Does occipital alpha phase and/or power influence motor cortex excitability?

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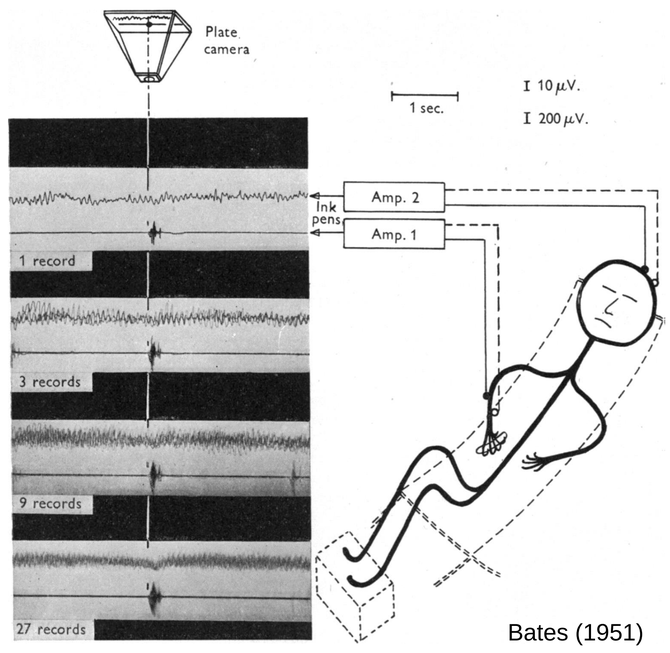
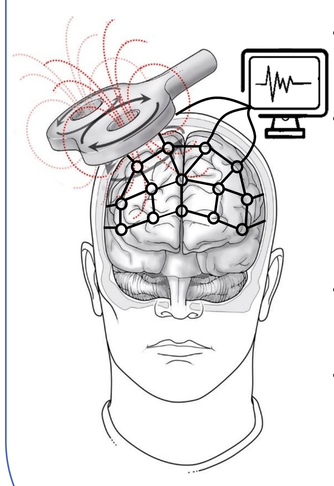
Introduction

Previous studies have suggested that there is a relationship between neuronal oscillations and cortical excitability (Sauseng et al., 2009). Specifically, it has been evidenced that even at rest, alpha power can determine the magnitude of cortical excitability, as measured by the amplitude of TMS Motor Evoked Potentials (MEPs; Sauseng et al., 2009; Mäki & Ilmoniemi, 2010). Recently, it has also been suggested that the phase of Rolandic rhythms can affect corticospinal excitability (e.g., Wischnewski et al., 2022). A few papers have additionally proposed that the phase of occipital alpha has an effect on motor cortex activity, as suggested by reaction times (Callaway, 1962) and changes in EEG potentials Bates (1951). However, the literature here is sparse and outdated. Thus, the main aim of our study is to address whether the occipital alpha power and/or phase has an influence on motor cortex activity using a more direct index of excitability, i.e., MEP amplitude.



Bates (1951)

Methods



Data is acquired from open access sources.

The final data sample was made up of 10 participants

- **Single-pulse TMS (spTMS)** was delivered to the left and right M1 area, during separate runs.
- For each run, **80 biphasic pulses** were delivered at **120%** resting motor threshold (rMT). These runs were repeated three times for conditions unrelated to the current analysis. Total spTMS = max. **240 trials** per participant.
- To ensure the correct brain region were being targeted and analysed, **MRIs** were also acquired for each participant.
- **Motor evoked potentials (MEPs)** were then measured from the contralateral first dorsal interosseous (FDI) hand muscle, as a direct index of cortical excitability.
- Concurrent **electroencephalography (EEG)** was also recorded from 64 channels.

Data Analysis

Initially, EEG trials were epoched to only contain pre-stimulation information (-4 to 0s)

EMG trials were epoched to contain both pre- and post-stimulation information (-1 to 1s). This was so that trials containing muscle artifacts pre-stimulation, could be excluded and MEPs after stimulation could reliably be seen.

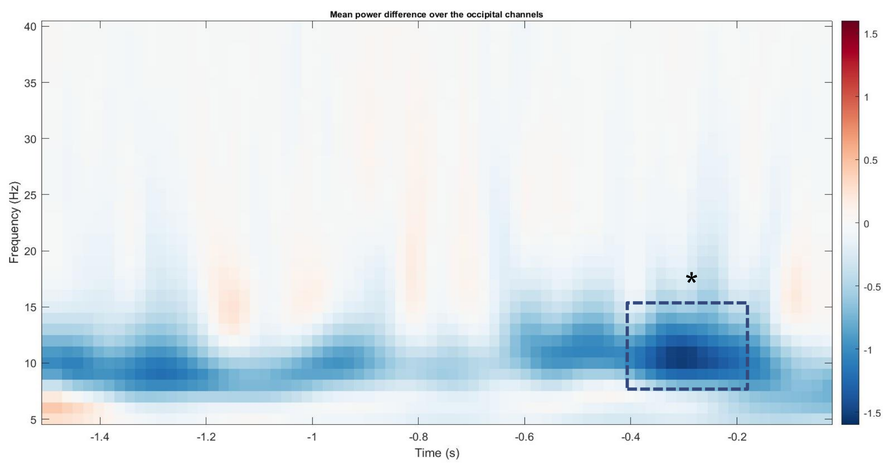
For each participant, trials were then grouped based on whether TMS induced a high or low MEP amplitude (using median values), indicative of high or low cortical excitability, respectively.

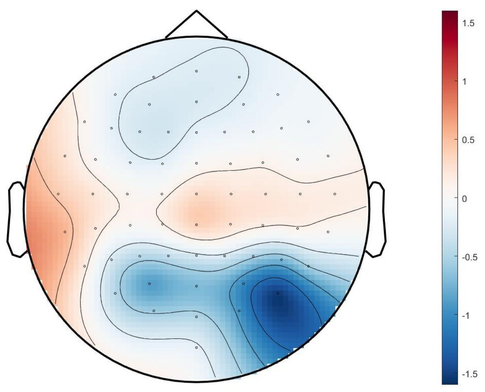
Since Left and Right M1 stimulation did not differ in the amount of pre-alpha activity, data from these conditions were collapsed.

Time frequency representations of **power** were calculated for high and low category trials separately. Power difference was then calculated by taking the power of high minus low MEP trials. A cluster-based permutation analysis was then performed to determine if there were any significant differences in the oscillatory power pre-stimulation, evoking either a high or low amplitude MEP. This was restricted to alpha (6-13 Hz) and to the 500ms before the TMS pulse.

Phase Opposition Index (VanRullen, 2016) was then calculated with pre-stimulation EEG recordings, taking into account individual differences (no phase binning). This was first conducted at an individual and then at a group level. For both, POS was calculated on the occipital channel exhibiting the highest alpha (see Results).

Power difference for high vs. low MEP amplitude trials, averaged over occipital channels





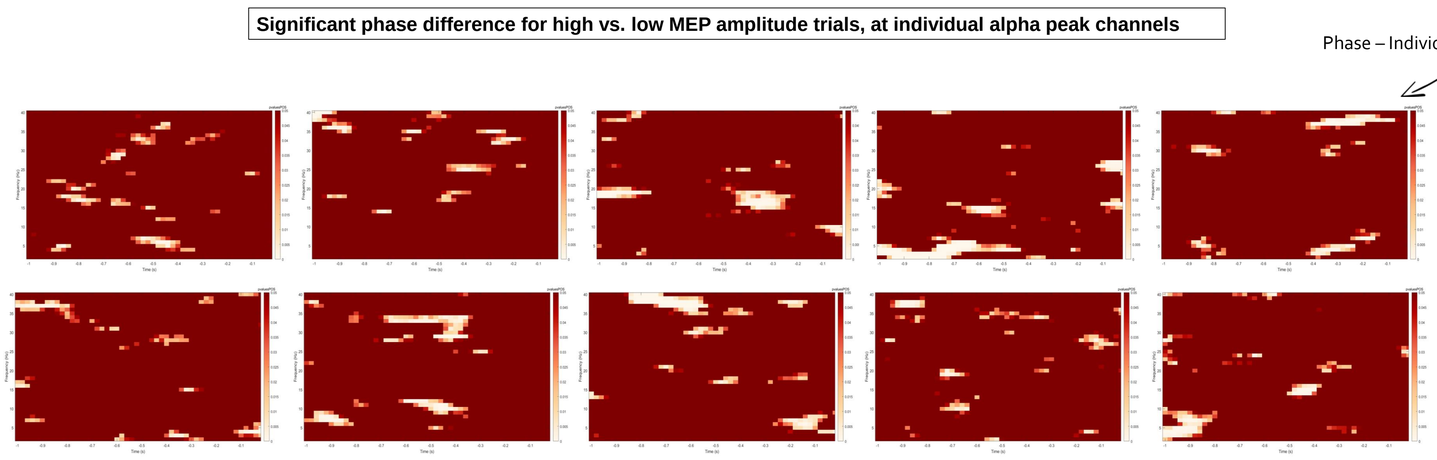
Results

POWER: We found an asymmetric distribution of alpha power, i.e., maximal over PO3/7; PO4/8. We also found a significant difference when comparing high and low-amplitude MEP, with high-amplitude MEP showing a reduction in power compared to low-amplitude trials (p = .03).

PHASE: At the individual level, electrodes with the highest occipital alpha included: PO8, P7, POz, P2, PO7, Pz, O1, Pz and PO3. At the group level, PO3 demonstrated the largest alpha.

POS analysis found significant effects at the individual level, but no effects when combining p-values.

Significant phase difference for high vs. low MEP amplitude trials, at individual alpha peak channels



Next Steps

Data analysis is still ongoing.
We still have many plans for this data, including:

- Source-projecting the alpha activity (we have individual electrode position).
- Grouping trials according to the pre-TMS occipital alpha phase (negative vs. positive peak), then testing for a significant difference in MEP amplitude.
- Investigating post-TMS occipital oscillations to explore whether it is the excitability of the motor cortex that can influence the activity of the occipital cortex.
- Perhaps gaining access to additional datasets to increase our sample size and become more accurate in our interpretations of the data.
- If the power effects are consistent, we will investigate if it relates to M1 activity in more complex ways (power to phase correlation).

References

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