Cerebellar Modulation of Motor Potentials and Beta Band Power via Focused Ultrasound

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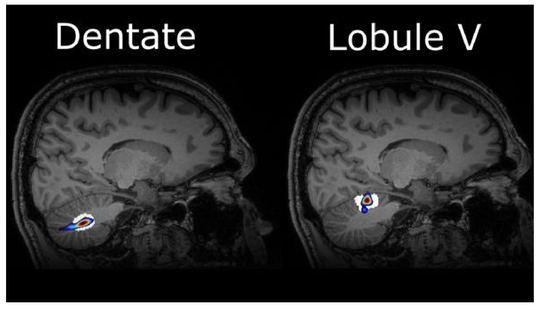
INTRODUCTION



The Bereitschaftspotential (BP) is a slow negative cortical potential that begins 1-2 seconds before self-initiated movement, reflecting preparatory activity.

Beta-band activity (13-30 Hz) is associated with sensorimotor functions, particularly during movement - reflecting both motor preparation and execution.

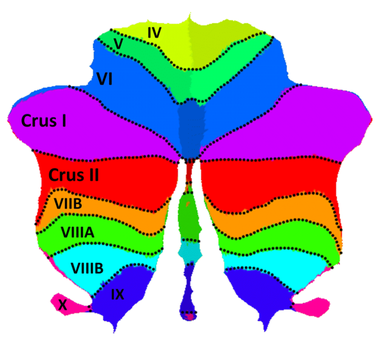
Traditionally, both BP and beta-band activity have been viewed as **cortical phenomena**.

METHODS

Participants performed self-paced, right-sided motor tasks during EEG recording from Cz, Pz, Fz, C3, C4 and P3.

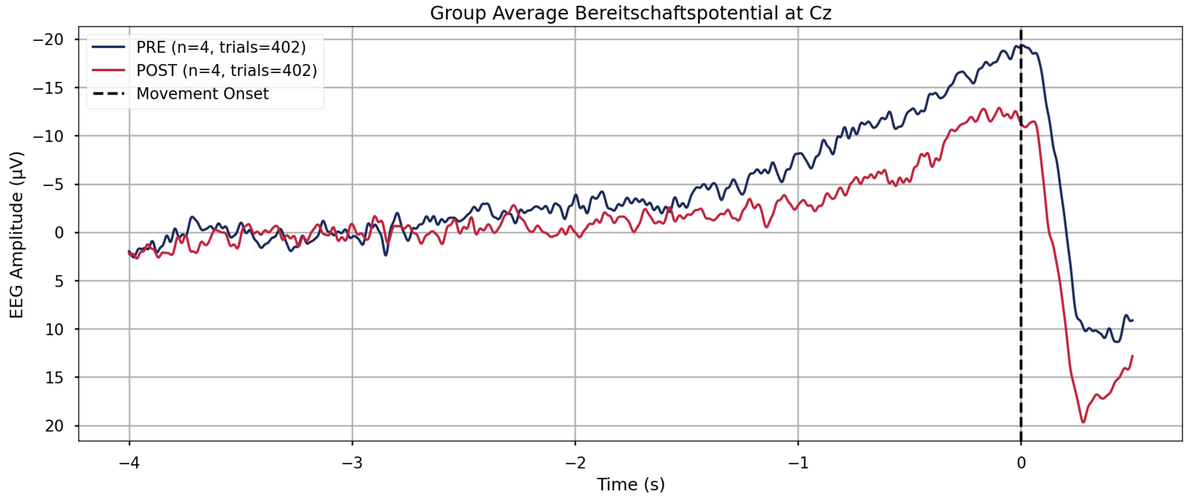
Task 1: Right wrist extension every 7-12 seconds. EEG recorded from Cz, Pz, Fz, C3, C4 and P3. EMG from Extensor Carpi Radialis (ECR). Task repeated twice with **offline TUS** in between.

Task 2: Externally-cued right index finger tapping during active or sham **online transcranial focused ultrasound (TUS).**



Cerebellar Flatmap (Diedrichsen 2006; Diedrichsen et al. 2009)

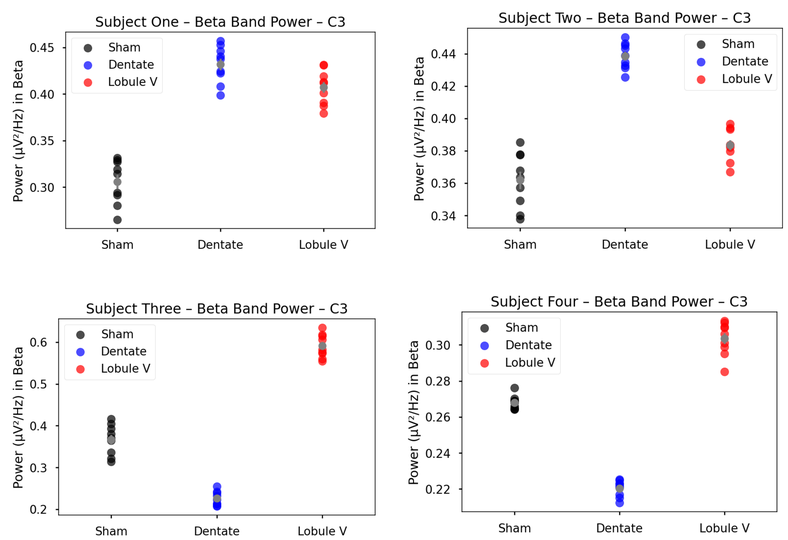
RESULTS



Modulation of the **Bereitschaftspotential (motor preparation)** is shown in this figure. The blue line represents the BP prior to the delivery of transcranial focused ultrasound, and the red line represents the BP after delivery of TUS. Notably, the attenuation of peak negativity over the central midline (Cz) electrode is prominent.

Offline sonication with a burst length of 20.00 ms, frequency of 500.00 kHz and period of 200.00 ms was applied to the right dentate nucleus (DN) for two minutes during a period of rest. Following sonication there was a resting period of five minutes in accordance with previously determined protocols using offline sonication in the Krembil Brain Institute.

This suggests that TUS targeting the dentate may modulate motor-related cortical potentials.



Modulation of **beta-band power** is shown in this figure. It is also important to note that modulation of the dentate resulted in bidirectional changes. This may be explained anatomically, by the presence of white matter tracts near the DN. Sonication of the white matter tracts may cause an opposing effect to the sonication of the dentate.

Beta-band activity changes:

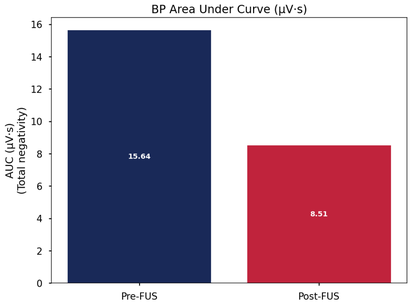
- TUS induced modulation of beta power at C3 across the entire motor task interval, including both tapping and resting periods.
- Additional beta power changes observed at Cz, Pz, Fz, C4 and P3 suggesting widespread cortical effects.

DISCUSSION

The BP and Beta-Band Activity are modulated during voluntary movement by transcranial focused ultrasound directed towards the dentate nucleus.

Specifically, an increase in power of 23% was seen in lobule V, while dentate stimulation resulted in bidirectional changes.

The peak negativity, slope and area under the curve of the bereitschaftspotential were attenuated by 6.07μV, 7.13 μV • s and 2.44 μV/s respectively.



Graphical Representation showing the reduction of Area Under the Curve post TUS

CONCLUSION

Our findings suggest that **transcranial focused ultrasound stimulation of the dentate nucleus modulates the BP and beta-band activity**, supporting the involvement of the dentato-thalamo-cortical pathway in shaping movement preparation signals. Dentate projections influence motor readiness through supplementary and primary motor cortices.

These signals are traditionally attributed solely to cortical structures. These results support the emerging view of cerebellar participation in human motor control networks specifically via the dentato-thalamo-cortical pathway.

Acknowledgements:
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Scan QR for references