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Strokes and traumatic spinal cord and brain injury

RANDOM CONTROLLED TRIAL ON THE POTENTIATING EFFECT TRANSCRANIAL RANDOM NOISE STIMULATION (TRNS) IN THE COGNITIVE REHABILITATION OF PATIENTS WITH TRAUMATIC BRAIN DAMAGE

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1. Project summary

The overall objective of the project has been to study the therapeutic potential of transcranial random noise stimulation (tRNS) to improve the therapeutic outcome of cognitive training, studying the overall effect of tRNS on the rehabilitation of attention, memory and executive functions with respect to sham tRNS.

Direct transcranial electrical stimulation applied with random frequencies (tRNS) is an innovative, safe and well-tolerated technique that allows increasing the signal-to-noise ratio in cognitive processing, which may result in beneficial effects on learning or retrieval of skills, based on stochastic resonance phenomena. We postulate this mechanism as a potentially useful strategy in targeting plastic changes resulting from diffuse axonal injury in TBI.

The study was developed in patients who had suffered a moderate or severe traumatic brain injury, with less than 18 months of evolution since their emergence from post-traumatic amnesia, and with moderate or severe impairment of their cognitive function (attention, memory and executive functions), and who had given their informed consent to participate in the study.

Furthermore, as an additional objective to those initially planned, we have studied the pattern of change in the patients' electroencephalographic EEG activity in order to characterize patterns of optimal response and patterns of non-optimal (and potentially modifiable) activity as an advanced strategy to increase the personalization and precision of neuromodulation strategies.

Quantitative analysis of EEG activity allows the identification of the frequency distribution of neuronal activity at each specific location, and its absolute and relative intensity, as a strategy for objective quantification of the degree of dysfunction and monitoring of its evolution.

This additional study was done in patients who had suffered a severe stroke with cognitive impairment requiring neuropsychological rehabilitation treatment.
The specific objectives of the study were:

1. To design a protocol to identify a cohort of patients who have undergone CTI and who are candidates to receive the combined application of SNR and intensive, monitored and personalized cognitive training.

2. To provide information on the feasibility and safety of the procedure.

3. To study the effect of cognitive training combined with real RNS compared to those of simulated tRNS, in order to analyze the existence of this effect and its capacity to enhance improvement.

4. To inform the scientific community of the study and disseminate the results as widely as possible.

5. To advance in the identification of bioelectrical characteristics of cognitive impairment and clinical response to optimize the personalization and precision of neuromodulation strategies.

2. Results obtained

From the activities performed within the framework of this project we have reached the following significant results:

- It is possible to accelerate cognitive rehabilitation by non-invasive brain stimulation.
- It is possible to modulate a distributed neural network by optimizing the correlation between nodes and inhibiting anti-correlations, with a positive impact on functional capacity.
- It is possible to characterize the changes induced by cognitive training using computerized electroencephalography.
- The absolute and relative increase of alpha wave activity at the occipital level and the absolute and relative increase of delta activity at the fronto-polar level correlate with a good clinical response to intensive computer-assisted cognitive training.

3. Relevance to possible future implications

Brain stimulation and neuromodulation techniques are among the most promising elements to reduce the impact of neurological and psychiatric diseases. This is an increasingly necessary objective due to the increase in their incidence and prevalence. The complexity of the nervous system makes it difficult to design precise and effective neuromodulation strategies. The most effective neuromodulation strategy at present is electroconvulsive therapy, but its unspecificity and the impact of side effects mean that it is considered the therapeutic strategy of last choice.

However, the introduction of transcranial magnetic stimulation and transcranial electrical stimulation have led to methodological, conceptual and therapeutic advances that envision a future similar to that of functional interventions in cardiology.
In this project we demonstrate two principles of great value for increasing the personalization of neuromodulation interventions in neurology, psychiatry and, specifically, in the rehabilitation of acquired brain injury.

First, we demonstrate the possibility of optimizing the residual functional capacity of the nervous system after injury by perturbing non-specific activity resulting, quite possibly, from maladaptive changes after injury.

Secondly, we advanced the concept of localization of cognitive functions, overcoming the node and set of critical nodes view, by proposing and demonstrating the feasibility and efficacy of modulating all, or a large part, of the nodes of a neural network with a dynamic strategy considering the correlations and anti-correlations of different brain areas, to optimize brain function and intensify the benefit of rehabilitation treatments.
Third, the possibility of neurophysiologically characterizing the correlation between the effect of cognitive rehabilitation interventions and EEG signal changes has been demonstrated. This finding opens the possibility of designing more precise neuromodulation strategies, based on the characterization of the type of bioelectrical dysfunction in each patient and its monitoring throughout the treatment.

All these three advances have a strategic value for the design of closed-ring neuromodulation treatments, combined with advanced neurorehabilitation techniques,

to guide the plastic capacity of the nervous system, enhancing favorable changes and inhibiting those that are not favorable or that interfere with the recovery of function.

4. Scientific bibliography generated

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