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[1]Istanbul University, Institute of Experimental Medicine, Department of Neuroscience, Istanbul, Turkey, [2]Istanbul University, Hulusi Behçet Life Sciences Research Laboratory, Istanbul, Turkey, [3]Istanbul Kültür University, Department of Electronic Engineering, Istanbul, Turkey, [4]Uskudar University, Istanbul, Turkey, [5]Istanbul University, Istanbul Faculty of Medicine, Department of Physiology, Istanbul, Turkey

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[1]Université de Rennes1, Rennes, France, [2]Télécom Bretagne (Institut Mines-Télécom), Brest, France

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[1]Hallym University, Anyang, Korea, Republic of, [2]Harvard Medical School — Berenson-Allen Center for Noninvasive Brain Stimulation, N/A, [3]Harvard Medical School — Berenson-Allen Center for Noninvasive Brain Stimulation, Boston, MA, [4]Berenson-Allen Center for Noninvasive Brain Stimulation, Harvard Medical School, Boston, United States, [5]Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, [6]Hallym Institute for Translational Genomics & Bioinformatics, Anyang, Korea, Republic of, [7]Department of Biomedical Engineering, Hanyang Universiy, Seoul, Korea, Republic of

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[1]BESA GmbH, Gräfelfing, Germany, [2]Munich University of Applied Sciences, Munich, Germany

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[1]BCCN Berlin, Berlin, Germany, [2]TU Berlin, Berlin, Germany, [3]City College of New York, New York, United States, [4]Technische Universität Berlin, Berlin, Germany, [5]Korea University, Seoul, Korea, Republic of, [6]Charite, Berlin, Germany

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Gökçer Eskikurt[1], Numan Ermutlu[2], Ümmühan İşoğlu-Alkaç[3]
[1]Istanbul University, Institute of Experimental Medicine, Department of Neuroscience, Istanbul, Turkey, [2]Istanbul Bilim University, Faculty of Medicine, Department of Physiology, Istanbul, Turkey, [3]Istanbul University, Istanbul Faculty of Medicine, Department of Physiology, Istanbul, Turkey

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[1]Institute of Scientific Instruments of the ASCR, v.v.i., Brno, Czech Republic, [2]Behavioral and Social Neuroscience Research Group, CEITEC-Central European Institute of Technology, Brno, Czech Republic

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Emel Erdogdu[1], Elif Kurt[2,3], Adil Deniz Duru[4], Atilla Uslu[5], Canan Basar Eroglu[6], Tamer Demiralp[5]
[1]University of Bremen, Bremen, Germany, [2]Istanbul University, Institute of Experimental Medicine, Department of Neuroscience, Istanbul, Turkey, [3]Istanbul University, Hulusi Behçet Life Sciences Research Laboratory, Istanbul, Turkey, [4]Marmara University, Istanbul, Turkey, [5]Istanbul University, Istanbul Faculty of Medicine, Department of Physiology, Istanbul, Turkey, [6]Institute of Psychology and Cognition Research, University of Bremen, Bremen, Germany

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Junling Gao[1,2], Raymond Cheung[3], Jicong Fan[1], Y.S. Hung[4], Hinhung Sik[5], Albert So[6], Zhiguo Zhang[7]
[1]Centre of Buddhists Studies, The University of Hong Kong, Hong Kong, Hong Kong, [2]Dept. of EEE, The University of Hong Kong, Hong Kong, [3]Dept. of Medicine, The University of Hong Kong, Hong Kong, Hong Kong, [4]Dept. of EEE, The University of Hong Kong, Hong Kong, Hong Kong, [5]Centre of Buddhism Studies, The University of Hong Kong, Hong Kong, Hong Kong, [6]The Asian Institute of Built Environment (AIBE), Hong Kong, Hong Kong, [7]Department of Electrical and Electronic Engineering, The University of Hong Kong., Hong Kong, China

Measurement of Cognitive Dynamics during Video Watching Through Event-Related Potentials

Emel Erdogdu[1], Elif Kurt[2,3], Adil Deniz Duru[4], Atilla Uslu[5], Canan Basar-Eroglu[6], Tamer Demiralp[5]

1 University of Bremen, Bremen, Germany
2 Istanbul University, Institute of Experimental Medicine, Department of Neuroscience, Istanbul, Turkey
3 Istanbul University, Hulusi Behçet Life Sciences Research Laboratory, Istanbul, Turkey
4 Marmara University, School of Physical Education and Sports, Istanbul, Turkey
5 Istanbul University, Istanbul Faculty of Medicine, Department of Physiology, Istanbul, Turkey
6 Institute of Psychology and Cognition Research, University of Bremen, Bremen, Germany

Introduction

The present study aims to develop a method to follow the cognitive dynamics in the electroencephalogram (EEG) during viewing a video. To obtain a high signal/noise (S/N) ratio we aimed to record event related potentials (ERPs) under passive condition by introducing temporal triggers in the visual stream that do not significantly interfere with the real world like dynamic visual experience. The hypothesis was that slight transient changes in short sequences of video frames will produce significant ERP waveforms resembling the P3a wave obtained with the distracters of the novelty paradigm [1, 4, 5], which might be used to follow the dynamics of the attention focused to the content of the video and to measure the changing distractibility of the subject due to the changing engagement [2] to the content of the video.

Methods

We chose video segments with strong changes in the emotional valence and arousal level, such that the engagement of the subjects to the video content might be modulated. A transient light intensity effect was introduced in the videos by increasing the luminance through adding a value of 50 to the present RGB values for 150 ms (4 frames) periods with a mean ISI of 3 sec (randomized between 2-4 sec). Behavioral correlates of the engagement to the video content were tested with a long-term memory (LTM) task, where either frames from the viewed or unknown distracting frames were shown in a separate session 30 min after the video presentation. The reaction times of recalled pictures, indicated by a left button press and non-recalled pictures by a right button press were collected. By relating the response accuracy and reaction times to the specific frames of the videos through the ERPs obtained from the triggers of a segment of 30 s surrounding the frame, we tested which ERP features were modulated with the engagement of the subjects to the video content.

Results

Clear ERPs are generated time-locked to the video frames with increased light intensity. The strongest ERP component was a positive wave around 440 ms followed by two negative peaks around 525 and 710 ms and another positive peak around 610 ms (see figure). We found different ERP patterns at different electrode sites related to the best (short RT & correct responses) and worst (long RT & incorrect response) performances in the memory test. In the worst memory performance condition, the topography of the ERP wave around 440 ms showed a strong, widespread positivity at centro-parietal recording sites resembling the topographical pattern of a P3a wave.

For best memory performance the positivity was smaller especially in posterior channels and the topographies of the two consecutive positive waves around 440 ms and 610 ms were characterized with a left frontal distribution and roughly correspond to a theta oscillation around 5 Hz.

Conclusion

ERPs were generated by simple passive viewing of the videos without significant disturbance of the visual experience resembling a real-world like scenario. The distractive effect of the introduced changes was not strong enough to produce a clear P3a when the subjects selective attention was focused to the content of the video, while larger P3a responses were obtained when the subjects attention was less engaged, as tested by the LTM task.

The left frontal theta oscillation is compatible with the hemispheric encoding/retrieval asymmetry (HERA) model which describes the stronger involvement of the left prefrontal cortex (PFC) in episodic memory encoding [3], because its' presence in the ERPs lead to faster and correct responses during the memory test.

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