Comparison analysis of evoked potentials generated by peripheral median nerve stimulation (PNS) and by deep brain stimulation (DBS) in VIM and PPN

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Introduction

- **Peripheral nerve stimulation (PNS) and Deep brain stimulation (DBS) of** ventral intermediate nucleus (VIM) of thalamus has proven to be an effective **symptomatic treatment** for patients with essential tremor.
- Present studies have shown that DBS and PNS have partial modulatory effects on certain targets, as well as local disruption of abnormal signals.
- We hypothesize **that indirect stimulation of VIM via the median nerve (PNS) may be operating through a similar mechanism.**
- This hypothesis was tested in this study by comparing the evoked potentials (EPs) in VIM and pedunculopontine nucleus (PPN) due to PNS and DBS of VIM and PPN.

Materials And Methods

- **Subjects:** One female and three male pediatric patients with **dystonia** underwent DBS surgery for clinical treatment and sEEG leads were implanted in VIM and/or PPN.
- **Data collection**: EPs of VIM and PPN are recorded due to **median** nerve stimulation as well as VIM and PPN direct electrical stimulation

Patient No	1	2	3	4
Recording location	VIM	VIM	PPN	PPN
PNS	X	X	X	X
DBS targets	VIM	VIM	VIM,PPN	VIM,PPN

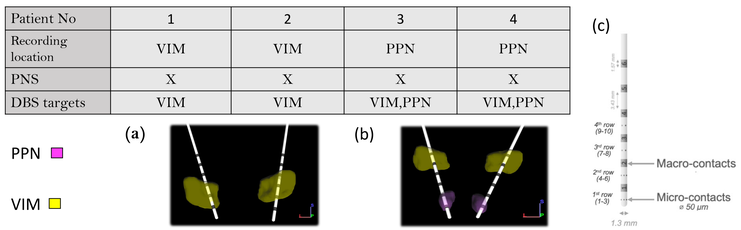


Figure 1: View of sEEG leads in (a) bilateral VIM (subjects 1 and 2), and (b) bilateral VIM and PPN (subjects 3 and 4). These figures help to determine the locations of VIM and PPN with respect to stimulating (macro) and recording (micro) contacts shown in (c). Normalized scans visualized onto the Montreal Neurological Institute (MNI) space. Deep brain boundaries were defined with the DISTAL atlas. (c) Schematic of temporary sEEG electrode implanted in DBS targets.

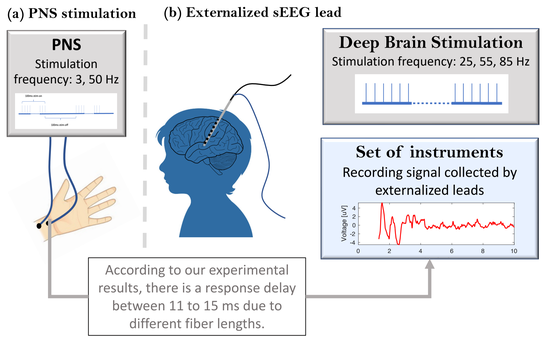
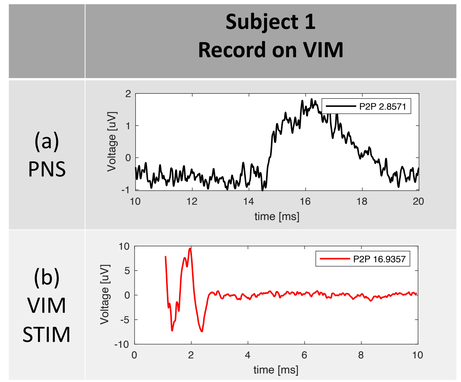


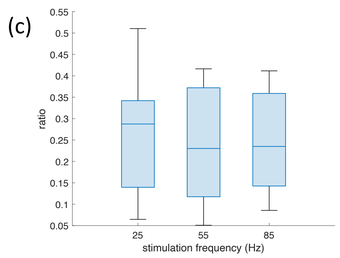
Figure 2:

(a) The PNS was given with a base frequency of 5 Hz and train frequency of 3 and 50 Hz stimulations.

(b) DBS was given with 25 Hz , 55 Hz and 85 Hz through macro-contacts.

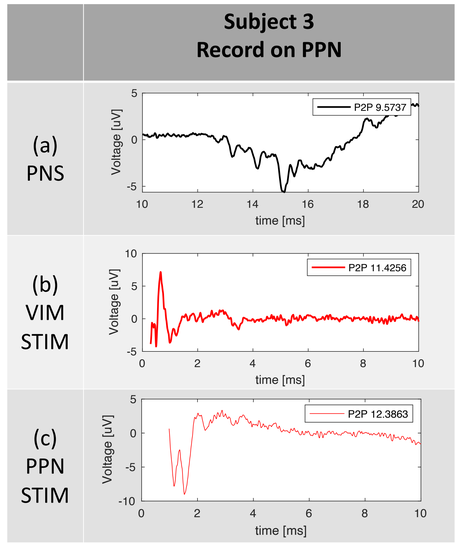
Results

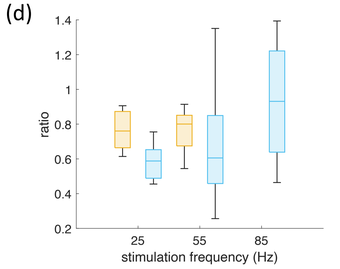




$$ratio = \frac{P2P\ of\ the\ PPN\ EP\ generated\ by\ PNS\ at\ 50Hz}{P2P\ of\ the\ PPN\ EP\ generated\ by\ VIM\ Stim}$$

Figure 3: (a) The evoked potentials is generated by PNS with a 50 Hz burst stimulation. There is a delayed response around 14 ms and the duration of the EP is larger than 6 ms. (b) DBS of VIM with 55 Hz continuous stimulation. The duration of the EP is shorter than 4 ms. (c) The statistic results of the P2P ratio with the listed equation is for subject 1 and 2. The magnitudes of EPs generated by DBS vary with the frequency of stimulation.





$$ratio = \frac{P2P\ of\ the\ PPN\ EP\ generated\ by\ PNS\ at\ 3\ Hz}{P2P\ of\ the\ PPN\ EP\ generated\ by\ VIM\ Stim}$$

$$ratio = \frac{P2P\ of\ the\ PPN\ EP\ generated\ by\ PNS\ at\ 3\ Hz}{P2P\ of\ the\ PPN\ EP\ generated\ by\ PPN\ Stim}$$

Figure 4: (a) The evoked potentials is generated by PSN with 3 Hz burst stimulation. There is a delayed response around 12 ms and the duration of the EP is larger than 7 ms. (b) DBS of VIM with 55 Hz continuous stimulation. The duration of the EP is shorter than 4ms.(c) DBS of PPN with 55 Hz continuous stimulation. The duration of the EP is less than 5 ms. (d) The statistic results of the P2P ratio with the listed equations is for subject 3 and 4. As the frequency increasing, the magnitudes of the EPs generated by DBS of VIM become larger.

Conclusions

- Results show that peripheral nerve stimulation of median nerve generates robust evoked potentials in both the VIM and the PPN, which indicates they receive sensory information from the periphery.
- Magnitude of EPs varies with stimulation frequency. Statistical analysis shows that compared with the EPs' magnitude generated by VIM, PNS can also generate EPs with similar magnitudes in PPN at higher frequency.
- The durations of the evoked potentials generated by PNS are longer, consistent with dispersion due to variability in axonal and synaptic transmission.

Further Work

- These results suggest the possibility that noninvasive peripheral stimulation could have effects similar to DBS in some patients.
- Additional EP measurements such as delays and frequency components may also help provide a clearer understanding the different effects generated by PNS and DBS.
- DBS of VIM and PPN in burst patterns may help to identify the different therapy effects by comparing responses during the on-stim and off-stim intervals with PNS.
- A similar demographic study of other people with movement disorder would help to understand the treatment mechanism differences between PNS and DBS.

Reference

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