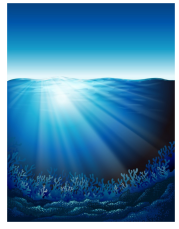
Intermittent Photic Stimulation in Healthy Controls in MEG

Veikko Jousmäki[1,2], Vimalan Vijayaragavan[2], Sachin Mishra[2], Sundramurthy Kumar[2], Parasuraman Padmanabhan[2], Balázs Gulyás[2]

[1]*MEG Core, Aalto NeuroImaging, Aalto University, Espoo, Finland*

[2]*Cognitive Neuroimaging Centre, Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore*



Introduction

Intermittent photic stimulation (IPS) is used in clinical electroencephalography (EEG) in eyes open (EO) and eyes closed (EC) conditions (Martins da Silva et al., 2017). IPS enhances the diagnostic sensitivity of EEG and cause epileptic seizures in patients suffering from photosensitive epilepsy (Lopes da Silva et al., 2011). IPS has not yet been included in clinical magnetoencephalography (MEG) (Bagic et al., 2011; Burgess et al., 2011).

We have recently developed an MEG-compatible LED-based ***Euphotic IPS*** stimulator (PCT patent pending/Aalto University) providing diffuse light IPS through the eye lid both in EO and EC conditions. Here we present preliminary results in healthy controls.

Introduction of EEG, IPS, and MEG

EEG Berger 1929 – Alpha rhythm EO/EC at the occipital cortex

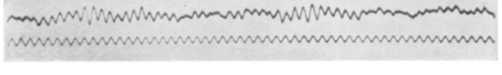


Abb. 13. Klaus im 15. Lebensjahre. Doppelspulengalvanometer. Kondensation. Ableitung von Stirn und Hinterhaupt mit Bleibandelektroden. Oben die von der Kopfhaut abgeleitete Kurve, unten die Zeit in $^1/_{10}$ Sekunden.

IPS Adrian and Matthews 1934 – Alpha rhythm can be driven by flickering light

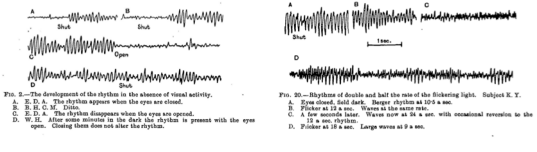
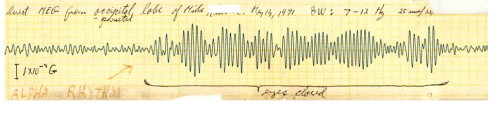


FIG. 2.—The development of the rhythm in the absence of visual activity.
A. E. D. A. The rhythm appears when the eyes are closed.
B. E. D. A. Eyes open.
C. E. D. A. The rhythm disappears when the eyes are opened.
D. W. H. After some minutes in the dark the rhythm is present with the eyes open. Closing them does not alter the rhythm.

FIG. 20.—Rhythms of double and half the rate of the flickering light. Subject K. Y.
A. Eyes closed, field dark. Berger rhythm at 10·5 a sec.
B. Flicker at 21 a sec. Waves at the same rate.
C. A few seconds later. Waves now at 24 a sec. with occasional reversion to the 10 a sec. rhythm.
D. Flicker at 10 a sec. Large waves at 5 a sec.

MEG Cohen 1971 – Alpha rhythm EO/EC at the occipital cortex



Materials and Methods

The cortical responses elicited by *Euphotic IPS* stimulation were measured by MEG (Elekta Neuromag TRIUX™; Elekta Oy, Helsinki Finland) inside a two-layer magnetically shielded room (Vacuumschmelze GmbH & Co. KG, Hanau, Germany). Magnetic resonance images (MRIs) were collected with a 3 T MRI scanner (Siemens 3T MAGNETOM Prisma, Erlangen, Germany). The measurements were approved by the institutional review board and carried out at the Cognitive Neuroimaging Centre (CoNiC) at Nanyang Technological University (NTU), Singapore.

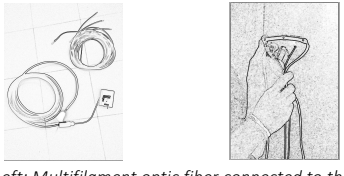


Figure 1. Left: Multifilament optic fiber connected to the LED light source. Right: Multifilament optic fiber connected to the goggles.

We measured six subjects without a history of epilepsy or problems associated with IPS. We measured MEG signals during a resting state (60 s) and during diffuse IPS stimulation (60 s at 6, 8, 10, and 12 Hz) followed by a resting state (60 s) in EO and EC conditions. The sources contributing to the averaged MEG signals coinciding with the IPS were modeled with equivalent current dipoles (Elekta Oy, Helsinki, Finland) and superimposed with co-registered MRIs.

Results

The *Euphotic IPS* stimulator did not produce any artefacts in MEG recordings. All the subjects tolerated IPS well. The MEG responses elicited with IPS were easily detectable and reproducible in four subjects – the data was not acceptable in two subjects due to the technical issues with continuous head tracking.

The responses at IPS frequencies were significantly stronger in EC conditions compared with EO conditions. The strongest responses were observed at 8 Hz IPS rate. The corresponding sources were located mostly at V6 area and V8/cerebellum both in EO and EC conditions.

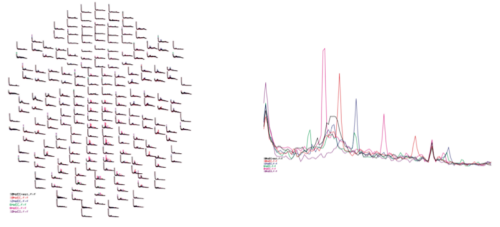


Figure 2. Left: The FFT spectra of the MEG signals in resting state (black) and diffuse IPS conditions (green 6 Hz, pink 8 Hz, red 10 Hz, blue 12 Hz) detected by the MEG sensor sensor (left) highlighting one MEG channel (right) in subject#1..

Discussion

Novel design for diffuse intermittent photic stimulation in EO condition
Does not obstruct vision – can be combined with visual stimulation
Potential tool for neuromodulation and quantifying cortical excitability

The present work presents the feasibility of the *Euphotic IPS* stimulator in eliciting IPS responses in healthy subjects and depicts that diffuse light can be used in humans both in EO and EC conditions. We consider *Euphotic IPS* as a potential tool to study non-invasively cortical excitability and neuromodulation in humans, both in basic and clinical research projects

Disclosure

Euphotic IPS stimulator (PCT patent pending) by Aalto NeuroImaging at Aalto University.
Euphotic team at Aalto: Veikko Jousmäki, Pia Kemppainen-Kajola, and Jani Issakainen.

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