

Measuring oscillatory behaviour of the primary visual cortex following saccadic eye movements

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Introduction

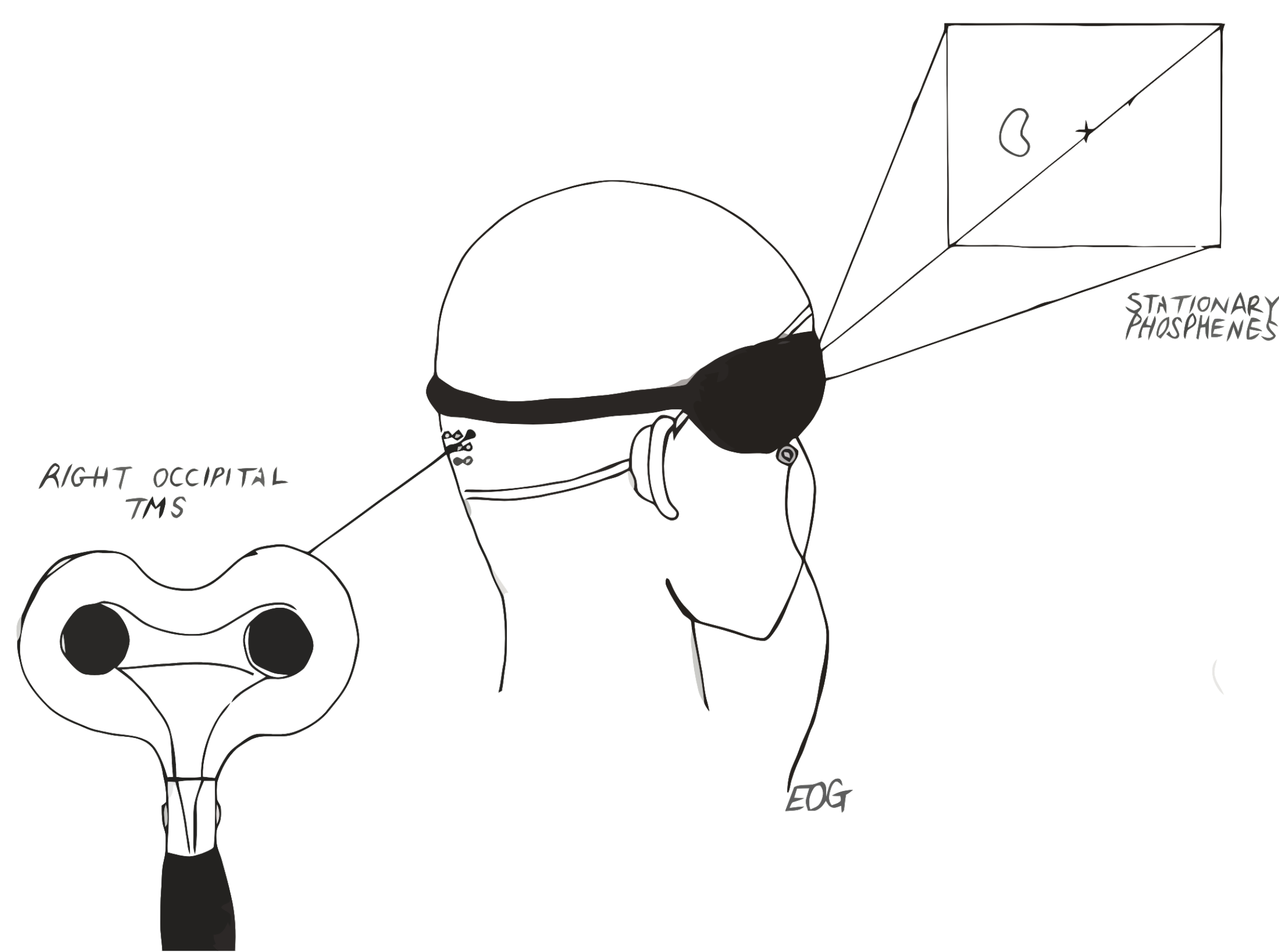
Exploration of a visual scene is an important function of our brain, it allows us to make sense of the busy world around us. Saccadic eye movements redirect the fovea to salient regions of a visual scene and are an integral part of visual exploration.

The main objective of this experiment was to measure the oscillatory effect of saccades on primary visual cortex (V1) excitability as indexed by phosphene perception rate. In the absence of visual stimuli i.e. in darkness, we hypothesized that saccades would affect visual cortex excitability by top-down signals which may be initiated by corollary discharge.

Methods

15 healthy volunteers participated in the full design (both sessions) of this experiment (10 females, 5 males, mean age = 25.4, sd = 4.3).

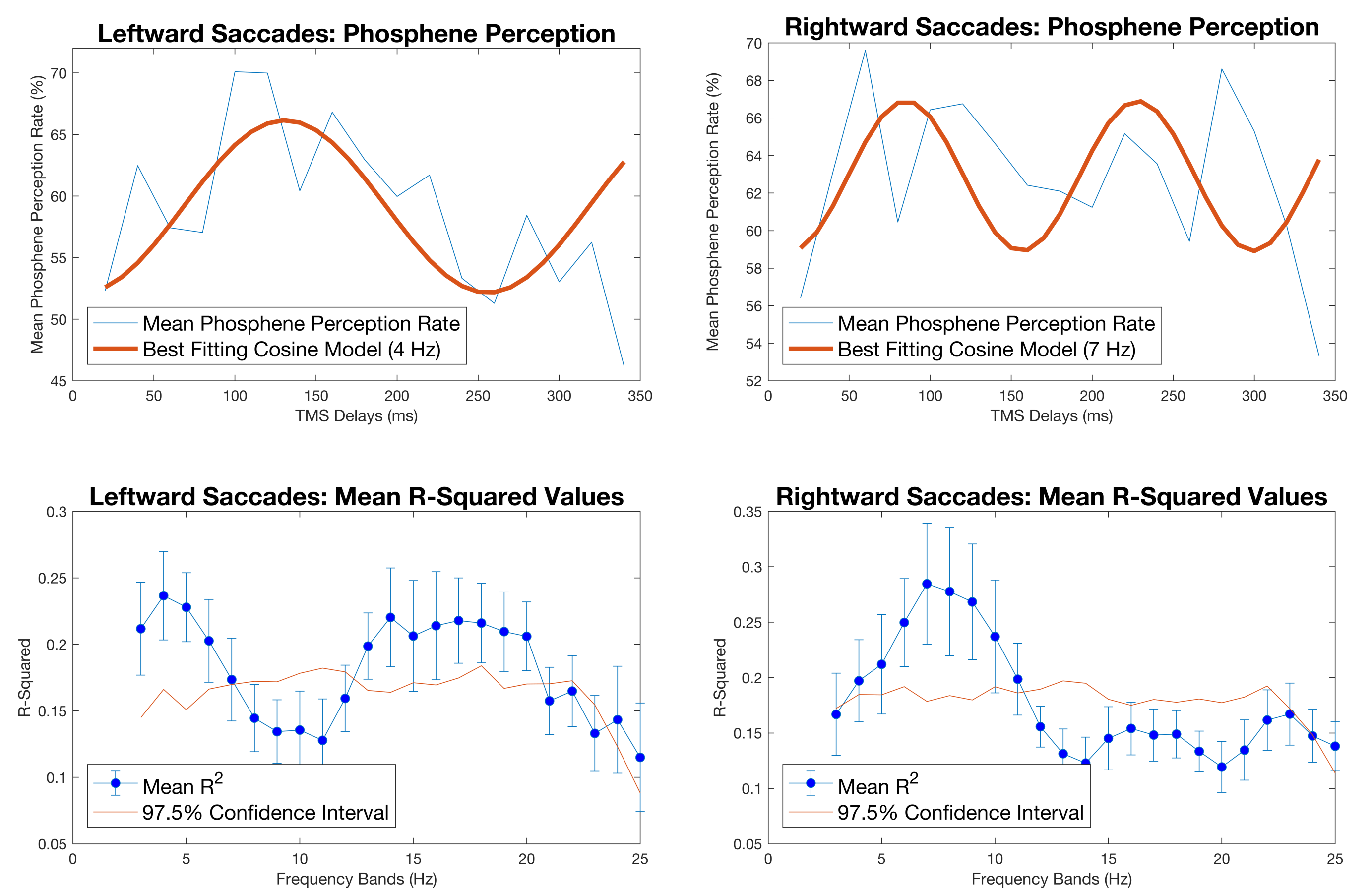
Pre-session: phosphene training and determining individual V1 sites and phosphene thresholds.



Experimental Session: blindfolded participants performed self-paced saccades to the left and right depending on the block (one every ~4 seconds).

- Participants reported whether they saw a phosphene or not on a keyboard.
- In total, there were 420 trials, each followed by a TMS pulse, amounting to 21 trials per block (20 blocks in total, 10 for each direction of the saccades).
- EOG was recorded to ensure that the saccades triggered (threshold of 4 mV) right occipital TMS at 17 time delays from saccade onset (20 - 340 ms).

Results



- Leftward saccades showed the presence of theta (4-7 Hz) and beta (16-18 Hz) frequencies.
- Rightward saccades showed a pattern of theta (4-7 Hz) and alpha frequencies (8-11 Hz).
- **Significant phase reset for theta and beta frequencies ($p < 0.01$) for leftward saccades.** No significant phase reset for theta and alpha frequencies for rightward saccades.

Discussion

Overall, we have shown that there is top-down modulation occurring from saccades in the form of phase resetting of ongoing oscillations in the primary visual cortex.

Our results are consistent with previous work into attentional sampling and the resetting of endogenous rhythms due to attention related actions [1]. In addition, the presence of a theta rhythm has been proposed to drive exploratory behaviours such as sniffing (in rodents) and eye movements [2]. Phase resetting of low frequencies have also been shown to be regulated by eye movements in monkeys [3].

- It is likely that top-down processes performed by these fast eye movements modulate V1 excitability.
- From research into frontal eye fields, top-down processing does occur in higher cortical areas to early sensory areas [4].
- An EEG study will be carried out with similar methods to see whether results would be replicated.

References:

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3. Rajkai, C., Lakatos, P., Chen, C. M., Pincze, Z., Karmos, G., & Schroeder, C. E. (2007). Transient cortical excitation at the onset of visual fixation. *Cerebral Cortex*, 18(1), 200-209.
4. Ruff, C. C., Blankenburg, F., Bjoertomt, O., Bestmann, S., Freeman, E., Haynes, J. D., Rees, G., Josephs, O., Deichmann, R., & Driver, J. (2006). Concurrent TMS-fMRI and psychophysics reveal frontal influences on human retinotopic visual cortex. *Current Biology*, 16(15), 1479-1488.