

# FINDING THALAMIC BOLD CORRELATES TO CORTICAL ALPHA MODULATION

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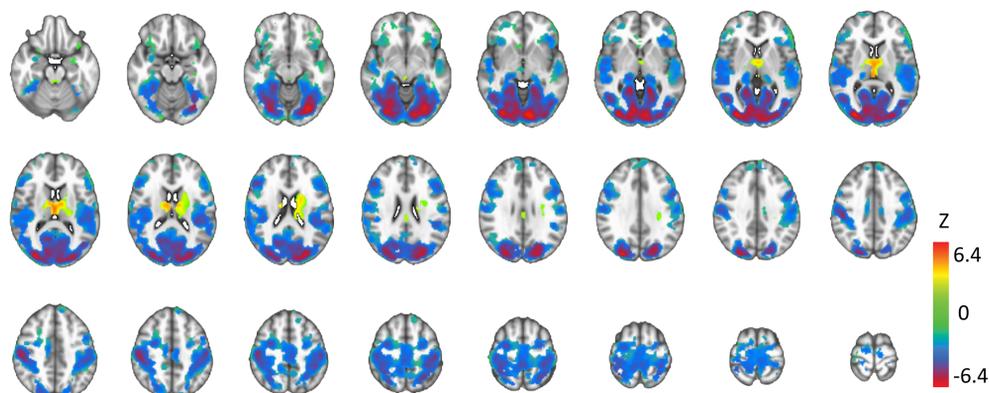
## Introduction

Oscillatory electrical brain activity in the alpha (8-13Hz) band is a prominent feature of human electroencephalography (EEG) during alert wakefulness. Although the alpha-band EEG is commonly thought to arise from the occipital and parietal cortices, previous animal electrophysiology studies suggest an important role of the thalamus in the generation and modulation of alpha rhythms. To study the thalamic contribution to cortical alpha rhythms in the human brain, we evaluated the correlation between the BOLD fMRI signals in the thalamus and the spontaneous modulation of posterior alpha EEG.

## Methods

We measured simultaneous EEG (32-channel) and fMRI (3T) data from 15 healthy subjects during the eyes-closed rest (10min), eyes-closed-eyes-open task (4min) and full-field visual stimulation (4min). The alpha frequency was individually determined for each subject based on the spectral contrast between the eyes-closed and eyes-open conditions. The temporal variation of the EEG power at the individual alpha frequency observed from occipital electrodes was correlated with the BOLD signal throughout the brain. The thalamic alpha-BOLD correlations were compared to the thalamic activation with visual stimulation and high-resolution phase images at 7T. Thalamocortical functional connectivity was also evaluated based on correlation within fMRI data.

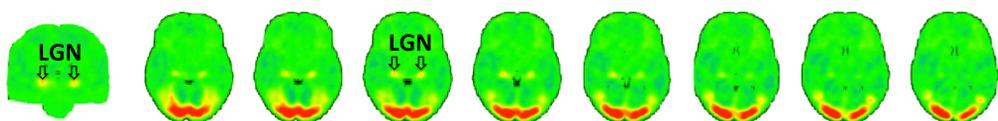
## BOLD Correlates of Posterior Alpha Modulation



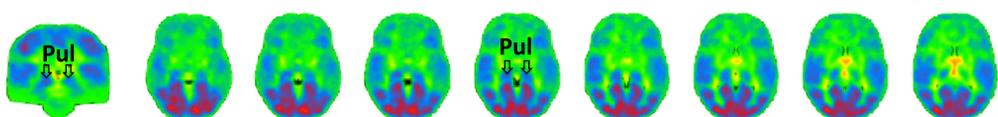
Group map of BOLD correlates of posterior alpha power ( $p < 0.02$  corrected for false discovery rate).

## Comparison with Visual Activation and Phase Images

### a) BOLD Responses to Visual Stimulation



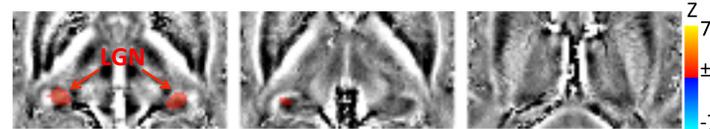
### b) BOLD Correlates of Posterior Alpha Modulation



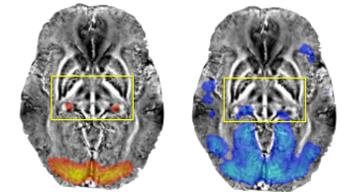
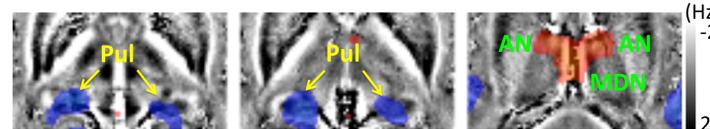
Comparison between BOLD activations with visual stimulation (a) and BOLD correlates of posterior alpha power (b) in the thalamus.

## Comparison with Anatomical and Histological References

### a) Thalamic foci responding to visual stimulation

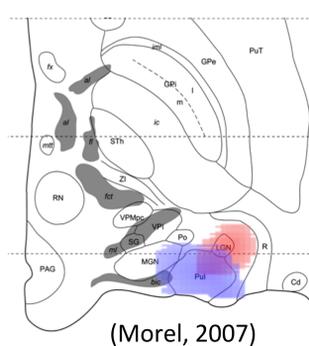


### b) Thalamic foci correlating to alpha modulation

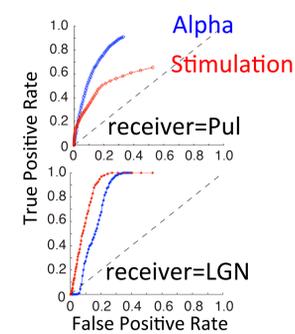


Thalamic sub-regions that respond to passive visual stimulation (a) or correlate with posterior alpha modulation (b) shown on gradient-echo phase images (a & b) and a histologically defined atlas of the thalamus (c). d) Receiver operating characteristic (ROC) curves with respect to Pul or LGN.

### c) Histology-based atlas

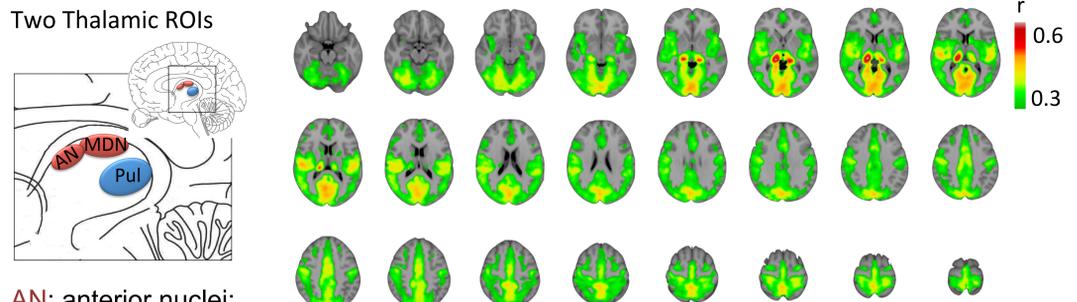


### d) ROC Analysis



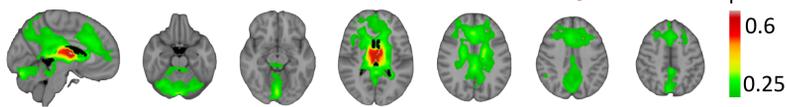
## Thalamocortical Functional Connectivity

### Pul-seeded Functional Connectivity



AN: anterior nuclei; MDN: medial dorsal nuclei; Pul: pulvinar

### AN/MDN-seeded Functional Connectivity



## Summary and Conclusions

In the human thalamus, there exist both negative and positive BOLD correlates to spontaneous modulation of posterior alpha rhythms, yet occurring at distinct thalamic nuclei. Negative correlations occur at the pulvinar whereas positive correlations occur at the medial dorsal and anterior nuclei. Functionally, the former connects with visual cortex, and the latter connects with cortex of anterior and posterior cingulate and cerebellum.

The current data support the notion that the visual thalamus, and the pulvinar in particular, is intimately involved in the generation and spontaneous modulation of posterior alpha rhythms. We further postulate that the anterior and medial dorsal nuclei, as part of the ascending neuromodulatory system, may indirectly modulate cortical alpha rhythms by affecting vigilance and arousal level.

