International Journal on Cybernetics & Informatics (IJCI) Vol.13, No.3, June 2024

A CREATIVITY MONITORING DEVICE (CMD) FOR NEW INSIGHT INTO THE BRAIN MECHANISMS OF ARTISTIC, SCIENTIFIC AND ENGINEERING CREATIVE ACTS

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ABSTRACT

This paper introduces the basic design of a novel neuroscientific device named Creativity Monitoring Device, CMD, able to provide new insights into the brain mechanisms of artistic, scientific and engineering creative acts. The novelty of the device is threefold. First, it allows the artifact-free recording of association cortical EEG waves during such creative acts as painting artistic visions, composing music, running novel experiments in a laboratory or working on an engineering invention. Second, it allows the synchronous monitoring of the sounds and visual events in the environment of such actions along with the artist's, scientist's or engineer's verbal and non-verbal interactions with this environment and his or her own notes on the engaged creative phase. Third, it allows the offline analysis of the synchronously collected EEG and audio-visual data with the new method of dynamic neurocombinatorics, which can reveal at 2 msec accuracy the relationships between the recorded objects of 5 sets: (1) the spatial occurrence codes of the recorded association cortical EEG waves; (2) the complexity codes of each of the recorded 0.2 - 200 Hz EEG waves; (3) the codes of the synchronously recorded environmental events including those of the subject's verbal and non-verbal interactions with this environment; (4) the subject's own dictated notes identifying the phase of the engaged creative act, and (5) the time-course of these continuously recorded objects within each of the indicated sets over the entire, at least 10-hour, creativity monitoring period. Thus, CMD studies should reveal the key electrical brain changes underlying the initiation, maintenance and termination of creative acts and should show the similarities and differences between artistic, scientific and engineering creativities.

KEYWORDS

Artifact-free EEG headset, Wearable environment monitor, Dynamic Neurocombinatorics

1. INTRODUCTION

This document describes the basics of a novel neuroscience device, a Creativity Monitoring Device, CMD, that should generate new insights into the brain mechanisms of artistic, scientific and engineering acts. It is essentially the combination of a wearable EEG recording headset and an audio-visual environment-monitor operating synchronously to generate an extensive, multifaceted dataset during the creative work of artists, scientists and engineers in natural conditions and absolute privacy for offline analysis with the new mathematics of dynamic neurocombinatorics.

Bibhu Dash et al: SCDD -2024
pp. 11-15, 2024. IJCI – 2024 DOI:10.5121/ijci.2024.130302

Such studies have not been done, not even envisioned. Nancy C. Andreasen's fundamental book on creativity [1] discusses creativity-related psychological, neuroimaging and anatomical studies, without expanding to the field of EEG examinations. Michio M. Kaku's exploration of the future of mind does mention informative EEG studies, but within the limits of research on telepathy, dreams, memory and decision-making [2]. The 64 chapters of the last, 6^{th}, Edition of Eric R. Kandel's and his co-authors' "*Principles of Neural Science*" does not include a chapter on the brain mechanisms of creativity [3]. Perhaps our time's leading EEG expert, György Buzsáki, published a comprehensive description of the EEG phenomenon Sharp Wave Ripples (SPW-Rs) and how these ripples may contribute to memory formation and "influence decisions, plan actions and potentially, allow for creative thoughts." Though not mentioning combined environmental and EEG studies in natural conditions during the creative acts of artists, scientists, engineers or others, nor data analysis with dynamic neurocombinatorics, Buzsáki did suggest the importance of answering the question of whether SPW-Rs contribute to the "preconscious creative process by linking never-before associated events." [4]. Other investigators undertook the task of reviewing EEG studies in creative people or performing such studies themselves [5 – 7], though these studies have been short-term laboratory experiments very different from the daylong CMD recordings in private settings proposed here. Still, such examinations during creative writing [8], art making [9], imaginations [10], music playing [11] or idea generation [12] will once surely reach the point when even geniuses like Paul McCartney, Sergey Brin, Katalin Karikó, Arundhati Roy, Akiane Kramarik or Kazuo Ishiguro agree to provide humankind with insights into their creativity with absolutely private and safe, environmentally coupled EEG recordings before, during and after their inspirations.

2. GENERAL CMD DESIGN

The general design of the CMD is shown in Figure 1.

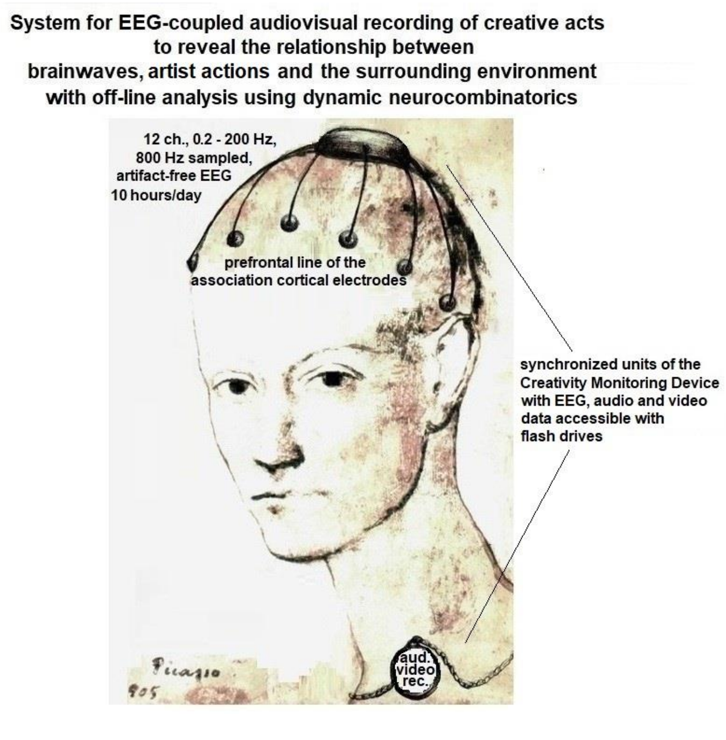

Figure 1. The EEG recording headset allowing the collection of artifact-free EEG signals is an advanced version of the seizure detection headset patented by this author's team [13].

The headset can be installed by the subject at home, in privacy, by the ~20-minute use of a removable helmet specially designed for this purpose [14]. The audio-video recorder is built in a medallion [15], but it can be another wearable device. USB flash drives are used for accessing the data without exposing the system to the risks of our time's internet. For the sake of simplicity, this system would first be used for 10-hour continuous data collection in daytime. However, as experience is gained with the device, it could also be used for 24-hour more sophisticated daytime/nighttime recordings, providing insight into the role of sleep in creativity.

As the figure indicates, the device would collect EEG data over 12 channels with 6 in the right hemispheric and 6 in the left hemispheric association cortices, likely locations of creative neural processes. The frequency of the recorded EEG waves would range from 0.2 to 200 Hz, with each wave-frequency further characterized by the coded complexity of the wave-shape. The device's audio-visual recorder would collect coded data on the primary characteristics of the creative act's environment, such as its sounds, lights, layout of used and non-used furniture, machines, instruments and decorations, the presence or absence of conversations and other interactions of the subject. This audio-visual recorder would also be used for taking notes from the subject on the phase of the creative process, whether it is related to preparations, inspirations, or the execution of the prepared and inspired acts. While the mathematics of combinatorics – beyond this author's expertise – would be used for the off-line analysis of these data, qualifying for the term "neurocombinatorics", this analysis would also be a dynamic neurocombinatorics, as the relationships between the recorded sets and their objects would critically include the course of these relationships in time, over an at least 10-hour period.

3. FUTURE CMD PROJECTS

This author sees the first CMD study, a stepping stone for further related studies, as follows: First, 4 groups are formed, each with a minimum of 6 experimental subjects. The first group includes artists, either painters or writers or composers. Obviously, all selected subjects of this group must do the same type of art. The second group includes scientists, either neurophysiologists or molecular biologists or physicists. Again, all selected subjects of this group must do the same type of science. The third group includes engineers, either neuroengineers or architects or chemical engineers. Here also the selected subjects must be engaged in the same type of engineering work. The fourth group is the control group, made of sex- and age-matched men and women who went through college or even university education but are not doing creative work. Ideally, the study should be run at the same time to exclude the confounding effects of different seasons and political changes. Each subject is personally given a CMD system, allowing a 2-3-hour demonstration of how to use the helmet to setting up the EEG headset, how to electrically recharge the system if needed, how to make notes on the phase of the creative act and how to start and finish the minimum 10-hour recording sessions. Once this is done, the contributing artist, scientist or engineer can use the device whenever he or she feels the time arrived for creative work in the very spiritual place of this activity for him or her, whether in a studio, office or natural environment and whether the creative act is painting, composing music, poetry or novel writing, working on a laboratory experiment or designing a new software or device.

Once the critical first study on CMD use is done, interested investigators can expand on this research by inviting different artists, scientists and engineers for subsequent studies and running both daytime and nighttime recordings. The use of dynamic neurocombinatorics for data analysis can surely undergo substantial improvements.

4. CONCLUSIONS

This paper introduced the idea of a Creativity Monitoring Device, CMD, to provide new insights into the brain mechanisms of artistic, scientific and engineering creative acts. The device allows the artifact-free recording of association cortical EEG waves during such creative acts as painting artistic visions, composing music, running novel experiments in a laboratory and working on an engineering invention. The device also allows the synchronous monitoring of the sounds and visual events in the environment of such actions along with the artist's, scientist's or engineer's verbal and non-verbal interactions with this environment and his or her own verbal notes on the engaged creative phase – continuously for at least 10 hours. Offline analysis of the synchronously collected EEG and audio-visual data would be performed with the new method of dynamic neurocombinatorics, which can reveal the relationships between (a) the spatial occurrences of the recorded EEG waves, (b) the complexity of each of the recorded waveshapes, (c) the synchronously recorded environmental changes including the creative subject's interactions, (d) the subject's own dictated notes identifying the phase of the engaged creative act, and (e) the time-course of these continuously recorded data. Such studies should reveal the electrical brain changes underlying the initiation, maintenance and termination of creative acts and should show the similarities and differences between artistic, scientific and engineering creativities.

ACKNOWLEDGEMENTS

This paper could not have been written without the original inspirations of my admired physiology professors, the late Dr. Kálmán Lissák and the late Dr. Endre Grastyán, in my medical school years back in Pécs, Hungary. Nor could it have been written without the few unforgettable meetings with the late Hungarian filmmaker Zoltán Huszárik who let me experience the soul of the genius. I am also indebted to my late surgery professor colleague and friend Dr. John G. Kral for teaching me that believing in one's capabilities is part of the creative mind. It was my almost 20-year collaboration with such talented engineers as Lóránt Kovács, MS; Géza Medveczky, MS; and Sándor Tóth, MS; that inspired me to envision neurodevices like the one discussed in this article, knowing well that only expertise like theirs can translate such visions to functioning products. The unwavering faith of my artist daughter Krista in my scientific, philosophical and literary endeavours was key to conceive this paper.

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