engineering proceedings

MDPI

Proceeding Paper

Detecting Emotions Using EEG Signals †

Ivan Ralev * and Georgi Krastev

Department of Computer Systems and Technologies, University of Ruse, 7017 Ruse, Bulgaria; georkk@uni-ruse.bg
* Correspondence: iralev@uni-ruse.bg
† Presented at the International Conference on Electronics, Engineering Physics and Earth Science (EEPES 2025), Alexandroupolis, Greece, 18–20 June 2025.

Abstract

Emotions represent the internal state of a person. They can be detected by observing external signs or by using specialized equipment. The aim of this paper is to investigate the possibility of determining emotions using a digital electroencephalograph. At the beginning of the paper, a definition of emotion is given in order to determine rules for distinguishing individual emotions. A presentation of the equipment used during the study is made. An analysis of the results obtained is carried out.

Keywords: EEG signals; emotions; digital electroencephalograph

1. Introduction

Every living being experiences emotions. It can be defined as a state of the organism expressing the internal mental state. It is characterized by a certain expressiveness, through which it can be perceived by surrounding individuals. Through the use of certain stimuli, it is possible to create emotions that change their appearance and characteristics over time [1]. Various physiological data are used to detect and recognize emotions. Examples of this could be are as follows: electroencephalography (EEG), electrocardiography (ECG), blood volume pulse (BVP), galvanic skin response (GSR), respiration rate (RT), electromyography (EMG), skin temperature (ST), and eye gaze [2]. Using the knowledge in the field of EEG signals, it is known that certain factors can lead to distortion of the data obtained during the study, and this can lead to incorrect recognition of an emotion. An example of this is individual differences in the expression of each person's emotional state [3]. With the development of science, it is possible to record the signals of the user's brain activity in real time, and on this basis to create models projecting their emotional state [4]. In contrast to various conventional methods, the application of an electroencephalogram investigates changes in a person's internal emotional state [5]. A major problem in using EEG signals is determining which characteristics, frequency bands, and electrode placement system to choose. The wrong use of some of the listed may lead to an inaccurate interpretation of the result [6]. Emotions can have protective, communicative, reproductive or other functions. In humans, the first two types are the most often observed. When using the visual method for recording an emotion, its recognition is carried out by determining the position of the body in space and the movement of the limbs, eyes, mouth, and other parts. In addition to using the musculoskeletal system, the emotion may also be expressed through other systems that make up the human body, such as the endocrine or cardiovascular system. Part of it may not be visible to the human eye. While sweating, changing the size of the pupil, goose bumps or changing the color of the skin have a visible side, other characteristics, such as, for example, an increase in body temperature, cannot be recorded. In certain

check for updates

Academic Editor: Grigor Mihaylov

Published: 25 August 2025

Citation: Ralev, I.; Krastev, G. Detecting Emotions Using EEG Signals. *Eng. Proc.* **2025**, *104*, 13. https://doi.org/10.3390/engproc2025104013

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

diseases of the nervous system, there may be damage to the hippocampus or gyrus and consequently an absence of emotion. A number of experiments are being carried out in the field of reading emotions with the help of medical equipment. Neurons in the human brain communicate and control other organs and systems through electrochemical impulses. These signals can be recorded using an electroencephalograph.

2. Digital Electroencephalograph Capabilities for Detecting Emotions

In modern technological systems, it is essential to choose the right mathematical modeling and hardware architecture [7]. The digital electroencephalograph is a specialized medical device that can be used to record the electrical activity of the brain. In healthcare, it is mainly used to study diseases such as epilepsy, sleep disorders, stroke, migraine, and other brain diseases of an unexplained nature. Through the correct placement of the electrodes on the user's scalp, it is possible to detect the change in the electrical signals created by the neurons and thus detect different emotional states [8]. The study could use an invasive or non-invasive approach. In the first, electrodes are implanted in the human body, while in the non-invasive one, they are placed on it. In the first approach, the signals obtained are of higher quality. Non-invasive electrodes only 'sample' the electrical activity synchronized over a large area of the brain [9]. In the non-invasive one, the data is of poorer quality, but it is a much gentler procedure. The electrodes can be divided into three groups: dry, semi-dry, and wet. The first ones do not require the use of any agent. In the semi-dry ones, a special gel is used. In the wet electrodes, a special solution is used, which is a mandatory procedure. Dry electrodes produce the weakest and lowest-quality signal, but the lack of the need to use a gel makes them most suitable for studying a person's emotional state.

3. Experimental Installation

Figure 1 is a diagram of the experimental installation used, which includes the use of a digital electroencephalograph and a multifunctional flash stimulator, connected to a laptop computer via a USB connection.

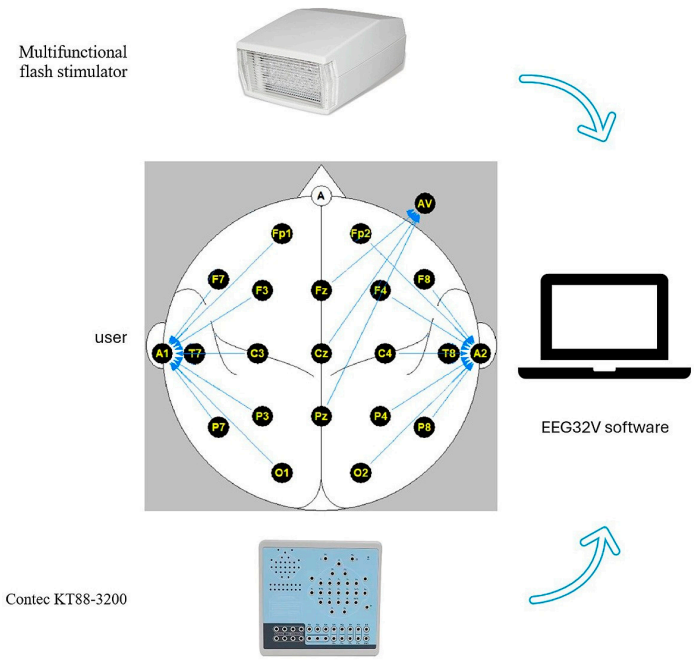

Figure 1. Diagram of the experimental installation.

The software used for detecting EEG signals, their processing, and their interpretation is EEG32V ver.1. It offers different ways to control the multifunctional flash stimulator. It supports up to 32 signal channels. Dry electrodes are placed on the head of the user being tested, connected by cables to the electroencephalograph. For proper detection of the signals, it is important that the room is isolated from strong electromagnetic fields, the temperature is in the range from +5 °C to +40 °C, the relative humidity is ≤85%, and the atmospheric pressure is 700 hPa~1060 hPa. It is important that the contact from which the electroencephalograph is powered is well grounded, because otherwise the results can be distorted.

For the study described in this paper, the Contec medical systems KT88-3200 electroencephalograph was used. It is a 32-channel system. During the testing of a small group of people, the 19-channel system was used. The international 10/20 system [10,11] was used for the placement of the electrodes. The connections between the individual points where the electrodes are located are as follows: Fp1-A1, Fp2-A2, F3-A1, F4-A2, C3-A1, C4-A2, P3-A1, P4-A2, O1-A1, O2-A2, F7-A1, F8-A2, T7-A1, T8-A2, P7-A1, P8-A2, Fz-AV, Pz-AV, Cz-AV.

The tests are performed under the following conditions:

- The user's eyes are closed;
- The user is open-eyed;
- A strobing light is turned on, provoking a blinding reaction (photostimulation);
- The condition is observed while performing routine actions.

The emotional state is studied when questions with an easy answer and those whose answer is not clear are asked, with the aim of provoking thought. The user is asked to perform certain actions—raising a leg or arm. The data is recorded when there are no outsiders in the room and when there are.

4. Analysis of the Results Obtained

Figure 2 presents the results obtained from the digital electroencephalography study. In this case, the user is a twenty-seven-year-old man in good physical condition with no medical complaints. The figure shows the data obtained when the user has their eyes closed. No paroxysms characteristic of reflex epilepsy is observed.

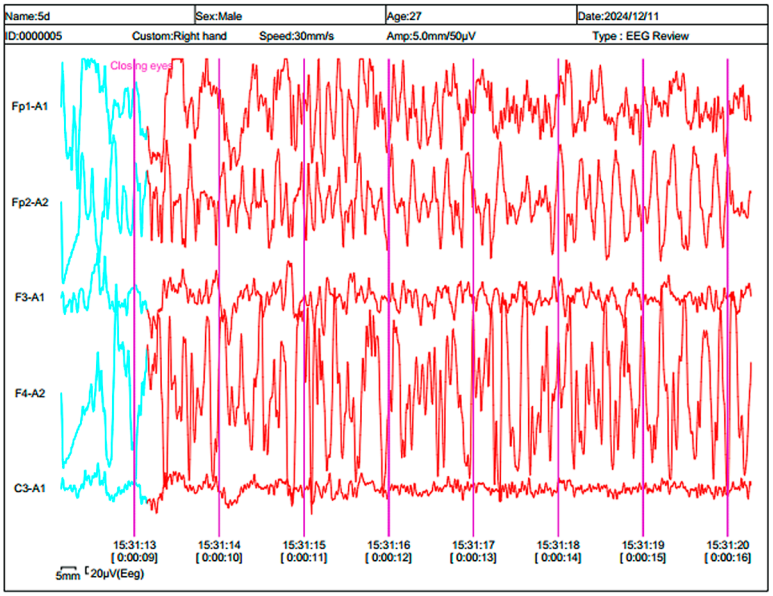

Figure 2. EEG data when the user's eyes are closed.

Figure 3 shows the data when the user has their eyes open. The data is normal and no change or abnormality can be observed based on comparison with the data obtained from the other participants in the study.

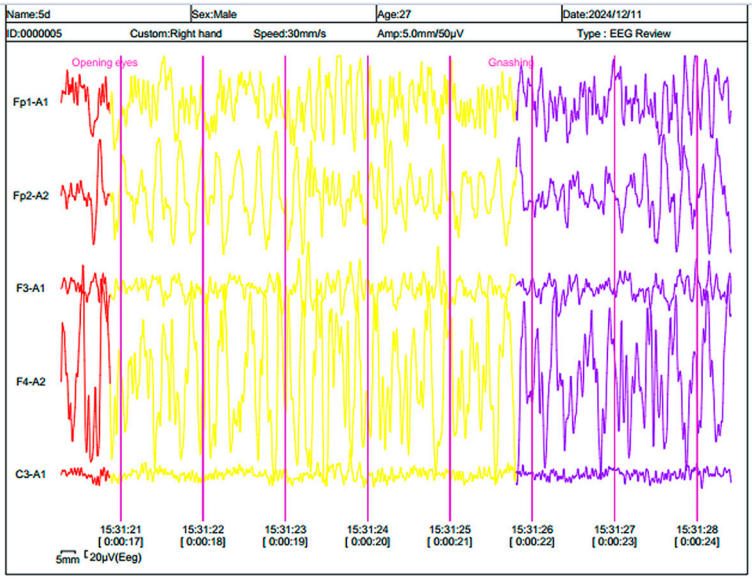

Figure 3. EEG data when the user is open-eyed.

Figure 4 presents the data obtained when the user is subjected to light stimulation, via a strobing light. At the beginning, the strobing light is periodic, and then the photo stimulation is aperiodic. The amplitude and wavelength of the observed signals do not differ significantly for the studied time. No increased sensitivity to light photophobia is observed.

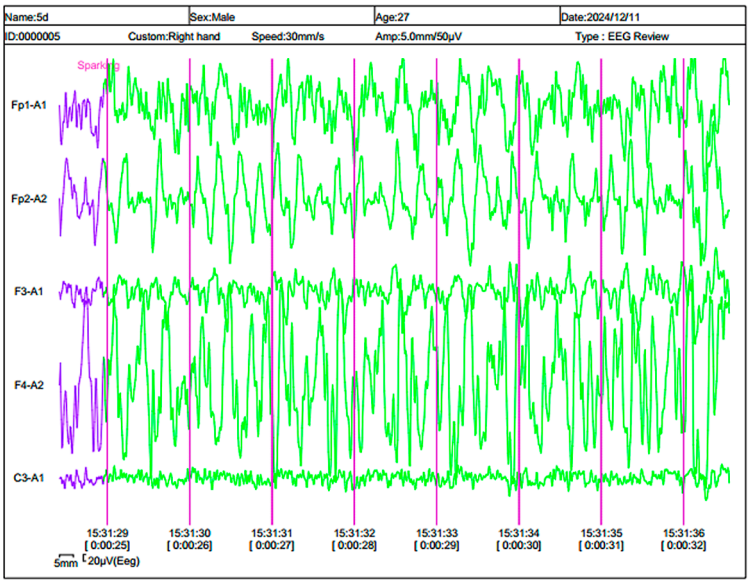

Figure 4. EEG data when the user is subjected to a strobing light.

Figure 5 presents part of the data obtained when the participant in the study performs routine things, such as conversation, movement of limbs, etc. In the first part, the signals are visible when the user answers a question the answer to which he does not know and tries to indicate this. In this case, he is asked the question: "How much is 1537 divided by 38?". An increase in the wavelength is observed. At the end of the figure, the data is visible when a question with an easy answer is asked: "What is the capital of

Bulgaria?". The change in the wave at the beginning and end of the figure is clearly visible, which is associated with a change in the user's mood. At the beginning of the test, his mind is burdened with calculating the correct answer, while at the end, he is confident in his knowledge.

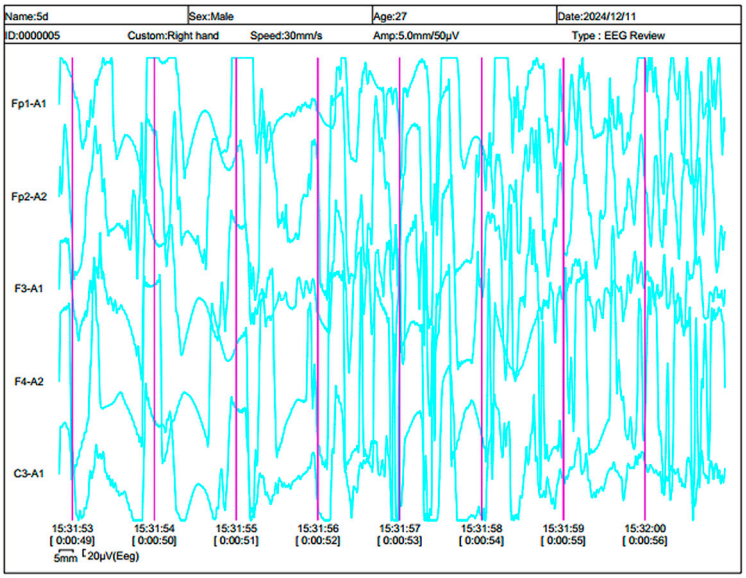

Figure 5. EEG data when the user performs routine tasks and answers various questions.

Figure 6 presents the data obtained from the electroencephalograph when the user is a woman. The result was taken with their eyes closed. The data is of poor quality because the user has long and thick hair and small ears, which makes it difficult to read the EEG signals.

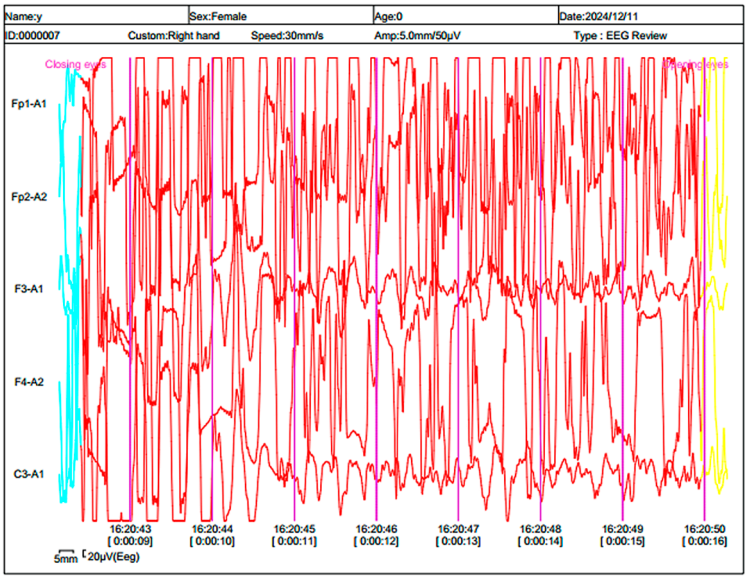

Figure 6. EEG data when the user's eyes are closed.

Figure 7 presents the data obtained while performing routine activities. The user is forced to lift their left hand, then their right hand. In the middle of the figure, an increase in wavelength is observed because the user had a problem with recognizing their left and right hands.

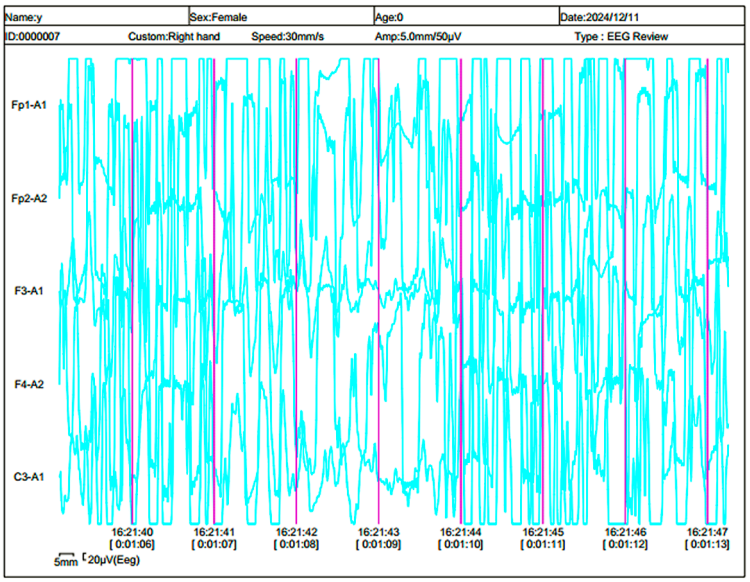

Figure 7. EEG data when the user performs routine activities.

Figure 8 presents an interesting case.

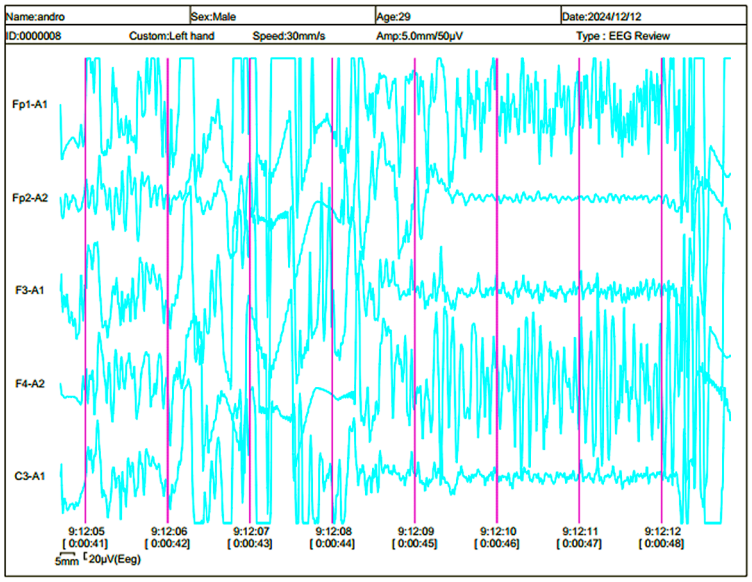

Figure 8. EEG data during confusion.

The user is asked the question "How much is 100 × 100?" and gives the wrong answer—"1000"—and is convinced that they gave the correct one. After being informed that they gave the wrong answer, a strong change in the amplitude and wavelength is observed (the second part of the figure). At this time, they are very confused.

5. Conclusions

The digital electroencephalograph can be used as a means of recording emotions. From the analysis of the data from the tests conducted on a small group of people, the following rule can be deduced—when a person laughs or is confident in their knowledge, the recorded EEG signal has a higher amplitude and a shorter wavelength, while when they are worried or thoughtful, the amplitude decreases and the length increases. Long and thick hair makes it difficult to obtain signals of good quality. The small size of the auricle, where the A1 and A2 electrodes are located, also leads to a deterioration in quality. In the

tests carried out, a significant problem was identified; this was the long time for preparing the user for the study, which is about twenty minutes, the time during which the electrodes are placed and connected to the electroencephalograph. The only inconvenience shared by the group of people studied is that when attaching the electrodes at points A1 and A2, which is by means of a clip, they expressed discomfort.

Author Contributions: Conceptualization, I.R. and G.K.; methodology, I.R. and G.K.; software, I.R.; resources, I.R.; writing—original draft preparation, I.R. and G.K.; writing—review and editing, I.R. and G.K.; visualization, I.R.; supervision, G.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are obtained in the article.

Acknowledgments: This research is supported by the Bulgarian Ministry of Education and Science under the National Program "Young scientists and Postdoctoral Students–2".

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

EEG	Electroencephalography
ECG	Electrocardiography
GSR	Galvanic skin response
BVP	Blood volume pulse
RT	Respiration rate
ST	Skin temperature
EMG	Electromyography

References

1. Soleymani, M.; Asghari-Esfeden, Y.F.; Pantic, M. Analysis of EEG Signals and Facial Expressions for Continuous Emotion Detection. *IEEE Trans. Affect. Comput.* **2016**, *7*, 17–28. [CrossRef]
2. Rahman, M.; Sarkar, A.K.; Hossain, A.; Hossain, S.; Islam, R.; Hossain, B.; Quinn, J.M.W.; Ali Moni, M. Recognition of human emotions using EEG signals: A review. *Comput. Biol. Med.* **2021**, *136*, 104696. [CrossRef] [PubMed]
3. Zhu, L.; Xu, M.; Huang, A.; Zhang, J.; Tan, X. Multiple class transfer learning framework with source label adaptive correction for EEG emotion recognition. *Biomed. Signal Process. Control* **2025**, *104*, 107536. [CrossRef]
4. Ramirez, R.; Vamvakousis, Z. Detecting Emotion from EEG Signals Using the Emotive Epoc Device. In *Brain Informatics. BI 2012. Lecture Notes in Computer Science*; Zanzotto, F.M., Tsumoto, S., Taatgen, N., Yao, Y., Eds.; Springer: Berlin/Heidelberg, Germany, 2012; Volume 7670. [CrossRef]
5. Murugappan, M.; Murugappan, S. Human emotion recognition through short time Electroencephalogram (EEG) signals using Fast Fourier Transform (FFT). In Proceedings of the 2013 IEEE 9th International Colloquium on Signal Processing and Its Applications, Kuala Lumpur, Malaysia, 8–10 March 2013; pp. 289–294. [CrossRef]
6. Ackermann, P.; Kohlschein, C.; Bitsch, J.Á.; Wehrle, K.; Jeschke, S. EEG-based automatic emotion recognition: Feature extraction, selection and classification methods. In Proceedings of the IEEE 18th International Conference on e-Health Networking, Applications and Services, Healthcom 2016, Munich, Germany, 14–17 September 2016; pp. 1–6. [CrossRef]
7. Zhetenbayev, N.; Balbayev, G.; Iliev, T.; Bakhtiyar, B. Investigation of a Passive Ankle Joint Exoskeleton Designed for Movements with Dorsal and Plantar Flexion. *Eng. Proc.* **2023**, *41*, 17. [CrossRef]
8. Kumara, N.; Khaunda, K.; Hazarika, S.M. Bispectral Analysis of EEG for E.motion Recognition. *Procedia Comput. Sci.* **2016**, *84*, 31–35. [CrossRef]
9. Morris, H.; Lüders, H. Electrodes. *Electroencephalogr. Clin. Neurophysiol. Suppl.* **1985**, *37*, 3–26. [PubMed]

10. Angeles Castillo Rodriguez, M.; Brandt, A.; Schulze-Bonhage, A. Differentiation of subclinical and clinical electrographic. *Epilepsia* **2023**, *64*, S47–S58. [CrossRef]
11. Macorig, G.; Crespel, A.; Nilo, A.; Phuong Loc Tang, N.; Valente, M.; Gigli, G.L.; Gélisse, P. Benign EEG variants in the sleep—Wake cycle: A prospective observational study using the 10—20 system and additional electrodes. *Neurophysiol. Clin.* **2021**, *51*, 233–242. [CrossRef] [PubMed]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.