Non-invasive Vagus Nerve Stimulation in treatment of disorders consciousness: longitudinal case study

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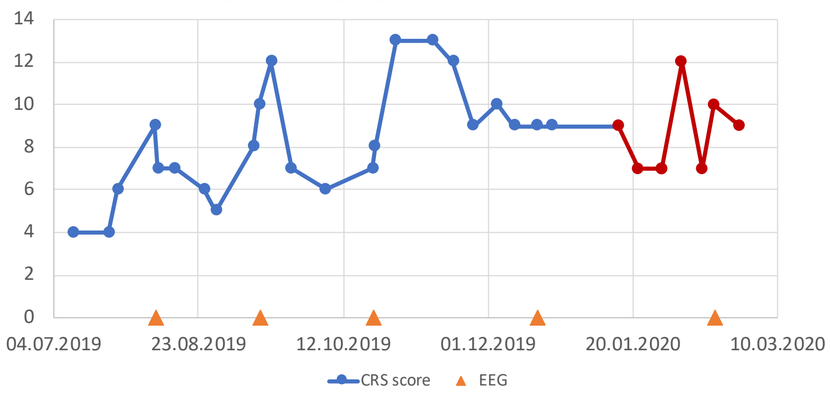
BACKGROUND

Disorders of consciousness (DoC) result from disconnections in the cortico-cortical and thalamo-cortical pathways. Vagus nerve is key in transmitting signals between the visceral organs and the brain. It projects to the nucleus tractus solitarious, which activates the dorsal raphe and other areas known to control alertness. Corazzol et. al., (2017) have shown long term vagus nerve stimulation via a surgically implanted device, raised a patient's diagnosis from unresponsive wakefulness to minimally conscious. Here, we stimulate the auricular branch of the vagus (Arnold's Nerve) noninvasively **(transcutaneous vagus nerve stimulation, tVNS**). This method has potential for widespread use.

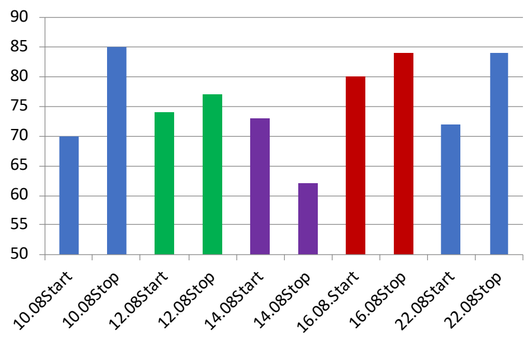
CRS-R total score



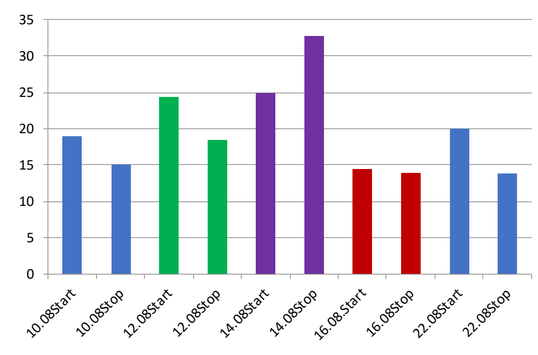
Assessment on the Coma Recovery Scale-Revised shows that since the stimulation started the scores fluctuated but increased, staying above the baseline of 4 points at the start of the stimulation, and remaining relativily high after if finished (red).

tVNS increases HR and dicreases HRV, consistently with the literature.

Heart Rate



Heart Rate Variability (RMSSD)



KEY FACTS & FINDINGS

> 6 months of 4h daily **tVNS**

> 2 months post-stimulation

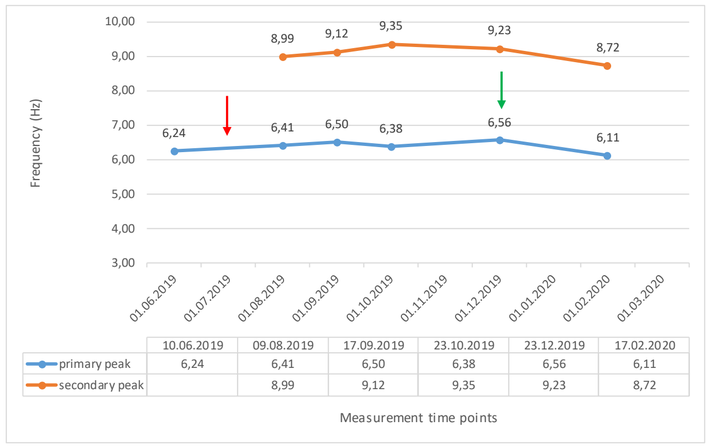
> CRS-R rise from 4 (unresponsive wakefulness) to 13 (minimally conscious) signs of functional communication.

> EEG: in resting state spectrum re-emergence of a second oscillation peak in the alpha range, typically observed in aware people.

> Cardiovascular activity: HR increasing, HRV decreasing from before to after daily tVNS.

> Physiology: return of menstruation, improved peristaltics.

EEG max peak frequencies across measurement points



	10.06.2019	09.08.2019	17.09.2019	23.10.2019	23.12.2019	17.02.2020
primary peak	6,24	6,41	6,50	6,38	6,56	6,11
secondary peak		8,99	9,12	9,35	9,23	8,72

Primary peak – the peak with the highest amplitude in the 3-14 Hz range

Secondary peak – the peak with the second highest amplitudę in the 3-14 Hz range

The red arrow indicates the start of stimulation protocol, the green arrow indicates termination of the stimulation protocol.

Analysis:

Averaged EEG signal from centroparietal channels was modelled using FOOOF (www.nitrc.org/projects/fooof/) in frequency domain.

Peaks with the highest and second highest amplitudę in theta-alfa range (3-14 Hz) are reported.

Results:

After one month of stimulation **a second smaller peak appeared in the spectrum around 9 Hz in the alpha range in the centro-parietal regions**, which was not present in this patient in a period preceding the stimulation. The location and the frequency of the second peak may suggest the return of thalamocortical network dynamics characteristic for aware subjects.

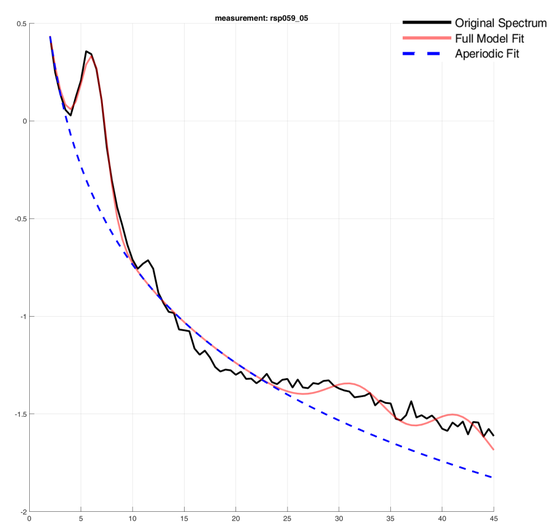
PATIENT

- Female, age: 28;
  in unresponsive wakefulness for 6 years after traumatic brain injury.

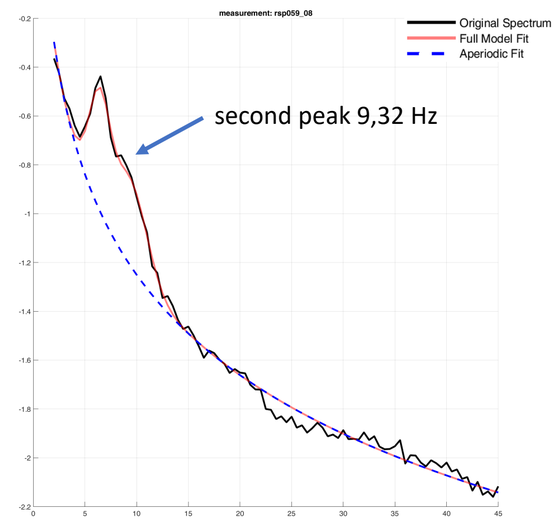
METHOD

- tVNS – 4h daily, 6 months, intensity from 0,2 mA at the beginning, to 1,5 mA by the 4th week, then stable at 1,5 mA, device: NEMOS by tVNS Technologies
- Every other day: ECG
- EEG: every 1,5 - 2 months, resting-state
- Qualitative verbal reports from personnel & volunteers

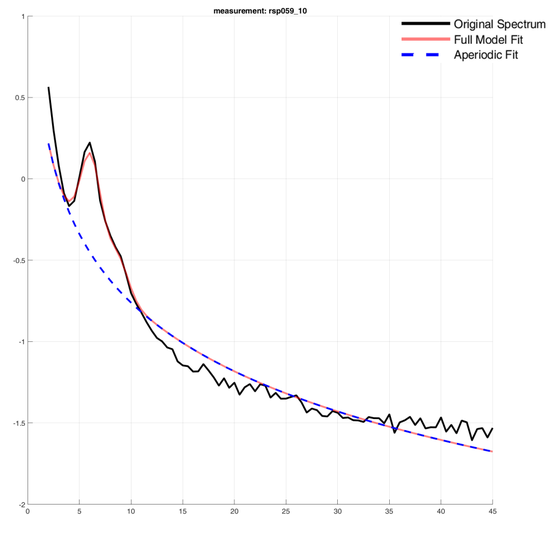
Before stimulation



4 months into stimulation



2 months after stimulation



CONCLUSION

tVNS is promising as a non-invasive treatment for DoC. Findings support theories of consciousness positing its embodiment. Future work should address patients in Minimally Conscious State as well as quick interventions.