Visual rehabilitation with Retimax Vision Trainer in patients with severe Acquired Brain Injury: report of two cases

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Abstract

Retimax Vision Trainer is a device that has the purpose to improve visual function by means of the detection of a visual evoked potential associated with a sound feed-back. We evaluated the effectiveness of rehabilitative treatment in two patients with Acquired Brain Injury (ABI). Results, subjectively appreciated, are objectively con-firmed by the improvement of visual function.

Keywords: Visual rehabilitation; Retimax Vision Trainer; Acquired Brain Injury (ABI)

1. Introduction

The impairment of visual function after brain or retinal damage has long been considered irreversibile. In fact, for nearly two decades it has been known that the brain has a remarkable ability to reshape the different neural network through learning process. This phenomenon called neuroplasticity opens up new fields of research on the nervous system's ability to adapt continuously throughout life (Frasnelli, Collignon, Voss & Lepore, 2011). Therefore, even with regard to visual processes, it can be said that there is a possibility of recov-ery, not only in children but also in adults (Vingolo, Salvatore, Domanico, Spadea & Nebbioso, 2013). Generally the damage to the visual pathways is not complete, but some structures are spared (Weil & Rees, 2011). However the residual structures cannot operate at full capacity; the consequent loss of activation makes them inadequate to their function and further reduces synaptic contacts. However the residual visual pathways can be reactivated with different methods of rehabilitation (Collignon, Champoux, Voss & Lepore, 2011). These methods lead to the strengthening of synaptic transmission and synchronization of partially damaged structures. Recovery can be induced at any time after the injury, at all ages and in all types of visual impairment (Raemaekers, Bergsma, van Wezel, van der Wildt & van den Berg, 2011). Retimax Vision Trainer is a device that has the purpose to improve visual function by means of the detection of a visual evoked potential associated with a sound feedback (Mazzolani, Lovisolo & Moretti, 2013). It consists of a device for Visual Evoked Potential (VEP) bioelectrical responses recording and electroretinogram (ERG), which constitutes a means of clinical investigation of the retinocortical visual structures and particularly for the diagnosis of abnormalities of vision with little obvious symptoms or in uncooperative patients. VEP generated in the visual areas of the brain exhibit a characteristic sinusoidal morphology and, if recorded on the scalp, it exceeds the amplitude of 10 microvolts. They are immersed in continuous cerebral electrical activity of several microvolts. To increase the signal/noise ratio in the VEP the Fast Fourier Transformer (FFT) is used. The combination between FFT e VEP involves the rapid discrimination of the bioelectric activity recorded in the visual central cortex. Fourier analysis shows that a signal which is repeated for f times/second does not include all possible frequencies, but a limited number of narrow bands of central frequency on f, 2f, 3f, etc. Thus the signal is formed by a finite number of harmonics. Fourier analyzer allows to distinguish the harmonic component of the visual cortex bioelectrical activity from the background noise not related to visual stimulation. Acoustic biofeedback related to the amplitude of the harmonic component provides the patient the right information for learning the voluntary control of his cortical and retinal response to stimuli which he is subjected during the treatment. Biofeedback (biological feedback), used for the treatment of various disorders in medicine and psychiatry, is a therapeutic technique that results from the information that the subject receives about his biological functions (Giggins, McCarthy Persson & Caulfield, 2013). It is based on the principle that it is possible to learn to control and self-regulate various physiological phenomena that are normally outside of volunteer awareness and control. Noting by suitable electronic instrumentation the activity of a biological function of the organism of which the subject is not aware and returning it to the subject in the form of return information (feedback), as a signal immediately perceived, he can gradually learn to control and self-regulate it. Detection is performed with electrodes or other methods which detect the bioelectric activity of the function being monitored and, after processing by a central unit of amplification and integration, return it in the form of signal as a light, sound or touch that the subject can perceive clearly. In ophthalmological field biofeedback techniques have been used in the past for correction of myopia, increase of visual performances, treatment of amblyopia, sports training (Amore et al., 2013). With Retimax Vision Trainer, turning the bioelectric cortical and retinal response in sound signal modulated in height, one can assess the degree of its efficiency: in practice this results in an improvement of the visual function of the patient in terms of visual acuity, contrast sensitivity, visual field amplitude, chromatic sense and reading speed. The session takes place while sitting in front of the monitor that has black and white squares of variable size and contrast. To the patient, that if ametropic must use the optical correction (glasses, contact lenses), are applied cutaneous electrodes as they do in VEP recording. By staring this structured stimulus a bioelectrical signal is produced in the retina, visual pathways and cortical areas. The bioelectric signal is detected by the electrodes and processed by the device thanks to FFT, which turns it into acoustic feedback. During the session the operator helps the patient by encouraging him to keep the fixation of a target located on the monitor. Each time the patient is able to maintain a foveal fixation the bioelectric signal detected by the electrodes increases its amplitude, and its phase is related to the visual stimulus presented to the patient. Consequently the tone enhances in height by driving the patient in search for better fixation, accommodation and attention and teaching him to control these functions. Performance of each session is recorded and stored. A graph objectively measures the amplitude of the potential, the level of attention and collaboration, and then the resulting effectiveness of treatment.

2. Method

We evaluated the effectiveness of rehabilitative treatment in two patients with ABI.

1. M.U., male, 53 aged, with a previous right hemisphere cerebral hemorrhage (24 months before), Level of Cognitive Function (LCF) = 8, no neglect. Neurophthalmological evaluation showed left homonymous hemianopia.
2. G.B., female, 24 aged with an outcome of cerebellar hemorrhage (9 years before, with a period of unresponsiveness of 7 years), LCF = 6. Oph-

thalmological examination highlighted bilateral visual acuity 2/10 for distance, 6 DW for near, nystagmus, right exotropia, left homonymous hemianopia.

Patients were submitted to the treatment of photostimulation, 10 sessions twice a week.

3. Results

Patients have joined willingly the treatment and showed good compliance. Subjectively in both cases there have been improvements in common activities of daily living (reading, using PC, cooking). Objectively in M.U. we noticed a significant visual field enlargement to the left (top and bottom sectors in right eye, bottom sector in left eye, documented by Goldmann perimetry). In G.B. case history was more complex for the many visual disorders. However, it was observed an increase of about 1/10 in visual acuity for distance and near. This resulted in a much better aptitude to watch TV and reading, as well as an improved ability to orient herself. In both cases visual recovery persisted after 12 weeks.

4. Discussion

Retimax Vision Trainer is used in patients with visual disabilities of various origins and severity. Staring at a pattern stimulus a bioelectric signal type is generated, while an acoustic signal related to the amplitude of VEP guides the patient in his pursuit of a fixation, accommodation and attention. This implies an increase of foveal detection, which is the period of time in which the image of the target impresses the fovea, as a result of the saccades control improvement. Moreover neuroplasticity allows the nervous stimulus to bypass the impaired visual pathways and head to the cortex indirectly (Safran & Landis, 1998). Due to visual stimulation existing neural network can remodel, in that repeated stimuli cause the formation of new synapses. These various components on which the treatment acts result in an enhancement of visual function (Poirier et al., 2005). Results, appreciated on a subjective level, are objectively confirmed by the improvement of the bioelectric reaction. In both our patients we have noticed an improvement of visual function that was stable after conclusion of treatment. The poorer outcome appreciated for G.B. can be attributed to the presence of a very compromised neurophthalmological state, to the long-lasting interval between acute event and treatment, with a huge period of non-responsiveness, and to the greater cognitive impairment.

5. Conclusion

In conclusion visual rehabilitation with Retimax Vision Trainer is of simple clinical application, effective and non-invasive. This first experience, unique in patients with ABI, is very promising and will lead us to recruit more subjects and to study the efficacy of a more intensive treatment, with prolonged follow-up periods. Whereas severe impairment of visual function is one of perceptive disorders that most interfere with rehabilitation plans, we believe that Retimax Vision Trainer may be an effective rehabilitative offer, provided that there is a satisfactory cognitive function.

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