The Underlying Effect of Burst Stimulation on Chronic Pain Using Multimodal Neuroimaging - EEG, fMRI and PET

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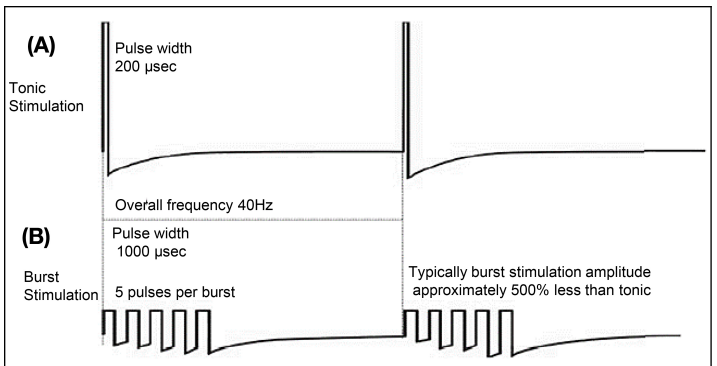
CNS 2017 ANNUAL MEETING
BOSTON, MASSACHUSETTS
OCTOBER 7–11, 2017

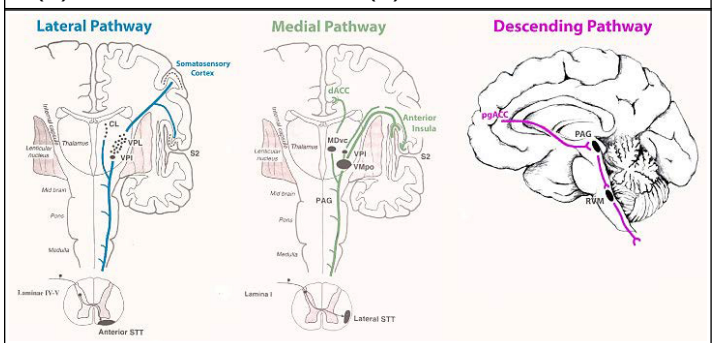
Introduction

- Minimal invasive neuromodulation - **Spinal Cord Stimulation (SCS)** or **Occipital nerve stimulation (ONS)** is common treatment for medically intractable neuropathic pain of different origin.
- In clinical trials, **burst stimulation improved** back, limb and general pain by 51%, 53% and 55% and tonic stimulation by 30%, 52% and 31% respectively.
- Burst stimulation is delivered as **packet of five spikes at 500Hz**, 40 Hz burst mode, 1msec pulse width.

Hypothesis- Investigate mechanism of action for burst stimulation in different patient group and healthy controls for burst stimulation using different multimodalities – EEG, fMRI and PET.



(A) Tonic stimulation mode; (B) Burst stimulation mode



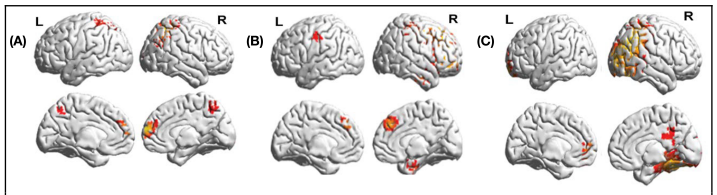
Lateral, Medial Ascending pain pathway and Descending pain pathway

Materials and Methods

Neuromodulation Technique	Population	Sample size	Stimulation Paradigm	Imaging Modality
SCS	Limb & Back Pain	15	B, T, P	EEG
SCS	FBSS	49	B,T,P	EEG
ONS	Fibromyalgia	7	B,T	PET
ONS	Healthy	1	B,T	fMRI

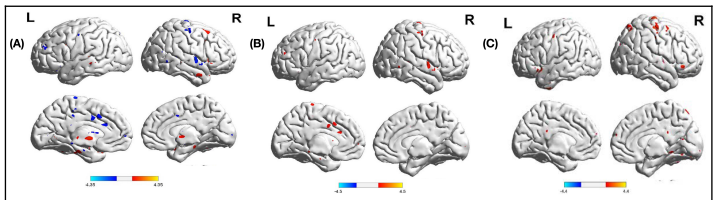
Abbreviations B = Burst, T = Tonic, P = Placebo, PET = Positron Emission Tomography, fMRI = Functional Magnetic Resonance Imaging

Results



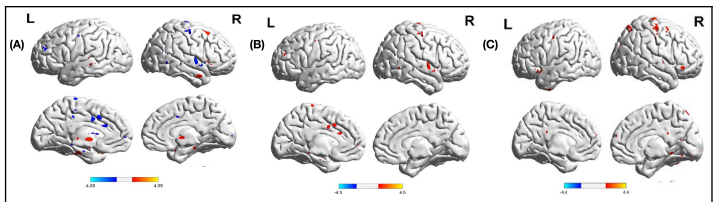
Significant changes during EEG (A) Burst Stimulation vs Baseline for Alpha 1; (B) Burst vs Tonic Stimulation for Alpha 1; (C) Tonic vs Burst stimulation for Theta band. dACC, dLPFC, M1, S1, pgACC

- Increase activity in burst stimulation for alpha band on medial and descending pain pathway.
- Increase activity in tonic stimulation for theta band on lateral and descending pain pathway.



Significant changes in metabolic rate during PET scan for (A)Tonic stimulation vs. Baseline; (B)Burst stimulation vs. Baseline; (C) Burst vs. Tonic Stimulation. dACC, pgACC

- Increased tracer capitation for burst stimulation in medial and descending pathway.



Significant changes in BOLD signal during fMRI scan for (A) Tonic stimulation vs Baseline; (B) Burst Stimulation vs Baseline; (C) Burst vs Tonic Stimulation. dACC, dLPFC, pgACC

- Increased BOLD signal for burst stimulation in medial pathway.

Discussion

- Burst stimulation normalizes imbalance by modulating **medial** and **descending pain** pathways.
- Tonic stimulation modulate the **lateral** and **descending pain** pathway.

Conclusion

- Multitarget brain structures investigated to understand pain pathway for burst in ONS and SCS.
- Multimodalities explored to understand mechanism of action in control and abnormal group.

References

- De Ridder (2010) Burst stimulation spinal cord stimulation:toward paresthesia-free pain suppresion.
- De Ridder (2013) Burst spinal cord stimulation for limb and back pain.

Abbreviation

dACC = Dorsal anterior cingulate cortex; pgACC = Pregenual Anterior cingulate cortex; dLPFC = Dorsal