EXPERIMENT 1: ***Spontaneous Fluctuations in Posterior a-Band EEG Activity Reflect Variability in Excitability of Human Visual Areas***, ***Romei et al., 2008***

**Introduction**

* **Question:** alpha oscillations reflect idling passive states or reflect the receptive state of mind?
* **Techniques:** in this experiment were used a combination of **two techniques** at the same time:
  + **TMS** to induce illusory visual percepts (phosphenes) in blindfolded participants, while simultaneously recording **EEG** (to record alpha-band activity (8-14 Hz))
* **Hypothesis**: this experiment showed that alpha-band activity was not related to an idling state of the brain, but these fluctuations are thought to index the momentary state of visual cortex excitability.
* **Results:**  researchers found that identical TMS-stimuli evoked a percept (P-yes) or not (P-no) depending on pre-stimulus alpha activity; **inverse relation**.
  + Low pre-stimulus alpha-band power resulted in TMS reliably inducing phospenes (P-yes trials)
  + High pre-stimulus alpha-band led the same TMS-stimuli failing to evoke a visual percept (P-no trials)

The intensity of TMS-stimuli was always the same, it did not change trial-by-trial. So the perception/non-perception depends only on the alpha activity and so on the momentary state of visual cortex excitability.

**Objective**

* Study the mechanism of how we perceive the world around us: whether a visual event is consciously perceived depends on external factors (such as its salience), but also on the internal state of the visual network at the time of visual input: study the neurophysiological basis of this state-dependency
* Exploiting the capacity if occipital TMS to create visual experiences (phosphenes)
* EEG recording online to TMS in order to look at anything that is happening before the presentation of the TMS pules; by looking at this we will **anticipate** if the subject will see or not the phosphene

**Protocol**

* Induction of phosphenes by single pulse TMS over occipital pole, phosphenes induced in 50% of trials
* TMS was delivered every 3/5 seconds and the subject reported whether received the phosphene or not
* EEG was recording continuously
* **EEG Analysis prior to TMS pulse delivery:** There was a pre-TMS analysis that was looking for the relationship between pre-TMS EEG activity and phosphene perception. (Future result: The internal state of the brain was encoding for the successful capacity to predict the presence of phosphenes.)

**Method**

* the experiment was tested over *fifteen subjects* that were *blind-folded* and subjected to many *TMS impulses on the lower-left area of the visual cortex* while their cerebral activity was recorded through an *EEG*
* of all the subjects, just *nine* were able to perceive phosphenes (obviously around the upper-right corner of their visual field) from the *TMS impulse* at least once and, for each of them, the machine intensity was calibrated so that they could perceive the phosphene with *50% of probability*
* those nine subjects were then subjected to a new round of *TMS impulses*(after 3/5 seconds as said in the second point of the protocol*)*  and their cerebral activity was recorded through an *EEG*, eventually (alla fine) the data related to the ***alpha band potential in the second before the application of the TMS stimulus*** was extracted via *FFT* (*Fast Fourier Transform*) and grouped depending whether the phosphene had been seen (***P-yes***) or not (***P-no***)
* the results exhibited no interesting differences between the *P-yes* and  
  *P-no* case except for those related to the ***three electrodes placed in the lower-left area of the head***
* indeed, in these cases, as we can see in the plot, ***a lower intensity in the alpha-band led to the perception of the phosphene while a higher intensity led to no perception***
* This last concept can be expressed also in terms of synchronization***: every time the alpha activity was desynchronized, this led to a higher probability of the perception of the phosphene, while when the alpha activity was synchronized, this led to no perception in the participants.***
* many **other tests** involving various aspects were made to prove the causal relationship between the fluctuation in the *alpha band* and the perception of the phosphene, for example
* the same test with *TMS impulse* applied in different areas or with different orientation of the magnetic field shown no significant difference
* a test using multiple *TMS impulses* at constant *ISI* shown that the perception of the phosphene was related neither to the ability of predicting the impulse nor to a higher attention of the subject, indeed the probability of getting a *P-yes* remained steady on *50%* over subsequent impulses (**pre-stimulus alpha is independent of the inter-stimulus interval for P/yes P/no trials)**
* a test on eye movement shown that there was no direct relationship between voluntary or involuntary modulation of the eyes and both the perception of the phosphene and the fluctuations in the alpha band **(eye movements before TMS pulses were not related to alpha-modulation)**
* a test on the sequences of *P-yes* and *P-no* by subjects shown that the results were not influenced by any voluntary action, indeed those sequences were consistent with the outcomes of Bernoulli process as they were following a binomial distribution **(intensity and site of stimulation were held constant across trials, confiermed by the random, binomial distribution of responses)**

Briefly, these additional tests, shown that the trial-to-trial variability in phosphene perception **cannot be explained**:

* by expectancy (TMS ISI)
* by overt attention (eye movements)
* by drowsiness

**Results**

results of this experiment provided further support to the alpha/excitability hypothesis and for an ***inverse relationship between oscillatory alpha band activity and cortical excitability*** *(*perception of phosphene*)*, proving thatalpha activity is not a passive idling state but instead reflects the momentary state of cortical excitability (correlation between individual alpha-power and cortical excitability confirm a functional role of alpha activity)

* practically, the *potential* of alpha waves sets a ***threshold of perception***, indeed whenever the fluctuation reaches a low point (around) neurons fire even when receiving a sufficiently powerless stimulus that, in case of high potential (around ), is not powerful enough to activate the action potential of the neurons in the area and, therefore, the stimulus gets bypassed