



R E V I E W

by Prof. Dr. Eugeniya Kovatcheva,

University of Library Science and Information Technologies

for the acquisition of the educational and scientific degree of Doctor of Science in the scientific specialty Application of the principles and methods of cybernetics in various fields of science with a dissertation on the topic:

A Neurocognitive Approach Based on a Brain–Computer Interface for Identifying Emotional and Mental States,

presented by Master of Engineering Gagandeep Kaur,

doctoral student in an independent form of study

with scientific supervisor: Prof. Dr. Anna Kostadinova Lekova –

Institute of Robotics at BAS

Order No. 44/16.04.26, of the Director of the Institute Prof. Dr. August Ivanov

I. Presentation of the doctoral student based on the submitted documentation

Gagandeep Kaur is a bachelor of Bachelor of Electronics and Communication Engineering 2007 MBSCET, University of Jammu, J&K, India and Master of Engineering in Electronic Product Design Engineering 2009 Punjab Engineering College Technological University Chandigarh, India. She was an assistant professor at the Department of Electronics and Communications, SUSCET, Tangori (Punjab Technical University) and since September 2022 is an assistant professor at the Department of "Interactive Robotics and Control Systems" at the Institute of Robotics at BAS.

II. Assessment of the qualities of the dissertation work

The topic of the dissertation work is very relevant in various spheres of life. It is necessary to identify the emotional and mental state. The fatigue factor at work is essential for reducing motivation and burnout. This problem is significant for teachers.

Eng. Kaur has precisely defined the goal of her dissertation and the specific tasks for achieving it. The dissertation is spread over 103 pages, divided into 4 chapters. 116 sources were used, most of which are from the last 10 years. No plagiarism was found.

The abstract follows the presentation in the dissertation.

The doctoral student has presented an in-depth literature review, a study of mental fatigue, EEG and mental fatigue, EEG oscillations and their functional consequences, Frontal Theta and attention and fatigue during load, Alpha activity during attention and fatigue, Beta band power and mental fatigue, BCI systems for detecting mental states. The significance of the theta, alpha, beta and delta frequency bands for fatigue during work processes has been established and the focus of the analysis is on them.

After a critical analysis, Eng. Kaur has identified the limitations and gaps in existing research and proposes a methodological framework for assessing mental fatigue in a real educational environment, which integrates EEG data recording, signal preprocessing, spectral feature extraction and statistical analysis.

The paper presents two stages of the methodological framework: a pilot and a main study.

The dissertation presents a systematic study of EEG on brain-computer interface (BCI)-based methods for assessing and analyzing mental states. Some techniques for forming a conceptual framework and research methods are considered. The EEG technique is central to the study and the doctoral student describes it in detail.

The main elements included in the methodological framework are systematically introduced in the dissertation presentation.

The mathematical apparatus used formalizes wave processes, which allows for in-depth research and referencing to already existing relationships.

The dissertation is in English, which allows for its better dissemination.

The work contains illustrative images and summary tables that support what the doctoral student presented, unfortunately I did not find their lists, and their numbering does not allow them to be easily counted.

It gives a good impression that the studies conducted are in accordance with ethical guidelines for informing the participants.

The presented pilot and main studies are well structured and described in the dissertation.

Eng. Gagandeep Kaur also presents guidelines in which she sees the development of her work with provisions for expanding the analytical framework and including statistical and non-statistical approaches.

III. Contributions of the dissertation research

Five principles have been formulated, which are categorized as scientific and applied.

1. A new model and methods for neurocognitive analysis and assessment of various emotional and cognitive states in working adults, based on EEG MCI (brain-computer interface), have been formulated.
2. A new methodology for EEG-based MCI for analysis and assessment of emotional and cognitive states in working adults has been formulated.
3. An adaptive software framework for processing and interpretation of fatigue has been created using an experimental design "before-after intervention", which takes into account the individual baseline level of the participants
4. A methodology for an innovative experimental procedure based on real data has been created, as the study was conducted outside a controlled laboratory environment, through a study of teachers teaching the Suggestopedia method directly in the classroom.
5. Through statistical analysis, an original neurophysiological model has been identified, not previously described in EEG studies of fatigue and characterized by dominant activity of the right hemisphere.

I accept the contributions thus proposed, but I would add two more, related to the literature review, namely:

1. Critical analysis of existing studies
2. Identification of limitations and gaps in existing studies

IV. Notes and recommendations

I had the pleasure of meeting Eng. Gagandeep Kaur and having a conversation with her in my office a year ago. She shared her research and the pleasure of working at the Institute of Neurology, Bulgarian Academy of Sciences.

I have no comments. She should continue her work and make connections with colleagues in India.

V. Publications and participation in scientific forums

Three publications are presented (one of which is a chapter of a book, where Eng. Kaur is an independent author, and in the other two publications she is a co-author) and 88.13 credits. They exceed the required two publications and 30 credits. The doctoral student has identified two citations.

The doctoral student has completed five specialized trainings with successful exams. She presented her dissertation at three scientific forums in Bulgaria and abroad.

VI. Conclusion

The topic of the dissertation is relevant. Doctoral student Kaur presents in-depth theoretical knowledge and skills for their application in practice. She has the ability for independent scientific research.

Scientific and scientific-applied results were obtained when working on the dissertation.

I believe that Master of Science Engineer Gagandeep Kaur fulfills the MNI, the requirements of the ZRASR, the Regulations for its implementation and the Regulations of the Bulgarian Academy of Sciences.

I positively evaluate the dissertation work and propose to the esteemed jury to award the educational and scientific degree of Doctor to Master of Science Engineer Gagandeep Kaur.

Prepared the review

Eugenia Kovatcheva