

Abstracts

Neural Correlates of Tavns: Scalp EEG and Insular Seeg Heartbeat Evoked Potentials Modulation in an Epileptic Patient

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Authors :

Presenting Author: Enrique Germany, PhD – Université Catholique de Louvain

Manon Dumoulin, MD – Université Catholique de Louvain

Roberto Santalucia, MD – Université Catholique de Louvain

Vincent Joris, MD – Université Catholique de Louvain

Venethia Danthine, MD, PhD student – Université Catholique de Louvain

Inci Cakiroglu, MS – Université Catholique de Louvain

Andres Torres, MS – Université Catholique de Louvain

Antoine Nonclercq, PhD – Université Libre de Bruxelles

Riëm El Tahry, MD, PhD – UC Louvain

Rationale: Heartbeat Evoked Potentials (HEPs) provide a window into the neural processing of interoceptive signals and are sensitive to various modulatory influences, including vagus nerve stimulation (VNS).

Transcutaneous auricular VNS (taVNS) has been shown to modulate brain regions involved in interoception, such as the insula 1. This study aims to investigate the impact of taVNS on HEPs in an epileptic patient undergoing stereotactic electroencephalography (sEEG) with electrodes implanted in the insular region2 and scalp EEG concomitantly. By analyzing HEP waveforms and Inter-Trial Coherence (ITC), we seek to understand how taVNS affects the neural processing of cardiac signals.

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Methods: One epileptic patient with sEEG electrodes implanted, including the insular region, was recorded both before and during taVNS stimulation in the Cymba-Concha region using a NEMOS taVNS stimulator. The same system was used stimulating the ear-lobe for a cutaneous Sham stimulation. 19 electrodes Scalp EEG and ECG data were concomitantly recorded. Scalp and Insular EEG were time-locked to the R-peak of the ECG signal and epoched within -500 ms to +500 ms with respect to the R-peak. HEP waveforms were analyzed to compare the amplitude and morphology between baseline, taVNS, and Sham conditions. Additionally, Inter-Trial Coherence (ITC), a measure of phase consistency across trials, was computed and compared between the conditions to assess the consistency of the neural response to heartbeats. Heart rate (HR) over the experimental time duration was monitored and analyzed.

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Results: HR before and during stimulation remained constant with no significant change. Analysis of the HEP

waveforms revealed significant changes in amplitude and morphology during taVNS compared to the baseline. Specifically, decreased HEP amplitudes were observed at electrodes in the insular region during taVNS compared to baseline and Sham conditions, suggesting modulation of neural processing of cardiac signals. ITC analysis showed increased phase coherence during stimulation, indicating more consistent phase-locked neural responses to heartbeats compared to the baseline condition. These findings suggest that taVNS modulates heartbeat-related neural activity in the insula, aligning with the literature hypothesis of VNS norepinephrine-mediated enchantment of central sensory processing.

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Conclusions: The study adds neural correlates of taVNS influence on HEPs linking scalp and Insular sEEG recordings. HEPs enhance both the amplitude and the phase consistency of neural responses to heartbeats in the insular region of an epileptic patient. These results provide evidence that taVNS modulates interoceptive processing pathways, potentially offering therapeutic benefits for conditions characterized by dysregulated interoception. Further research with larger sample sizes is needed to confirm these findings and to explore the clinical applications of taVNS in modulating interoceptive awareness and related neural mechanisms.

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Basic Mechanisms

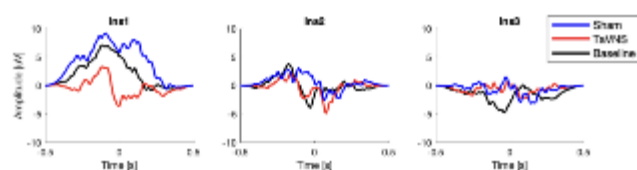


Figure 1: Amplitude modulation and polarity reversal behavior over insular electrodes 1,2 and 3. Grand average Field Potential (GFP) is displayed for Baseline (black), TaVNS (red), and Sham (blue) stimulations time-locked at R-peaks ($t=0$).

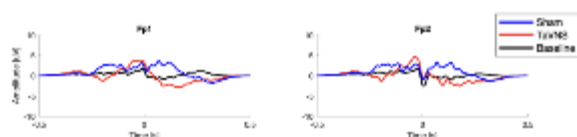


Figure 2: Amplitude modulation over frontal scalp electrodes (Fp1, Fp2). Grand average Field Potential (GFP) is displayed for Baseline (black), TaVNS (red), and Sham (blue) stimulations time-locked at R-peaks ($t=0$). Enhanced positive peak after P wave and enhanced negative peak after R peak and T wave.