithm) is possible.**

Keywords— brain computer interface; learning; attention

I. THE MRCP AND PLASTICITY

For BCI performance plasticity has significant implications, since the algorithm used to extract user intend is based on a training set recorded at the start of a BCI session. This has already been recognized by other groups working within BCI [1-3] and thus it is generally acknowledged that if the BCI user is subjected to plasticity induction then the algorithm performance may be seriously affected. Indeed, both skill acquisition using the finger flexors or extensors [4], the index finger [5] or explosive strength training involving the hamstring muscle group [6] affect the MRCP amplitude and slope. Explosive strength training can also affect the onset of the MRCP being 28% earlier following training [6]. It is thus surprising why efforts have failed to concentrate on developing an adaptable algorithm capable of detecting alterations in brain activity due to plasticity. Daly was the first to propose a BCI intended for neuromodulation and thus plasticity induction when she reported on a single case where functional electrical stimulation was triggered using brain signals captured from the lesioned hemisphere [7]. Following three weeks of training, the patient had recovered some volitional isolated index finger extension movement abilities. Since her work, several groups have applied BCI training for neuromodulation in particular to stroke patients. In all of these studies, plasticity has been quantified by functional improvements changes in extracted EEG parameters or through fMRI. However in none of these studies has an attempt been made to adapt the extraction algorithm to the new user state. While the positive changes reported on user performance of the BCI in some of these studies are encouraging, it is possible that performance may have been further enhanced and at an earlier stage if changes in brain state had been integrated into the BCI extraction algorithm.

II. THE MRCP AND ATTENTION

In an effort to better understand how attention affects task performance, several models have been proposed [8]. Fundamentally these differ in what modulates attention: the task demands or the performers goal. For BCI performance this poses a seminal problem, since if it is the task demands that dictate attention then the BCI needs to be tuned to the users attention capabilities. In the case of the performers goals dictating attention, the requirement shifts so that both BCI and user need to be tuned to meet the demands of the users goals. In our BCI paradigm, we were initially interested if changes in attention of the user would affect our extracted parameter the MRCP, and therefore also the performance of our BCI algorithm.

III. FUTURE PERSPECTIVES

I will present data to show that plasticity and attention affect the MRCP in significantly different ways yet both cause significant declines in the performance of the non-adaptive algorithm. While plasticity induction leads to an increased variability of the signal at electrodes located frontally, attentional shifts induce a more global change in all underlying electrodes. The consequence is that we are able to differentiate between these two brain states and are currently working towards an integration in our algorithm. As such it is our vision that MRCP in the future will not be limited to neuromodulation but will offer a robust signal modality for accurate device control in other BCI applications.

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Ultrasound Imaging and Muscle Function - New Chance for Trunk Muscles?

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Abstract — **Rehabilitative Ultrasound Imaging (RUSI) is imaging technique aimed to follow muscle's morphology and morphometry for rehabilitative purposes. Although the idea of estimating muscle function according to changes in muscle dimensions captures by ultrasound is appealing, this application of RUSI is yet to be fully proven for both research and clinical purposes.**

Keywords — ***RUSI, neuromuscular disorders, muscle function***

I. WHAT CAN WE VISUALIZE AND MEASURE USING ULTRASOUND?

US imaging can visualize and measure muscle thickness, cross sectional area, muscle fascicle length and pennation angle. The change of these morphologic features during muscle contraction inspired the application of ultrasound imaging as a tool for estimating it's function.

II. ULTRASOUND IMAGING AND MUSCLE FUNCTION

The potential of ultrasound imaging for real-time visualization of static and dynamic features of muscle at rest and activation generated the idea to engage this technique for muscle behavior assessment. So far, it has been used for the assessment and analysis of altered motor behavior in individuals with neuromuscular dysfunctions, identification of a subgroup of patients who would benefit from a specific exercise strengthening program, as a visual feedback to assist with lumbar stabilization and pelvic floor strengthening exercises, for estimating the influence of treatments on muscular behavior [1-3]. The function of trunk muscles that act as deep stabilizers of lumbar spine and pelvic floor muscles are not easily estimated by usual clinical tests or needle electromyography, due to their location. On the other hand, their insufficient motor behavior is commonly found in low back pain and urinary incontinence which are quite prevalent pathologic conditions [1].

III. CAN WE MEASURE MUSCLE FUNCTION USING ULTRASOUND?

Concentric muscle contraction results in thickening, increasing the cross sectional area, shortening of the fascicle length and increasing the pennation angle of the fibers. But muscle contraction *in vivo* happens in more complex biophysical environment. Therefore, it is not straightforward conclusion that muscle thickening is equivalent to increased activation and vice versa. However, under controlled condition, strong correlations between thickness change of transversal abdominal muscle and its activity have been established (1,3). On the way from establishing the level of muscle activation) to the full interpretation of it's function and motor control, there is more work to do. The most important is to find measurement characteristic that is of clinical interest for patient treatment.

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EEG-based Classification of Positive and Negative Affective States

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Abstract—**This paper explores the neurophysiological correlates of positive/negative affective states elicited by continuous video stimuli. General/individualized linear/quadratic Discriminant Function Analysis (lDFA/qDFA) models were built based on the EEG data. The classifiers' generalization capability was further estimated in a study where participants watched videos that incorporated narratives with varying levels of justice.**

Keywords—EEG; emotion recognition; positive/negative affect

I. Introduction

Emotion recognition has emerged as a notable research topic in the field of affective Brain Computer Interfaces (aBCI). The use of physiological measures was limited by the obtrusive nature of instrumentation, but this has changed with the embedded platforms capable of real-time signal processing techniques. EEG-based emotion assessment is inexpensive providing continuous measures with high temporal resolution.

We present the results' summary from a study [1] aiming to develop a classification model for positive/negative affective states. These two emotions are aroused states, but opposite in their valence. We investigated several ways to overcome individual differences in EEG-signals, cross-validated the models, and analyzed their benefits and shortcomings. The classifiers' generalization capability was also estimated in an experiment that administered a narrative-storytelling session.
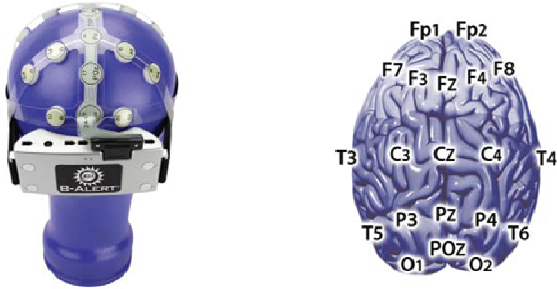

Fig. 1. EEG wireless sensor headset and map of channel locations

II. Methods

The emotion elicitation experiment was completed by 161 participants. The first 98 participants were used for training the emotion classifier and the other 63 participants were used for cross-validation. The affective states were induced as in [2] by humorous clips and the battle scene from the war drama movie. A subset of 63 participants were able to also complete the narrative-storytelling experiment. The narrative story [3] involved themes of injustice against women and illegal immigrants in an attempt to elicit negative emotional responses. The story was developed with variable segments to enable different story's resolution variations ("more/least just").

EEG was acquired using the B-Alert® X24 wireless sensor headset (Figure 1). The algorithm [4] was utilized to detect and remove artifacts. Overall, the feature vector comprised 420 PSD bandwidth and wavelet variables. The most discriminative variables selected by step-vise selection were utilized into lDFA/qDFA. The individualized models were also built for each participant. The generalization capabilities of the model were assessed by leave-one-participant-out cross-validation as well as on the narrative-storytelling dataset.

TABLE 1. Accuracy of the lDFA and qDFA general and individualized models during model development auto-validation (AV) and leave-one-participant-out cross-validation (LOO-CV) as well as cross-validation (CV).

	General model			Individualized model	
	AV	LOO-CV	CV	AV	CV
lDFA	74.2%	73.0%	74.3%	92.8%	94.5%
qDFA	70.7%	67.8%	69.4%	94.7%	94.5%

III. Results

In Table 1 the model development and cross-validation classification results suggest that the classifiers were not overfitted. Individualized models were able to discriminate between positive/negative affective states with accuracy of over 90%. Similarly, during the narrative storytelling the posterior probabilities of the negative class were relatively high (up to 0.91) proposing the participants felt more negative which was expected due to the intended scenario. The "most just" story version typically induced a lower level of negative affect than the "least just" version.

IV. Conclusion

In this paper, we presented a comparative evaluation of different methods to discriminate positive/negative affective states based on the EEG-derived profiles that could be easily applied in different aBCI-based applications.

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The Brain and the Legs: Here Comes Walking

Analysis of Gait during the Dual-task Walking

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Abstract — **Gait is no longer considers simply an automated motor activity. Even in healthy adults the strides fluctuate, and studies describe the impact of brain executive function and attention impairment on gait performance. This impact shows great variability during central executive functioning in complex gait situations, such as dual-task performance while walking. In some of the neurodegenerative diseases gait analysis and its characteristics and pattern changes during the disease progression could point toward underlying causes of present disturbances, helping in adequate choice of therapy approaches and rehabilitation procedures.**

Keywords—cycle time; gait analysis; mental task; stride; posture; walkway system

I. INTRODUCTION

Gait is not an automated motor activity – even in healthy adults the strides fluctuate [1]. Studies in healthy subjects describe the impact of executive functions of the brain and attention impairment on gait performance. This impact shows great variability during executive functioning in complex gait situations, such as dual-task performance while walking. Dual tasking paradigm relies upon executive function and the ability to divide attention during different tasks during gait, i.e., while subjects perform given motor task (walking with a glass cup filled with water) or mental tasks (talking or serial subtractions). Influence has been tested in healthy older adults as well as in patients with neurodegenerative disorders, mainly with Parkinson's disease, patients with dementia or depression, Alzheimer's disease or some other diseases [2], [3].

Many recent studies further focus importance of cognition in gait coordination, postulating that it is far from being automatic function. This is supported by the observation that performing attention-demanding dual-tasks while walking can affect gait parameters. Particular attention has been drawn to increased gait variability occurring in dual task condition, since it seems to be correlated to increased risk of falls.

Gait disturbances, presented through reduced gait velocity, shortened stride length, longer single or double support are integral parts of clinical manifestations of neurodegenerative diseases, such as Parkinson's disease, and most disabling symptoms for patients quality of life. Also, patients exhibit problems with gait initiation, maintaining symmetry and rhythmicity of the gait, turning, and they also suffer from motor blocks i.e., freezing episodes during gait. All these issues contribute to higher risk of falling during walking. Analysis of gait pattern could point toward underlying causes of disturbances and helps in adequate choice of therapy.

Measurement and analysis of spatiotemporal gait characteristics include determination of parameters such as duration of gait cycle, gait velocity, stride length, single and double limb support, or swing time. It is important to calculate stride-to-stride variability and rhythmicity of gait, all of which have been associated with increased posture and gait stability and fall risk. Further, gait analysis could provide information about profiles exerted by each foot to the ground during walking and gait symmetry between legs. Comparison of analyzed data would distinguish among different forms of disorders, draw attention to some of the disease characteristics and provide follow-up during disease progression.

II. DISCUSSION

Comparison of gait parameters of healthy subjects and neurodegenerative diseases patients – Parkinson's disease, with or without present dementia or depression, Alzheimer's or other diseases [2], [3] separates different disorders, and estimate gait during disease progression and disease impact on gait function. Gait characterization could help to prevent negative effect on gait changes during disease progression, such as falls. Differences in the gait pattern relatively specific for the disease could point to postural instability and warn for possible falls in complex walking situations.

Gait pattern changes in neurodegenerative disorders could point toward underlying causes of present disturbances and helps in adequate choice of therapy approaches and medication or rehabilitation procedures and therefore improve therapeutic effects.

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How to Manage Multiplidisciplinary Clinical Research

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Abstract — **This narrative review highlights the state of the art and main challenges in managing of multidisciplinary clinical research in biomedical engineering studies.**

Keywords—multidisciplinarity; interdisciplinarity; management clinical research

I. INTRODUCTION REMARKS

The problems in clinical medicine requires shifting from individual to collaborative research team for further progress especially in translational research (solving the clinical problem with engineering solutions). This represents a challenge for the engineers and clinicians, who are now confronted with a problem of heterogeneous methodologies and data-integration. This summary points out multidisciplinary research in the sense that it includes all research collaboration involving several disciplines as „multi-modal" insight into the biological or biomedical problem at hand in multidisciplinary or interdisciplinary approach. Definitions of terms such as "multidisciplinary", or "interdisciplinary" are not well differentiated, but these terms should not be used interchangeably. In fact these terms refer to the involvement of multiple disciplines to varying degrees on the same continuum [1].

II. STATE OF ART

Generally speaking there is little literature on the characteristics of research collaboration involving different disciplines. The main problems faced by multidisciplinary research teams are related to the difference in research objectives, dissemination of work and methodologies of work between basic, engineering or clinical science. The strength of multidisciplinary researches arises from providing different approaches to problems, with augmented response in recognition of problems. Important strength also could come from increasing of available research tools and solving solutions. The weakness of multidisciplinary research is due to different educational background and different view on problems significance and problems solutions. Additional

difficulties arise from the challenges in the maintaing the dual role of care providers and scientists [2].

III. KEY FACTORS OF MANAGING

Managing of multidisciplinary research is required to exchange knowledge, methodologies and constraints between disciplines. The key factors are related to leading role of coordinators, team building, time, project management, mutual interests and knowledge sharing.

The main goal of the multidisciplinary team is to develop multistep protocol through the complex process from initial idea to final protocol. Some of the important phases of this process are multifaceted identification of clinical problems and engineering solutions, definition and describing of initial project proposal, development of conceptual design, preliminary and final design of study. This complexity has generated a number of novel ethical issues for clinical investigators and managing multiple institutional roles and responsibilities. An important factor is to put efforts in carefully designing the project from the beginning while writing the detailed proposal with time and action plan and finally with testing and validated results. It seems that it is possible through regular communication meetings, workshops and checkpoints to define and refine status of team goals, background rationale, action plans, duties and responsibilities [3].

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Towards Automatic Calibration of Multi-pad Electrodes and Computer Vision Control of FES Assisted Grasping

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Abstract — **State of the art intelligent electrical stimulators can store stimulation patterns that are used for FES assisted grasping. Pattern selection and stimulation triggering can be controlled by the Microsoft Kinect sensor and computer vision algorithms.**

Keywords — FES; Kinect; automatic control

I. Introduction

Functional Electrical Stimulation (FES) is a technique of providing control signals to peripheral motor systems that are paralyzed or paretic as a result of nervous system lesion (e.g. stroke, spinal cord injury) [1, 2]. Recently developed grasping systems comprising multi-pad electrodes, hardware capable of distributing stimulation and wearable sensors [3] provide possibility of electrode calibration and automatic control of stimulation patterns during grasp.

Obstacles we face in restoring the functional grasp with state of the art FES systems include a relatively tedious process of electrode placement and system setup, the need for manual selection of desired hand function and triggering of stimulation in order to achieve grasp. We are addressing these problems in our ongoing research.

II. Calibration of Multi-pad electrode

In order to control hand opening and closing with cutaneous electrical stimulation we are relying on FES-a system (Tecnalia Research and Innovation, San Sebastian, Spain). This system incorporates multi-pad electrodes that are designed to stimulate the forearm muscles needed to produce a functional grasp and intelligent stimulator that can be controlled with a Bluetooth (BT) interface from a PC, tablet or smartphone.

Selection of virtual electrodes on the multi-pad, i.e. active stimulation points that produce selective finger and wrist movements, can be done automatically in the calibration process. During calibration, pads on the electrode are activated one by one with several electrical pulses, and the resulting muscle twitch responses are measured with sensors. BEAGLE v3 wireless sensor glove (Tecnalia Research and Innovation, San Sebastian, Spain) estimates relative change of angles of fingers and wrist from the data measured by five IMUs positioned on thumb, index, middle and ring finger and wrist. Optimization algorithm promotes selectivity of movements that are of interest for producing functional grasp through electrical stimulation patterns.

LabView application that controls the simulation parameters was developed for tablet PC and touch interface. This application enables user to define virtual electrodes manualy and to define stimulation patterns for different grasps in a form of time sequence. The information about the virtual electrodes and grasping patterns are after callibration stored in the IntFES v2 memory and can be activated via BT from any system that is in charge of grasp control.

III. Computer Vision control of FES

We chose to tackle the problem of automatic selection of grasp of interest and triggering of stimulation protocol with artificial perception [4]. Microsoft Kinect is the only sensory device in the proposed system setup that ensures easy integration in clinical environment and unaltered FES setting. Computer vision algorithms that we developed enable localization of the object of interest, selection of the grasp type, as well as tracking of the position and orientation of the stimulated hand [5]. This system sends the IntFES v2 stimulator BT commands to start adequate stimulation pattern while the hand is reaching for the object and to stop the stimulation after subject performed the task and object is again safely positioned on the table.

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Electrotactile Feedback in Closed Loop Control

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Abstract— **Providing a somatosensory feedback in a myoelectric prosthesis is an important goal yet to be achieved. Electrical stimulation of the skin to activate the tactile sense is one possible method to restore the missing sensory information. We have developed a flexible real time setup to investigate this context.**

Keywords— *myoelectric prosthesis; electrotactile feedback; closed loop control; electrical stimulation*

I. INTRODUCTION

Myoelectric prostheses are in routine use since many years. The command interface is based on capturing the electrical activity of the user's muscles, decoding the intent and commanding the prosthesis accordingly [1]. The most important drawback of active prostheses is the lack of direct somatosensory feedback. The researchers have been investigating various approaches to provide feedback artificially, ranging from direct neural stimulation to non-invasive sensory substitution methods. In the latter, the state of the prosthesis (e.g., joint angles or grasping forces) is communicated to the user by stimulating the skin of the residual limb using mechanical (e.g., vibration motors, pressure cuffs, motor driven pushers) or electrical stimulation, [2], [3].

II. METHOD

The used experimental setup emulated the closed-loop control of dynamic systems when the feedback was delivered through electrical stimulation (see Fig. 1). The controlled system dynamics was defined in Simulink in the form of a transfer function. The joystick signal was input into the controlled system.
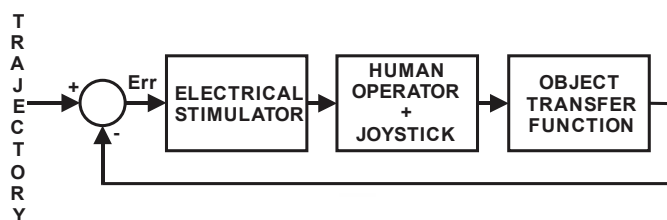
Fig. 1. The experimental setup for the real time closed-loop control at 100Hz using electrotactile feedback. The pseudo random multi step signal was used as trajectory.

Two concentric electrodes were placed on the dorsal and volar side of the subject forearm. One electrode coded the positive and the other negative deviation from the desired trajectory, while the stimulation intensity was proportional to the size of the error. Output signal of the transfer function and its deviation from the referenced trajectory were observed. As the performance measures, we have selected: 1) percent overshoot, 2) rising time of the desired steady state value, and 3) settling time, which is the time needed for the system output to enter and stay within a predefined window around the desired steady state value.

III. DISCUSSION AND CONCLUSIONS

Both position and velocity controlled systems with different gains and time constants were tested. The tests have demonstrated that the tracking via electrotactile feedback was feasible in all the cases (see Fig. 2). The performance was similar between position and velocity systems with different gains and low time lags. However, increasing the time lag had a profound influence on the tracking results. In this case, the system behaved as if it had inertia, forcing the subject to control predictively. On the other hand, the tracking with visual feedback, used as benchmark, was much better, more consistent and less influenced by the system dynamics. The experiments have demonstrated that the electrotactile feedback can be successfully employed for the closed-loop control in both control modes (position and velocity), but that time lag has a significant and more profound effect on the control performance.
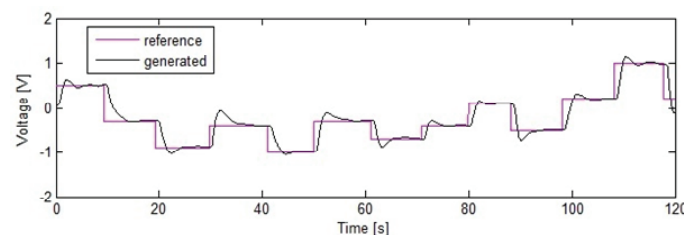
Fig. 2. The representative trials recorded during closed-loop control of position controlled system with small time lag using electrotactile feedback. The magnitude of the signals are presented as voltage in accordance with the dynamic range of the joystick output signal of ±2.5V.

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Eye-tracking Traces: Insights into Cognition

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Abstract—**In the last thirty years eye-tracking methodology experienced rapid expansion and is now considered as a core tool in the field of cognitive psychology. Not surprisingly though, given the tight relationship between eye-movements and many aspects of human cognitive processing (reading, attention, problems solving etc.).**

Keywords—eye-tracking methodology; reading; attention; pecception; problem solving; autism

I. General Description of Eye-tracking Methodology

Whilst reading a book or newspapers, our eyes are scrolling though the text, and, intuitively, it seems that these eye-movements are continuous, uninterrupted. In the 19. century, a French ophthalmologist, Louis Émile Javal, based on plain observation, was the first one to notice and describe the rapid jumps that our eyes constantly make (i.e. saccades), which are interrupted with resting periods (i.e. fixations). Soon after, the others started with the crude-methodological attempts to measure and quantify the eye-movements, as well as to interpret them. Only in the mid 20th century, the more serious methodological improvements were introduced in order to make precise measuring of eye-movements, particularly given the insights that they could be linked to various cognitive processing, and to understanding complex functioning of language systems and reading especially. The variables that are informative of participants behaviour in eye-tracking research are mainly: latency (first look), longest look, total looking time, number of fixations, order of looks etc.

II. Applications in Psychology - Reading

It is noteworthy that our understanding of the relationship between reading and eye-movements has improved to the extent that we nowadays have a few models postulated around eye-movements and their role in reading. One of the most significant models, with no doubt, is that of Reichle, Rayner, and Pollatsek (2003) which is evaluated and described in details [1]. One of the key findings in the eye-tracking field of research is that humans gather information during stabilised fixations, and use saccades to redirect the gaze as rapidly as possible (Liversedge, Gilchrist & Everling, 2013) [2]. Similarly, the key finding in the field of reading is that the visual information is being processed during periods of fixations, from left to right. Fixations usually last about 200-250ms (although, the range may be even 50-500ms). Saccades usually last 20-30ms and during these stages we have a suppression of visual processing. On average, readers of alphabet systems make eye-movements after every 7-8 letter (but, it could range up to 20 letters), see Figure 1.

Fig. 1. SMI (iView X™ Hi-Speed) Eye-tracking methodology specifically designed for investigating reading.

III. Applications in Other Cognitive Domains

Apart from reading, eye-tracking methodology offered very valuable insights in the field of attention (an example will be given from attentional blindness studies), problem solving (example from chess playing and Einstellung (set) effect), in decision making in supermarkets, in research on safety in car driving, on web-designing etc. Also, eye-tracking has proven to be a very valuable tool in the field cognitive development. Recently, it's been shown that the attention to eyes is present but in decline in 2–6-month-old infants later diagnosed with autism [3].

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Neural Network Based Brain-Computer Interfaces

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Abstract—**This paper describes procedure and tools for building EEG signal classifier using open source neural network software Neuroph. It also outlines some open research questions.**

Keywords— classification of EEG data; brain-computer interfaces; neural networks

I. BRAIN-COMPUTER INTERFACE DATA CLASSIFICATION

Brain-computer interface (BCI) is a computer-based system that acquires, analyzes and translates brain signals into commands that are sent to an output device to accomplish a desired action. Commonly used approach in translating patterns in BCI EEG signal processing, is to treat this as a classification problem. [1, 2, 3, 4] In this approach, a sample EEG signal is assigned to one of the predefined classes, based on the observed signal features.

Various machine learning classification methods are employed to recognize these patterns of EEG activities, i.e. to learn the mapping between the EEG data and classes corresponding to mental tasks [2].

From machine learning point of view this is a difficult learning task due to noisy and correlated signal, and difficulties for selecting optimal frequency band for sample and feature extraction [4].

Also the quality of the data is affected by the different degree of attention of the subject and changes in their concentration [4].

This paper presents a procedure and tools for development of EEG signal classification tools based on neural networks with Neuroph software.

I. NEUROPH FRAMEWORK

Neuroph Framework [5] is an open source Java software for neural network development. It provides a Java software component library, a simulator and an integrated development environment (IDE) for neural networks, based on popular Java IDE NetBeans, called Neuroph Studio. Neuroph Studio provides easy to use tools to create, simulate, analyze and deploy neural networks. These tools come in the form of wizards which guide users through a series of steps, in order to create application specific neural networks. One of the supported tools, is BCI signal classifier based on neural networks.

Neuroph BCI support is developed for MindWave BCI device from NeuroSky, however it can be adapted to work with any other BCI hardware. Main components of the Neuroph BCI support are:

- software connector to BCI
- signal visualization and sampling tool
- BCI wizard system
- neural network training tool

These components support the entire cycle of BCI data processing: from signal acquisition and preprocessing to classification. EEG signals are recorded directly in NeurophStudio using BCI connector software, and then used to create datasets to train and validate neural network classifiers.

BCI Wizard tool, generates Multi Layer Perceptrons neural network with Backpropagation learning rule, that is used as the neural network classifier.

In this way Neuroph provides complete environment to create neural network based BCI classifier in Java, that can be easily integrated in any other external application. Availability of source code, and permission to use it and modify, granted by its open source licence is a big advantage for research and educational applications, compared to proprietary options.

Questions open for discussion are:

1. What is the best practice for preprocessing and feature extraction (eg. discrete fourier transform, spectrum density, principal component analysis etc.) ?

2. What classification methods in general work best for this type of problems , and how they compare to neural networks?

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Detection of Epileptiform Activity in EEG Signals based on Time-frequency and Nonlinear Analysis

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Abstract—**We propose a new technique for detection of epileptiform activity in EEG signals based on time-frequency and nonlinear analysis.**

Keywords—electroencephalogram; epileptiform activity; nonlinear analysis; scatter matrices; quadratic classifiers

I. INTRODUCTION

An epileptiform activity in EEG signals can be evident not only during an epileptic seizure but also a short time before as well as between seizures. We propose a new technique for the detection of epileptiform activity in EEG signals that could ensure an objective and facilitating treatment of epileptic patients and thus improve the diagnosis of epilepsy [1].

II. METHODS

The proposed technique consists of four successive steps: preprocessing, feature extraction, dimension reduction in feature space and classification. Preprocessing involves filtering, artifacts removal, segmentation and normalization of EEG signals. Representative features are extracted from five sub-bands of clinical interest, i.e. delta (0–4 Hz), theta (4–8 Hz), alpha (8–12 Hz), beta (12–30 Hz) and gamma (30–60 Hz), since they showed much better discriminatory characteristics compared with the entire frequency band between 0 and 60 Hz. The features are extracted in both the time and frequency domain as well as in the time-frequency domain taking into account nonstationary nature of EEG signals. Using nonlinear analysis, the correlation dimension and the largest Lyapunov exponent as features able to capture chaotic behavior and nonlinearity present in EEG signals. After the feature extraction we optimally reduce the dimension of the feature space to two using scatter matrices. A final decision about the presence of epileptiform activity in EEG signals is made by quadratic classifiers designed in the reduced two-dimensional feature space as shown in Fig. 1.

III. RESULTS

The accuracy of the technique was tested on three sets of EEG signals recorded at the University Hospital Bonn: surface EEG signals from healthy volunteers, intracranial EEG signals of the epileptic patients during the seizure free interval recorded at seizure focus and intracranial EEG signals of epileptic seizures also from within the seizure focus [2]. An overall detection accuracy of 98.7% was achieved.
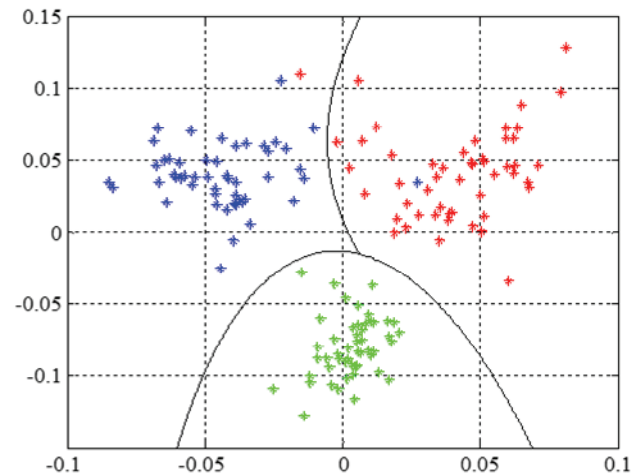

Fig. 1. Piecewise quadratic classifier which separates epileptic (in red) from nonepileptic (unhealthy in blue and healthy brain tissue in green) segments of EEG signals.

IV. DISCUSSION AND CONCLUSIONS

By extraction of the features from five sub-bands and in four domains of interest as well as by their optimal combination and classification by quadratic classifiers the proposed technique achieved a high level of accuracy and robustness. Further investigation should be directed to application of the proposed technique for detection of emotions (e.g. alertness, happiness, sadness, depression, etc.) as well as detection of abnormal activities associated with other brain disorders such as Alzheimer's disease and schizophrenia.

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The Electromyographic Control of Lego Robot

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Abstract—**We designed electromyography (EMG) based control of Lego robot for application in treatment of ADHD (Attention Deficit Hyperactivity Disorder) in children. The EMG envelopes are used for obtaining control signals for automatic guidance of Lego robot through the designed polygon. The proposed control algorithm is tested in 6 healthy individuals.**

Keywords—ADHD; EMG; NI Lego Robot; navigation

I.   INTRODUCTION

For treatment of ADHD (Attention Deficit Hyperactivity Disorder) in children a neurofeedback is considered as alternative or additional method to standard clinical procedure [1]. Based on the successful rate of electromyography (EMG) based feedback in training regulation performance [2], we propose an EMG control of Lego robot for possible application in children with ADHD.

II.   METHODS AND MATERIALS

For EMG measurements, we used H92SG electrodes (Covidien, Germany), EMG amplifier (Biovision, Germany), NI USB 6212 A/D convertor (National Instruments, USA), standard PC and Lego robot (The Lego Group, Denmark). The dedicated software application for robot control was developed in LabVIEW 2013 (National Instruments, USA). EMG signals were recorded from *biceps brachii m.* on the left and right arm. In order to obtain EMG envelopes, signals were filtered online by notch filter (3rd order, 50 Hz), and afterwards band pass filter (3rd order, [10 150] Hz).

In order to obtain control signals ("on/off" commands) for moving Lego robot, we compared the EMG envelopes with amplitude limits (AL). At the beginning of each navigation session, maximal voluntary contraction (MVC) for each muscle was performed in order to set the ALs to 60% of MVC. We implemented the following rule-based control: 1) if both EMG envelopes (corresponding to left and right *biceps brachii m.*) exceeds ALs, robot moves straight forward; 2) if only one EMG envelope exceeds AL, then robot moves to the appropriate direction (left or right); 3) if both EMG envelopes are below the ALs, there is no action; and 4) if robot approaches an obstacle which is detected with built-in ultrasound sensor, robot moves backward one second (this event is identified as "fault"). With this rule-based control, we enabled subjects to control the robot's movements. Designed polygon (100x140 cm) had 7 obstacles placed in a random order. The program enabled storage of EMG signals, measurement of elapsed time for crossing the polygon, and counting failures.

We tested the system in 6 healthy subjects with no known neuro-muscular diseases (all subjects signed an Informed Consent approved by Local Ethical Committee) during 3 sessions (Table I). Subjects were instructed to control the robot by muscle activation, cross the polygon, and avoid obstacles.

III.   RESULTS AND DISCUSSION

For each subject, we calculated total number of faults, and elapsed time (Table I). Crossing times varies among subjects, and the elapsed time increases due to failures, as it is expected (Table I). The number of faults might be also dependent on the concentration of the subject, which possibly makes this setup a good candidate for application in treatment of ADHD. All subjects reported muscle fatigue after a certain number of attempts to cross the polygon, so the proposed system might be used as biofeedback application for muscle strengthening. While testing, subjects gave positive feedback (subjects were willing to continue testing the robot for several sessions more). In future work, we will test the system in children with ADHD.

TABLE I, Subject's data and navigation parameters

Subject ID	Age [years]	Gender [M-male, F-female]	Elapsed time [seconds]	Number of faults
ID1	25	M	45	0
			32	0
			40	1
ID2	24	F	56	0
			66	4
			50	0
ID3	31	M	52	0
			82	2
			80	1
ID4	24	F	90	3
			80	4
			75	0
ID5	26	F	45	0
			52	0
			50	0
ID6	23	F	31	0
			31	1
			34	0

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Classification of Motor Imagery Movements Based on Event Related Desynchronization/Synchronization

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Abstract—**This paper presents features extraction algorithm within electroencephalogram (EEG) signals and classification of motor imagery of the right and left hand movements based on those features.**

Keywords—Electroencephalogram (EEG); Event-Related Desynchronization (ERD); Event-Related Synchronization (ERS); Motor Imagery

I. INTRODUCTION

The most commonly used feature in EEG signals for classification of different movements is event-related desynchronization (ERD). In this study, in addition to the classification results based on ERD, we presented classification based on event-related synchronization (ERS), power increase of spectrum of EEG signal. During physical and motor imagery of right and left hand movements, ERD occurs predominantly over the contralateral left and right motor areas. ERS occurs in the period after movement and it can also be found over the contralateral motor areas. ERS is spatially more focal on the specific brain areas than ERD and the detection of ERS is more reliable [1].

II. METHODS

The signals were collected in experiments with physical and motor imagery of right and left hand movements. Collected signals were first filtered with Butterworth fifth order band-pass filter (7-30 Hz), and then with spatial filter, to reduce noise level. ERD and ERS with the physical and motor imagery of left hand movements can be detected at the electrode C4, while the movements of the right hand are detected at C3. Besides these two electrodes spatial filter uses electrodes from surrounding of C3 (T3, P3, F3, Cz), and from surrounding of C4 (T4, P4, F4, Cz), to enhance spatial resolution [2]. From C3 and C4 was subtracted average of its surrounding electrodes. Based on timestamps set in signals during the experiment, it is possible to find and extract periods during and after motor execution/imagery of left and right hand, where ERD and ERS occur.

Using spectral analysis of signal from extracted periods, we can find the frequency sub-bands for which the ERD and ERS are the most prominent. Frequency sub-bands were calculated from signal with physical movements, and later used for classification of signal with motor imagery. These sub-bands vary from subject to subject [3], as well as for ERD and ERS.

Spectrum of signal from extracted period was averaged in frequency sub-bands. Based on the obtained values for ERD and ERS, we could determine whether the subject imagined movement of left or right hand. Obtained value for ERD is lower on C3 compared to C4, during the motor execution/imagery of the right hand, while for the left hand situation is reversed. Obtained value for ERS is greater on C3 compared to C4, during the motor execution/imagery of the right hand, while for the left hand situation is reversed.

III. RESULTS AND DISCUSSION

The results were obtained from three healthy right-handed male subjects aged 24 to 26 years. From signals obtained in first experiment, with physical movements, were calculated frequency sub-bands, which were used for classification of signals obtained from second experiment, with motor imagery. Experiments consisted of 20 motor execution/imagery trials, 10 for left hand and 10 for right hand in random order. The classification results obtained by this method are shown in Table I.

TABLE I
CLASSIFICATION RESULTS (%) OBTAINED FOR EACH SUBJECT

Subject	ERD	ERS
S1	90	95
S2	65	80
S3	65	95

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Expert System for Traditional Serbian Medicine

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Abstract—**This paper represents idea of Expert system for Traditional Serbian Medicine. It is conceived as a technical support to physicians in hospitals and clinics, especially in intractable health issues like allergies, inflammations and chronic diseases.**

Keywords—*Expert systems; Traditional Serbian Medicine; Traditional Chinese Medicine; herbal remedies*

I. INTRODUCTION

Basic concept of expert systems (ES) is storing knowledge (information) from experts into computer memory and designing simple rules for easy manipulation with these information. ES may be used for making (fast) decisions in medicine (diagnostics and therapy) [1]. In recent years several ES for Traditional Chinese medicine (TCM) were developed. They have good diagnostic results and they are successfully used for prescription TCM therapies. It enables physicians without years of dedication in TCM to practice it [1]. Similarities between TCM and Traditional Serbian Medicine (TSM) in diagnostics and use of herbal remedies [2] have intuitively led us to try model ES for TSM after ES for TCM.

II. DEFINING ARCHITECTURE OF ES FOR TCM

So far there are no ES for TSM and before constructing one, collecting information (knowledge) about TSM diagnostics and therapeutic principles from TSM experts (phytotherapists, chiropractors and other folk physicians) by interviewing and from TSM manuals should be done. After that, all information will be technically systematized into constructive parts of ES. Therefore, we have idea of following ES for TSM architecture:

1. **Personal electronic health record cards**. It should consist: *basic data* (patient name, address, gender, date and place of birth) and *electronic questionnaire* (analogous with TCM anamnesis): questions about symptomatic like type, intensity, duration, place of pain or pathology or health issue; history of diseases, diagnoses of classical medicine, natural, emotional, psycho-social factors, taking medicaments, physical activities... and basic health parameters like blood pressure, pulse, weight, height. It will have optional many for selecting type of questions for specific (e. g. cardiac, allergy, etc) symptomatic.

2. **TSM diagnostic patterns of health**. Information about practical methods used by TSM experts should be collected and generalized in form of abstract rules. Then, it would be possible to derive diagnostic principles for TSM diagnostic device. Most probably those could be: measuring temperature of acupuncture points, palpation (infra-red or piezoelectric detection of pulse at different parts of body and organs), analyzing of images and sound of voice (skin color, face look, eyes, eye circles, lips, tong properties, breathing, voice tones etc.).

3. **STM expert data base**. Requires collecting information about recipes of TSM phytotherapy (herbal recipes, teas, specimen, creams, salves...) and TSM methods of healing. It needs to include indication and contraindications of herbal remedies, duration and method of application of therapy. All information have to be systematized and enabled in form of data base folders.

Functional scheme of ES. From electronic health record card (EHRC) (1) and diagnostic manifestations/patterns (2) should come out evaluation of health state (diagnostics). By means of algorithmic rule *if a certain diagnose is determined then follows recommendation of certain recipes or therapies from expert data base* (3). Evaluation will be done through algorithmic procedure, e. g. guidelines from EHRC combines with 1-8 marked diagnostic signs into assessing diagnosis. We expect that such ES for TSM will be capable to make up to 100 diagnoses and recommend over 500 TSM recipes and therapies from data base (each diagnose will fit several TSM recommendations from which physician (or patient) have to decide for certain one or combination of more). This could be realized as an on line software or as a software inside diagnostic device with computer interface.
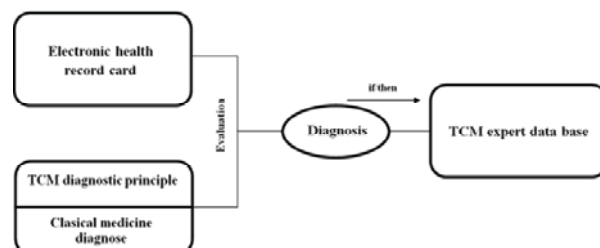

Figure: Functional scheme of ES for TSM

III. GENERAL SIGNIFICANCE OF ES FOR TSM

ES for TSM might enable systematization and easy use of TSM in public health systems compatible with classical medicine since TSM is recognized as a branch of complementary and alternative medicine in the Ministry of Health of Serbia [3]. Also ES for TSM may be developed in an effective unique method of modern quantum medicine trends [2].

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Influence of Acupuncture on Autonomic Nervous System: A Case Study

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Abstract—The aim of this study is detection of heart rate variability (HRV) and blood pressure variability (BPV) decrease after application of long term acupuncture needling in order to find correlation of therapeutic effects of the acupuncture and HRV and BPV changes that reflect symphatetic/parasymphatetic autonomic nervous system (ANS) regulation affected by acupuncture therapy.

Keywords—HRV; PBV; ANS; acupuncture

I. BACKGROUND

HRV and BPV are key measurable indicators of autonomic regulation functions [1] and, since recently, diagnostic parameters of physiological and pathological states of human organism [2,3]. Their time variations are mainly caused by influence of sympathetic/parasympathetic ANS on cardiovascular system (CVS) [3]. Also, HRV and BPV are often used in evaluation of effect of acupuncture on ANS. Lack of long term experimental procedures in related literature [1,4], motivated our research.

II. MATERIALS AND METHODS

Experiment was conducted in a healthy subject with slightly elevated blood pressure. First, we used Task Force Monitor (TFM) (CNSystems, Austria; 1000 Hz sampling rate, ECG main leads, finger sensor and forearm cuff for PB continuous monitoring) for recording HRV and BPV during 10 minutes in rest. Then, 24 h ECG and pressure holter monitoring were used. Afterwards, physician with 2 years of experience in acupuncture stimulated acupuncture points of large intestine, stomach, heart, spleen, kidneys [5] for 7 days. After acupuncture, we repeated the same measuring procedure. Signals before and after acupuncture were analyzed and compared (in time and frequent domain) using Matlab (The Mathworks, Natick, USA) software. Additionally, systematic health exemination was done with Quantum Magnetic Resonance Analyzer (QMRA) (Essentials of life, New Hampshire).

III. PREPARE YOUR PAPER BEFORE STYLING

Holter recording has shown no significant changes of HRV and BPV. But, TFM recording has shown decrease of HRV and BPV/systolic sBPV, mean mBPV, diastolic dBPV (standard deviation: HRV (58%), sBPV (31%), mBPV (55%), dBPV (47%); max: HRV (21%), sBPV (1%), mBPV (16%), dBPV (17%); mean: HRV (14%), sBPV (4%), mBPV (9%), dBPV (9%); min: HRV (7%), sBPV (2%), mBPV(5%), dBPV (8%)). QMRA diagnostic reports after acupunture treatments also indicate high energetic balance of acupuncture channels and normal parameters of CVS, in agreement with patient's anamnesis: relaxation and energy inflow.
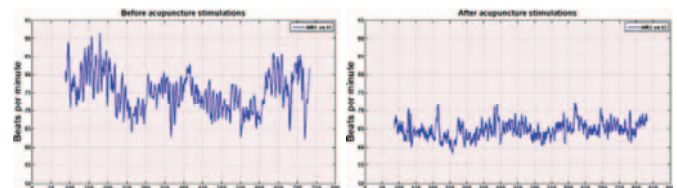

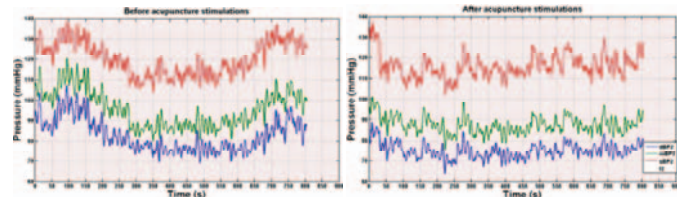Figure 1: HRV before (left) and after (right) acupuncturetreatments.

Figure 2: Systolic sBPV (red), mean mBPV (green) and diastolic dBPV (blue) before (left) and after (right) acupuncture treatments.

IV. CONCLUSION

HRV and BPV are parameters sensitive to physical activities and emotional states of patient. We have succeeded to get expected decrease of HRV and BPV by using TFM in rest (but not by holter recording, requiring more rigorous experimental conditions in further). We assume that measured decrease is caused by reaction (excess) of parasympathetic ANS to acupuncture therapy. The obtained results are preliminary and must be confirmed by more research studies [6].

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Classification of sEMG-based Hand Movements is Affected by Electrode Array Positioning

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Abstract — **The aim of this study is to indicate the effects of electrode array positioning over the forearm on sEMG-based classification of grasping and wrist movements.**

Keywords — *sEMG; electrode placement; PCA*

I. INTRODUCTION

Atzori et al. [1] presented publicly available NINAPRO database of surface electromyography (sEMG) signals, and used the first two principal components (PCs) of sEMG signals as classification features. Principal Component Analysis (PCA) is a feature extraction technique that can significantly reduce classification error in pattern recognition-based myoelectric control [2]. Using data from NINAPRO database, we showed that classification error is reduced when using the first three PCs as features [3]. Another important issue that affects classification error is displacement of electrodes [4]. In this study we investigated the effects of shifting the electrode array positioned on the forearm in a proximal direction on PCA feature extraction and classification.

II. METHODOLOGY

sEMG data were recorded from one healthy volunteer (female, 29 years, right-handed) using 8 Skintact F-TC1 (Leonhard Lang GmbH, Austria) electrode pairs placed circumferentially around the forearm, with reference electrode placed over the *articulatio cubiti*. Signals were recorded using EMG amplifiers (Biovision Inc., Germany) and digitalized using NI6212 A/D converter (National Instruments Inc., USA) at sampling rate of 1000Hz. The subject performed 10 repetitions of three grasping (power grasp, three finger spherical grasp, prismatic grasp) and six wrist movements (flexion, extension, pronation, supination, radial deviation, ulnar deviation) in a sitting position. The protocol was repeated for two positions of electrode array: at 1/3 the distance between wrist and elbow (position 1) and 1cm translation in proximal direction (position 2). Signal preprocessing, feature extraction and classification were performed according to method presented in [3].

III. RESULTS AND DISCUSSION

Fig. 1 illustrates the difference in cumulative sum of variance accounted for the first three PCs between two electrode positions for three grasping movements. The effects of differences between two electrode positions are reduced when higher number of PCs are accounted for. We obtained similar results for the set of six wrist movements. Classification accuracy increases when three PCs are used as features for both electrode positions and both sets of movements (Table 1), as obtained in [3].
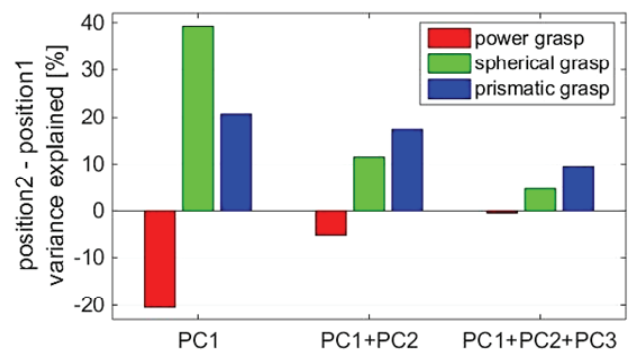

Figure 1. Difference between overall variance accounted for one, two, and three PCs for two electrode positions. The absolute difference decreases for all three grasping movements when more PCs are included.

TABLE 1. Classification accuracies for two sets of movements and two electrode positions, when using two and three PCs

	Position 1		Position 2	
	2 PCs	3 PCs	2 PCs	3 PCs
Grasping movements	85%	90%	92%	95%
Wrist movements	67%	79%	61%	87%

The preliminary results are encouraging and indicate that the effects of electrode placement can be amended by appropriate number of PCs. Further study should include sEMG signals from more subject and electrode shifting in different directions.

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PhysioACQ:

A Software Tool for Video-assisted Multi-channel Data Acquisition

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Abstract – **Using reliable and versatile software for signal acquisition is as important as well as having high sensitive electrodes and high performance electrical equipment. The ability to have real-time monitoring over multiple channels, together with visual recording and data archiving is crucial for data processing and study of various diseases and medical phenomena.**

Keywords - physiological monitoring; multi-channel data acquisition; vision, software

I. INTRODUCTION

Depending on the type of recording protocol, different acquisition parameters have to be set (different number of channels, file path, include video recording, etc.). The acquisition software used in medical researches should be easy-to-use and allow user a simple way of saving acquisition data and settings to speed up a preparation for recording. By doing so, user has an option of creating his own database of settings and this archive could be shared with other users. In some studies (e.g. electroencephalography (EEG), facial electromyography (EMG)), it is extremely important to have simultaneous recording of electrophysiological signals and corresponding video sequence of movement.

Software, such as ActiView706 (open-source) [1] and HBM's CatmanAP (commercial) [2] are available but they should be more flexible. The first one has 256 channels open for signal acquisition with immense interface and inability for visual monitoring and second one has no option for saving acquisition settings, unless user types them in comment area when saving data.

In this paper, we present the PhysioACQ software for multi-channel signal recordings and simultaneous video recording with the possibility of archiving acquisition parameter settings for re-recordings.

II. INTERFACE

PhysioACQ software is developed in LabVIEW 2009 environment (National Instruments, Texas,) with Vision Acquisition Software. Controls on the left side of the screen are positioned in order in which they will be used. Following options are available:

- Channels set-up – user selects acquisition device and opens proper number of channels (adaptable to the maximal number of analog-to-digital convertor channels). For each channel there is an option of changing name and selecting auto-scale.

- Acquisition settings – controls which regulate sample rate, amplitude axis and scaling options for all channels. There is an option for saving these settings and reading them afterwards, which can be done by selecting *save settings* or *read settings file* buttons.
- Video and data acquisition – if there is need for visual acquisition, *start camera* button should be pressed before running data acquisition. This way a new window opens which allows visual monitoring.
- Saving data – Saving data acquisition in spreadsheet format requires file path and name, and starts and finishes as soon as user selects *save to file path* button.

III. EXAMPLE

An example of PhysioACQ application is presented in Fig. 1, in facial EMG study. We used EMG amplifier (Biovision, Germany), analog-to-digital convertor (NI USB 6212, National Instruments, Texas) and surface electrodes (Skintckt, Austria). Electrodes were placed on *zygomaticus major* muscle on both sides of the face, and a reference electrode was placed on earlap. Two EMG signals are visible on screen with video recording of face movements, Fig. 1.
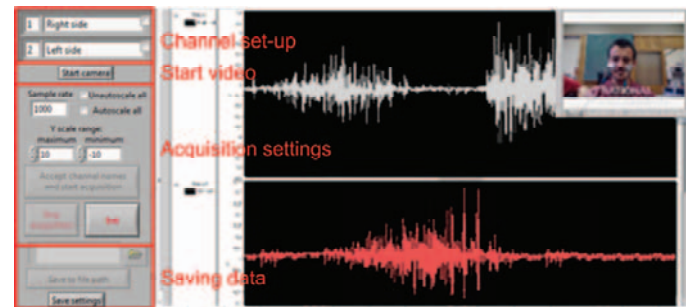

Fig. 1 PhysioACQ interface

IV. CONCLUSION

We have developed easy-to-use acquisition software with selective number of channels, visual assistance and option for saving acquisition data and settings. Wide area of application that this software offers is enabled with selective number of channels. We intend to test software in various biomedical fields.

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It is All About Looks!

Eye-movement Patterns Reveal Conceptual Preference for Thematic Knowledge

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Abstract— **In order to investigate the conceptual preference for thematic and taxonomic knowledge, two eye-tracking experiments have been conducted. The patterns of eye-movements have shown early competition of thematic and taxonomic information, but also a strong thematic preference.**

Keywords – eye-tracking; thematic, taxonomic; conceptual preference; semantic memory

I. INTRODUCTION

The fundamental principles of organization of our knowledge about the world are based on the types of conceptual relations: taxonomic and thematic [1]. Taxonomic relations rely on perceived similarity between objects (e.g. cow and donkey both have two eyes, two ears, four legs, hairy body covering, etc.), while thematic relations are based on information about objects' co-occurrences in time and space (e.g. cow and milk). While taxonomically related objects are typically members of the same semantic category (e.g. monkey and giraffe are mammals), thematically related objects are those that play complementary roles in the same scenarios or events (e.g. cows produce milk).

Although this distinction is long recognized, there is still little we know about the roles these two types of information play in shaping our mental world. In this study, we address this issue by investigating the patterns of visual attention in situations in which participants are presented with both thematic and taxonomic types of information.

II. METHOD

Two experiments were conducted. In both experiments, we have tracked participants' eye-movements during a matching task [2]. Participants were presented with an auditory cue, followed by simultaneous presentation of three visual items: one thematically related, one taxonomically related and one that is not related to the cue. They were instructed to choose the option that matches the base (cue) best. In **Experiment 1** option stimuli were presented pictorially, while in **Experiment 2** they were presented verbally (Fig 1).
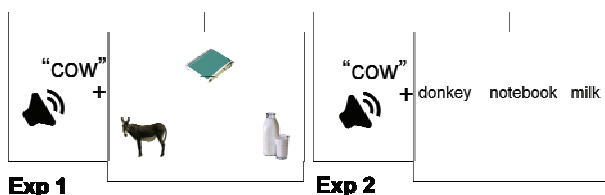

Fig. 1. Illustration of typical trials

In addition to participants' choices, we have collected a set of eye-movement measures. These were: First fixation position, Number of fixations, Percentage of the number of fixations, Looking time, and Percentage of looking time.

III. RESULTS AND DISCUSSION

In both experiments, participants consistently chose to group objects based on their thematic relatedness. The analysis of eye-movement patterns revealed that, although both types of relations, thematic and taxonomic, are automatically activated, participants spent more time and made more fixations towards thematic in comparison to taxonomic options. This was true both when option stimuli were pictures and when options were presented verbally.

When options were presented pictorially, the first fixation landed on the taxonomic item. This was not the case when verbal stimuli were presented.

The results of our studies suggest that conceptual preference is not simple due to the participants' strategy but may reflect the salience of relation types in the organization of semantic memory.
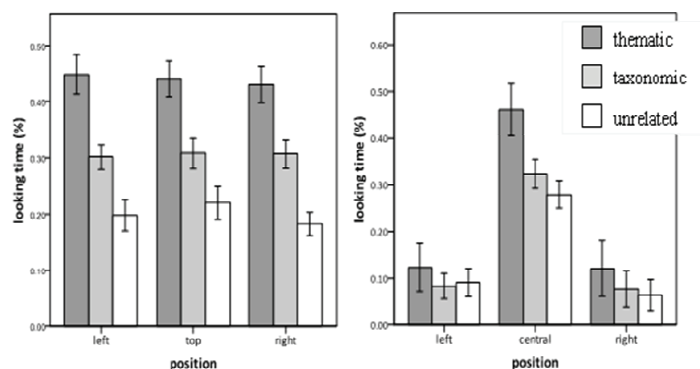

Fig. 2. Average looking time in **Experiment 1** (left) and **Experiment 2** (right): position by stimuli type

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Correlation Between EEG and EMG Signals

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Abstract— **We present preliminary results for the assessment of correlation between electroencephalographic (EEG) and electromyographic (EMG) signals during wrist flexion, extension and co-contraction under two loadings. Event-related desynchronization/ synchronization (ERD/ERS) analysis was applied on EEG signals, and envelope was calculated from EMG signal. The determined EEG-EMG coherence showed region of high activity around 23.30±1.52 Hz. We can establish that the defined set-up can be used for similar future studies.**

Keywords— coherence; EEG; EMG; ERD/ERS

I. Introduction

The simultaneous recording of the electroencephalographic (EEG) and electromyographic (EMG) activity can provide information about the organization of motor control (e.g., planning, movement preparation) [1]. It is known that there is link between the voluntary movements and the changes in the cortical rhythmic activity. The amplitude decrease and increase can be seen few seconds before and after the onset of movements and it is called event-related desynchronization/ synchronization (ERD/ERS). The most significant changes of these potentials can be noticed within the alpha (primarily μ rhythm 9-11 Hz) and beta rhythm [2]. Another method is the determination of coherence within some frequency ranges (usually from 15 to 35 Hz), where the existence of the peak was localized at 23±3 Hz [3]. Our main goal was to improve and test the instrumentation for future research in the domain of motor control which includes both EEG and EMG.

II. Methods and Materials

A. Instrumentation and procedure

We recorded EEG with the Smarting (mBrainTrain, Belgrade, Serbia) 24–channel digital amplifier (reference at FCz) with wireless communication, and an EEG (10-20) cap with 24 Ag/AgCl electrodes. We recorded EMG from the wrist/fingers flexors and extensors, with surface, pregelled, and disposable Ag/AgCl electrodes. Biovision (Biovision, Wehrheim, Germany) analog amplifier with gain 1000, and 16-bit A/D card NI USB 6212 (National Instruments Inc., Austin, USA) were used. Both systems were set at 500 Hz sampling rate. A force sensing resistor (FSR) was placed above the Fz electrode on the EEG cap. Systems were synchronized by the on-off signal coming from the FSR (on the EMG recorder), and major artifact on the Fz channel (EEG recordings). One healthy adult male subject (Age: 26) was involved in the test. Two sessions, both including five repetitions of wrist flexion, extension and co-contraction, without and with a hand load of 1kg were performed. The study was realized in accordance with the ethical standards of the Declaration of Helsinki.

B. Signal processing

The synchronized two channels of EMG and four channels of EEG (four electrodes above the motor cortex: C3, C4, Cz, Cpz) were used in this study. We used band-pass filters around 10 Hz and 20 Hz. Based on the onsets of the movements, we extracted power sequences from the filtered EEGs [4]. The final ERD/ERS were expressed as the percentage of power change comparing to the reference value (i.e., the average of all samples). We analyzed the coherence in the frequency range from 15 to 35 Hz (as in [3]) and defined two parameters for quantification: the area under the coherence curve as the percentage of total area within that frequency range, and set of indicators of the prominent peaks frequency and height (f, h).

III. Results and Discussion

The calculated area (in average 24.67±2.43 %) didn't show any specific behavior in the terms of different EEG electrodes, movements and loads. Unfortunately, the obtained ERD/ERS (Fig. 1) didn't fully confirm the expected result. However, the established region of high activity in coherence localized at f=23.30±1.52 Hz (h=0.30±0.09), corresponds to the results presented in the literature and shows that proposed instrumentation can be used for similar future studies.
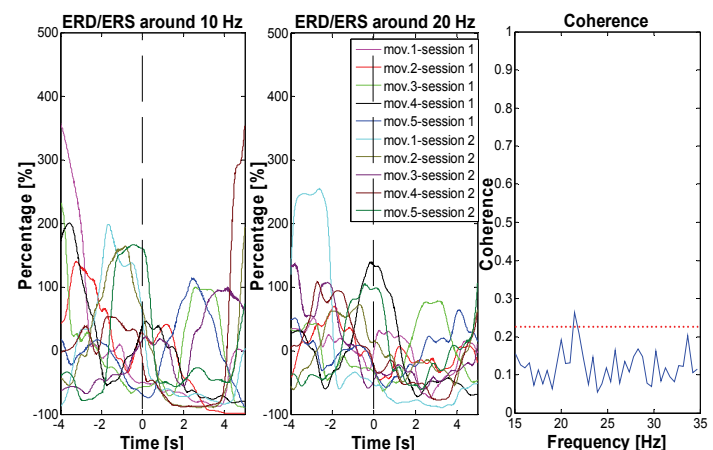

Fig. 1. The example of results for wrist flexion, hand load of 1 kg, and electrode Cz. The dashed black line marks the beginning of a movement.

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Acceleration and Acoustic Signals of Abdominal Muscles

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Abstract—**MMG (mechanomyography) is shown as a vital complementary modality for EMG (electromyography). We measured acceleration and acoustic signals from abdominal muscles and compared it with EMG.**

Keywords —Acoustic Myography (AMG); Electromyography (EMG); Mechanomyography (MMG)

I. INTRODUCTION

Mechanomyogryphy (MMG) reflects the mechanical nature of muscles. As force depends on acceleration, it is shown that MMG reflects muscle force [1]. MMG signals typically have better signal to noise ratio (SNR) than EMG signals and are higher in magnitude, also noise such as unwanted motion artefacts can be easily detected and removed. Using the EMG to measure direct muscle response to electrical stimulation has a serious limitation compare to the MMG [2]. In the other hand, EMG can be used to detect abnormal electrical activity of muscle that can occur in many diseases.

In our study, we measured and compared surface EMG with MMG (assessed with accelerometer and microphone) signals recorded on abdominal muscles.

II. METHOD

We recorded EMG and MMG signals from three positions over abdomen in order to assess the activation of *transversus abdominis* (TrA) muscle (proximal, middle and distal positions), and from *rectus abdominis* (RA) muscle. The subject was instructed to lie in supine hook-lying position. Signals were measured while the participant breathed normally (relaxation) and then after exhaling to draw the stomach in as much as possible and keep it in that position for a few seconds (activation). This maneuver was chosen due to high selectivity in muscles activation [3]. Root mean square (RMS) for each activation and relaxation was calculated. Afterward, we calculated relations of $RMS_{activation}/RMS_{relaxation}$ for individual muscles and their mean values and standard deviation.

EMG signals were acquired in custom made LabVIEW software (National Instruments Inc., Austin, USA) and sampled at 1000 Hz with 16 bits A/D resolution. Gain was set to 1000 (AceLAB, Tecnalia Serbia Ltd., Belgrade, Serbia). Acceleration signals were measured with 3-axial wireless accelerometer (Beagle 2.0, Tecnalia Serbia Ltd., Belgrade, Serbia) with 0.001g resolution and at a sampling rate of 100 Hz. For acoustic measurements, the capacitive microphone was placed in a stethoscope tube, and dedicated circuitry was

designed and housed. AMG signals were acquired by AceLAB setup: sampled at 1000 Hz and digitized with 16 bits.

III. RESULTS AND DISCUSSION

In Fig. 1, the activation of TrA from three positions is obvious. Relations for RA muscle showed that there was no activation for the presented maneuver, as it is expected [3]. The highest relative RMS for TrA are different between MMG and EMG, probably due to different muscle property recorded: mechanical *vs.* electrical, respectively.
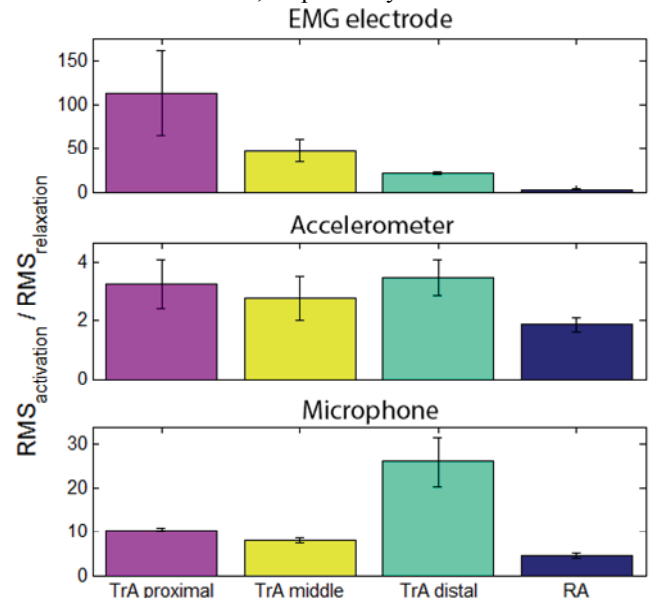

Fig. 1. Relative RMS relations for EMG and MMG (accelerometer and microphone) modalities, in the case of abdominal muscles.

Today, usage of MMG is far from its full potential. MMG sensors are usually produced in low-cost MEMS technology which makes it a lot more accessible than EMG devices. Our future aim is to experiment with other processing techniques (such as independent component analysis and spectral analysis) and discover specific characteristics of MMG that can improve EMG especially in clinical practice.

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Kinematic Analysis of Handwriting in Children with Attention Deficit Hyperactivity Disorder

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Abstract—**Writing is one of the basic forms of communication. Handwriting can be altered in attention deficit hyperactivity disorder (ADHD) and these changes could be analyzed using a graphic tablet.**

Keywords—handwriting; ADHD; kinematic parameters

I. INTRODUCTION

Writing is the most direct form of graphic communication [1]. Good handwriting is a fundamental skill necessary for success at school. Children who have difficulty producing legible handwriting often experience frustration, lowered self-esteem, and a decreased level of motivation [2].

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder that affects approximately 1 in 20 children. Children with ADHD are characterized by symptoms: hyperactivity, inattention, and impulsivity [3].

Several handwriting difficulties are seen in children with ADHD such as irregular spatial arrangement, unrecognizable letters, inaccuracy, larger height and width of words, or increased pen pressure [3].

The aim of this pilot study was to test the feasibility of using a graphic tablet as a method of the analysis of handwriting in children with ADHD.

II. MATERIAL AND METHODS

The study included three boys from elementary school. Two boys (ages 8 and 9 years) had ADHD (DSM-V; no comorbidity, no stimulant medication). One boy (9 years) was a healthy subject. All boys were right-handed, IQ>80 and had excellent school achievement. All participants were involved in performing 12 drawing and writing tasks. Kinematic parameters of handwriting were sampled using Wacom Intuos4 XL (sampling rate 133 Hz, resolution 0.005 mm).

III. RESULTS

Comparing the mean values of writing velocity (rate at which the position of a pen changes with time) between drawing tasks revealed that there was a significant difference between simpler tasks (e.g. linking two dots with a line, drawing a circle) and more complex tasks (e.g. copying a rectilinear shape, drawing an eight) respectively. This difference was noted in the eight-year-old boy with ADHD but not in the nine-year-old boy with ADHD and healthy nine-year-old control.

In sentence writing tasks (adapted to the age and Serbian-speaking language area), the vertical direction velocity mean value for all subjects was observed [4]. Sentence "Danas pada kiša" ("It's raining today") was written on pure white background with visual feedback of written content (continuously monitoring the screen positioned in front of the subjects at eye level) and without visual feedback of written content (the pen didn't leave trace on the writing surface). No statistical difference of vertical direction velocity mean values between these two tasks was found.

When the same sentence was written on a background divided with horizontal lines, statistically significant difference in the mean values, of stroke time (i.e. the duration of each stroke), velocity (i.e. both horizontal and vertical direction) and acceleration (i.e. the rate at which the velocity of a pen changes with time) was noted for all subjects in comparison with writing the same sentence on a clean white background.

IV. DISCUSSION

Difference in drawing tasks velocity observed in the 8 year-old- boy with ADHD, but not present in the 9 year-old-boy and 9 year-old-healthy control, can be explained by the results of previous studies showing that some kinematic parameters of drawing skills progress during time [4,5].

No statistical difference in vertical direction velocity mean between writing a sentence with and without visual feedback is a result of younger participant age, where handwriting as a motor skill is still developing and it is not fully automated, so level of attention during both tasks is high [2,5].

Differences in writing between horizontal lines and on clean white background are consequences of the impact that lines have on the stroke time, velocity and acceleration values; which is shown in earlier research [6].

Based on the results that correlate with previous findings, we conclude that the applied methods can be used in further research of handwriting in children with ADHD. We are planning a study of kinematic parameters of handwriting in children with ADHD on a bigger, clinical sample, which will include children of different age and both genders, either treated with stimulants or behavioral techniques, untreated, and age and gender-matched healthy controls.

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Author Index

A

Antić Milan, 23
Avramović Marija, 18

B

Berka Chris, 10
Bijelić Goran, 12, 26
Bobić N. Vladislava, 25
Borovac S. Stefan, 25

C

Crocher Vincent, 4

D/Đ

Di Gennaro Stefano, 17
Djordjevic Olivera, 9, 26
Došen Strahinja, 14
Đozić Damir, 14
Đurović Željko, 17

G

Gajić Dragoljub, 17
Gavrovska M. Ana, 6
Guillaume Morel, 4

H

Husein Al-Taleb Manaf Kadum, 5

I

Ilić Olivera, 24
Isaković S. Milica, 22
Ivančević Nikola, 7, 27

J

Jančić Jasna, 7, 27
Janković Milica, 23
Jarrassé Nathanael, 2
Johnson R. Robin, 10
Jerković Miler Vera, 27
Jorgovanović Nikola, 14

K

Kojić Vladimir, 13, 26, 27

Konstantinović Ljubica, 12, 21, 26
Ković Vanja, 15, 24
Krajoski Goran, 14, 19

L

Lakić Aneta, 7, 27

M

Malešević Jovana, 13
Malešević Nebojša, 13
Marjanović Dragan, 19
Matić Zoran, 20, 21
Miljković Nadica, 18, 22, 26
Milovanović Branislav, 21
Mišić Tatjana, 21
Mrachacz-Kersting Natalie, 8

P

Popov Nikola, 19
Popović B. Mirjana, 22, 27
Popović Dejan, 13
Popović Nenad, 23
Proietti Tommaso, 4

R

Radovanović Saša, 11
Raković Dejan, 21
Robertson Johanna, 4
Roby-Brami Agnes, 4

S/Š

Ševarac V. Zoran, 16
Stanković Srđan, 20
Stevanović Dejan, 7, 27
Stikic Maja, 10
Štrbac Matija, 13, 22, 26

T

Tan Vaesna, 10
Tepić Željko, 19

V

Vuckovic Aleksandra, 5

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