Disruption of Frontal Activity Asymmetry Using tACS to Modulate Risk-taking Behavior

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ABSTRACT

Risk-taking behavior is consciously or unconsciously controlled behavior with uncertain outcomes, costs or rewards. For e.g., investing in stocks, taking unplanned professional decisions, trying some new cuisine or simply leaving your window open at night. It is a common behavior, which makes its comprehension highly important for both academia and society.

Based on previous studies, it is expected that the electrophysiological mechanism that underlies risk-taking regulation involves theta frequency (4-8 Hz) oscillations prevalent in the right prefrontal cortex (PFC), as opposed to the left PFC. **These frequencies might play an important role on individual differences in risk-taking.** However, this mechanism is still not clear.

We investigate **if the theta-band asymmetry has a causal role in the regulatory control of risk-taking behavior.** For that we applied brain stimulation in theta frequency and two controls (gamma and sham) during a gambling task.

RESEARCH QUESTIONS

- Is the **theta-band asymmetry** crucial for the **regulatory control** of risk-taking behavior?
- Are these effects dependent on the **frequency**?
- Is the theta-band asymmetry predictive of **different levels** of risk-taking behavior?

ANALYSES

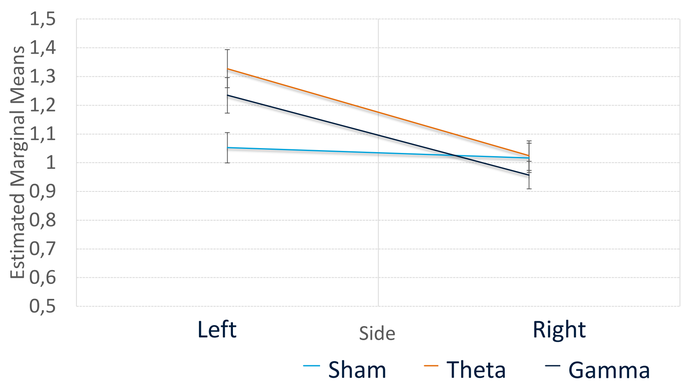
- Classified trials according to the levels of contrast between the two alternatives (pink and blue) in terms of **expected value**:

Cluster	Trials	Expected value diff
LC (Low contrast)	68	1.67< |x| <16.67
MC (Medium contrast)	68	16.67<= |x| <= 33.33
HC (High contrast)	68	65>= |x| >33.33

Risk was measured according to the probability chosen by the participant (RSK) and the level of dispersion calculated as the standard deviation (SD) of the alternative chosen. In addition we measured the reactivity to values (VAL) and the response times (RT).

EEG FINDINGS

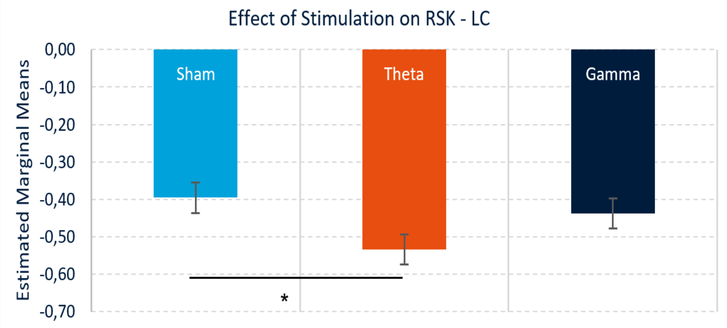
- Significant theta-power increase in lDLPFC compared to baseline and its contralateral equivalent (right PFC).

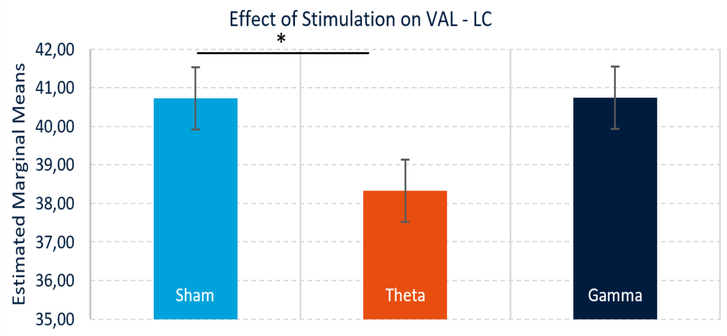


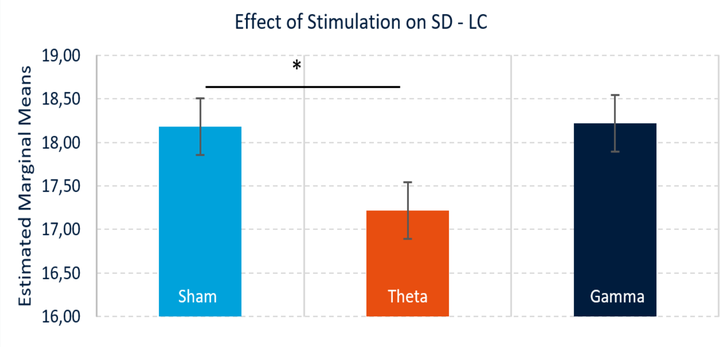
Significant quadratic main effect of stimulation on theta-power.

BEHAVIORAL RESULTS

- Observed significant effects of type of stimulation on RSK, VAL and SD, in the **LC trials**: theta-band stimulation had a significant effect in all risk measurements in the behavioral task during the trials with low contrast of expected values.
- Results significantly differ from both control conditions.





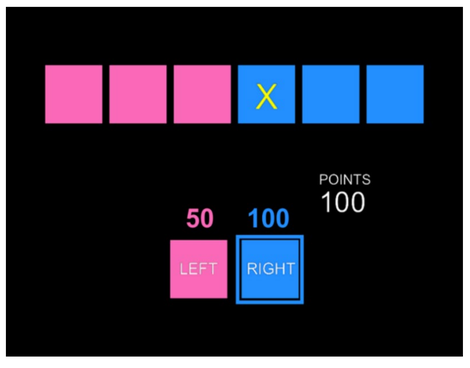


Theta-band stimulation significantly increased theta-power, and the levels of resting-state theta-band asymmetry was a good predictor of the behavioral changes observed.

METHODS

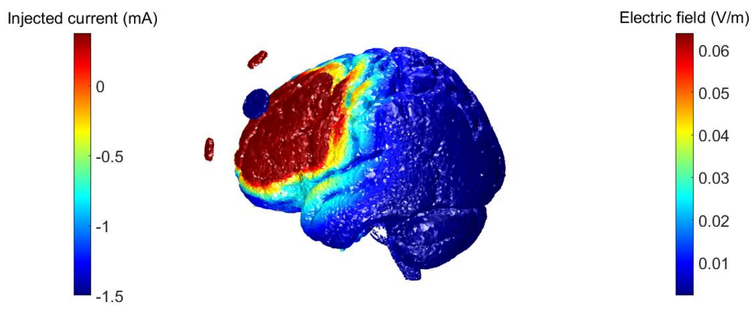
Maastricht Gambling Task:

- Adapted from the Cambridge Gambling Task (Rogers et al.,1999).
- Bet values randomly defined, representing potential earnings (hit).
- No loss aversion: participants could not lose money.
- Reduction of memory effects: independent trials.
- Motivation: participants were informed a random trial would be selected for receiving payment.

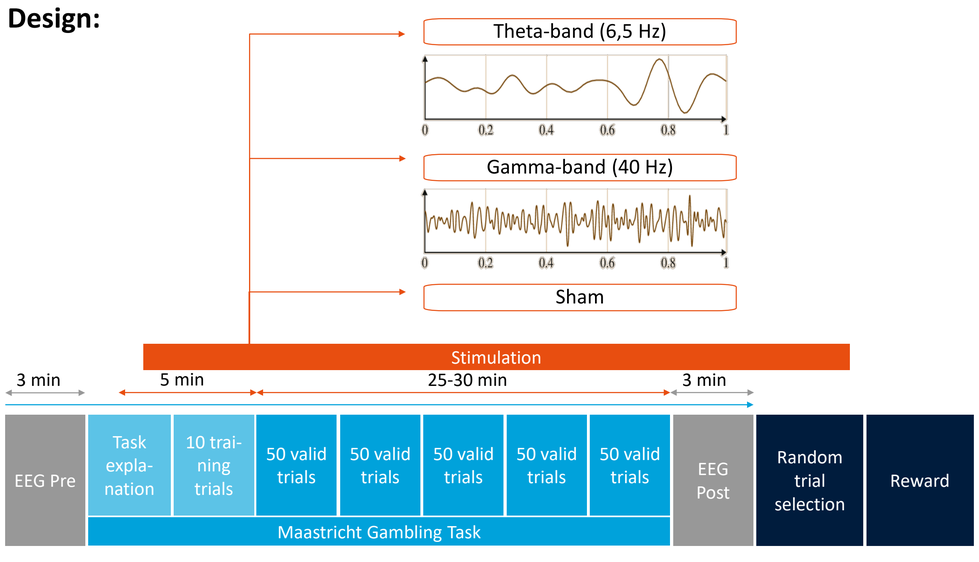


Brain stimulation:

- tACS applied over left dorsolateral prefrontal cortex (lDLPFC).
- Experimental conditions: Theta, Gamma and Sham.



Design:



DISCUSSION

- Measurement of risk reducing the impulsivity factor.
- Effects were clear in trials that presented low contrast of expected value. As expected there is a limit of risk a healthy participant would incur in such task, since participants tend to be more risk averse when there is a larger potential loss (Arkes, Herren, & Isen, 1988).
- Reduction in risk taking was clear and significant after theta-band stimulation & this effect was not observed after gamma-band entrainment or sham.

Findings indicate risk-taking behavior modulation is frequency dependent, reinforcing the causal role of theta-band asymmetry on individual differences in risk aversion.

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