

The role of neural theta oscillations in semantic memory

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■ Neural oscillations

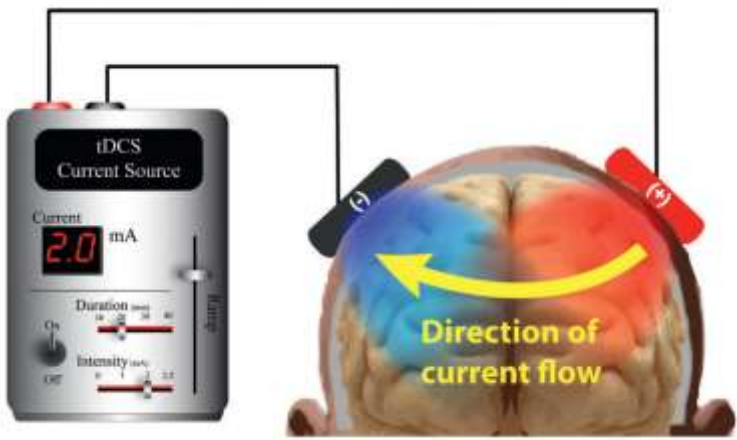
- **Neural oscillations**, rhythmic synchronization of neural activity, are considered to play a major role in cognition and complex behaviors.
- **Semantic memory** is a declarative long-term memory for knowledge, meaning, understanding and concepts.
- Research indicates that **theta band (4-8 Hz)** synchrony may play role in semantic cognition.

Theta oscillations

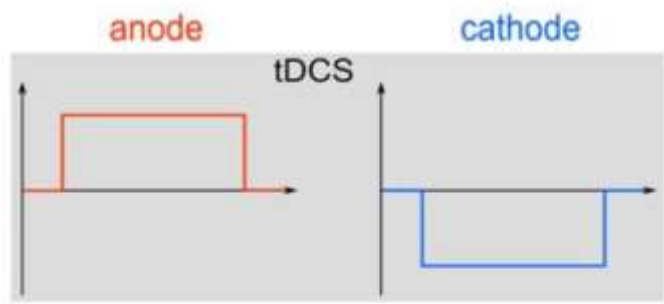
- are increased during **semantic retrieval**, indicating that theta could mediate the activation, propagation, and coupling of semantic representations distributed over the cortex.
- are increased also during engagement of **cognitive control** processes; indicating their possible role in top-down modulation of broad brain networks (especially in situations involving increased processing demands, novelty, interference, or error monitoring).

■ Transcranial electric stimulation

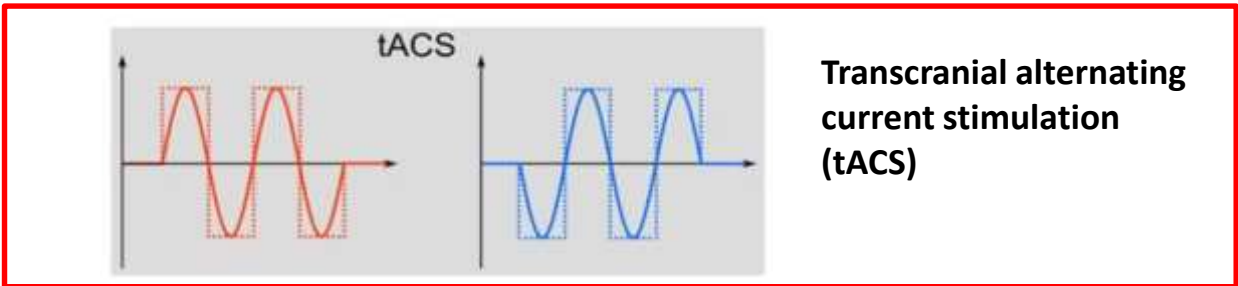
- A low-intensity (0.5–2 mA) current is applied, penetrates the skull, and enters the brain.
- The current flows between electrodes with potential difference, an anode (positive site) and a cathode (negative site).



- **Transcranial alternating current stimulation (tACS)** modulates endogenous brain oscillations and leads to frequency-specific changes in oscillatory power.

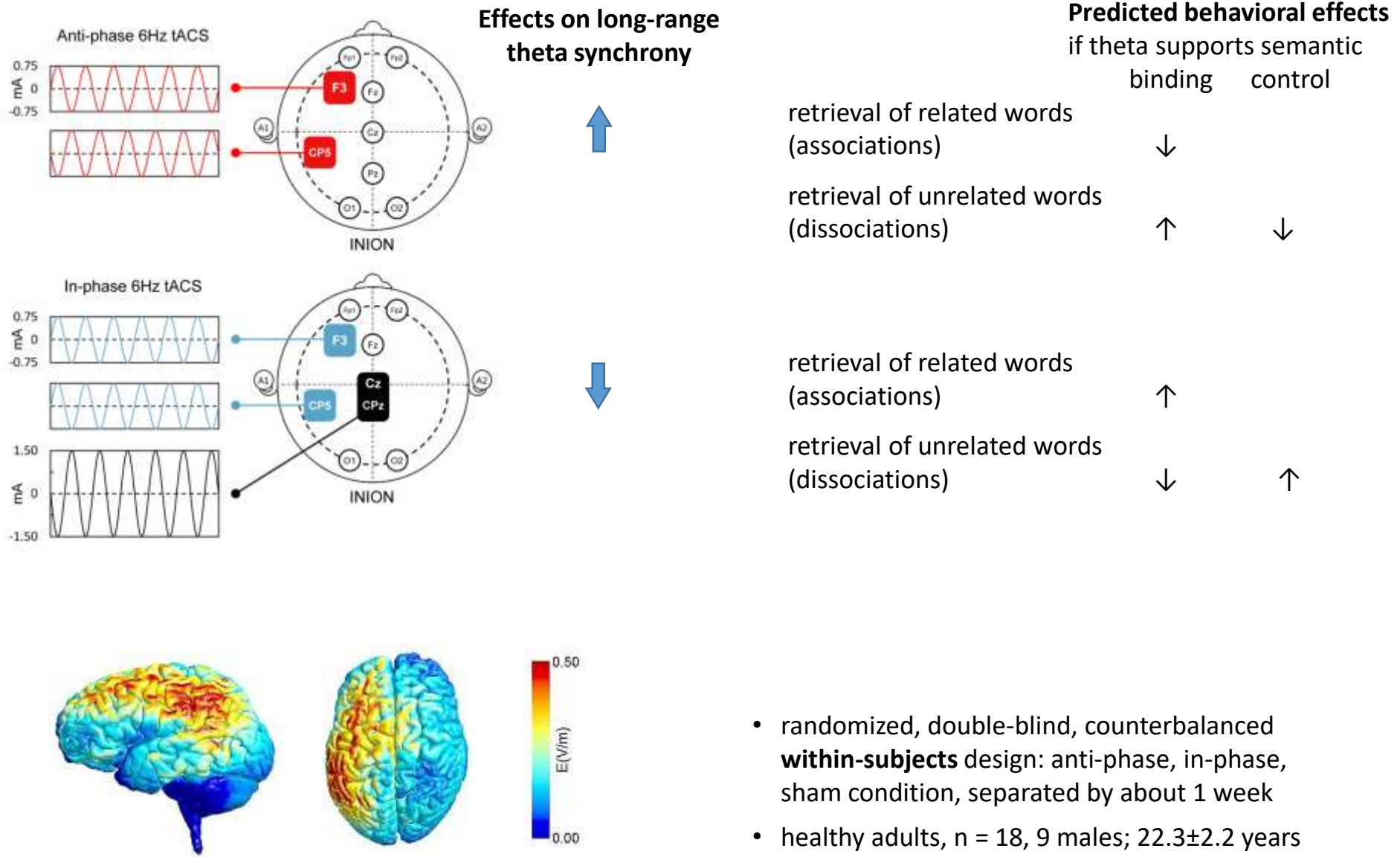


Transcranial direct current stimulation (tDCS)



Transcranial alternating current stimulation (tACS)

■ Methods: tACS



- randomized, double-blind, counterbalanced **within-subjects** design: anti-phase, in-phase, sham condition, separated by about 1 week
- healthy adults, n = 18, 9 males; 22.3±2.2 years

■ Methods: cognitive tests

- category retrieval
- associate chain: retrieval of semantically related words
eg. Hospital – Doctor – Health – Sport...
- dissociate chain: retrieval of semantically unrelated words
eg. Teacher – Kitchen – Hockey – Apple...
- associate–dissociate chain: retrieval of associations and dissociations in alternation
eg. Phone – Call – Banana – Monkey...

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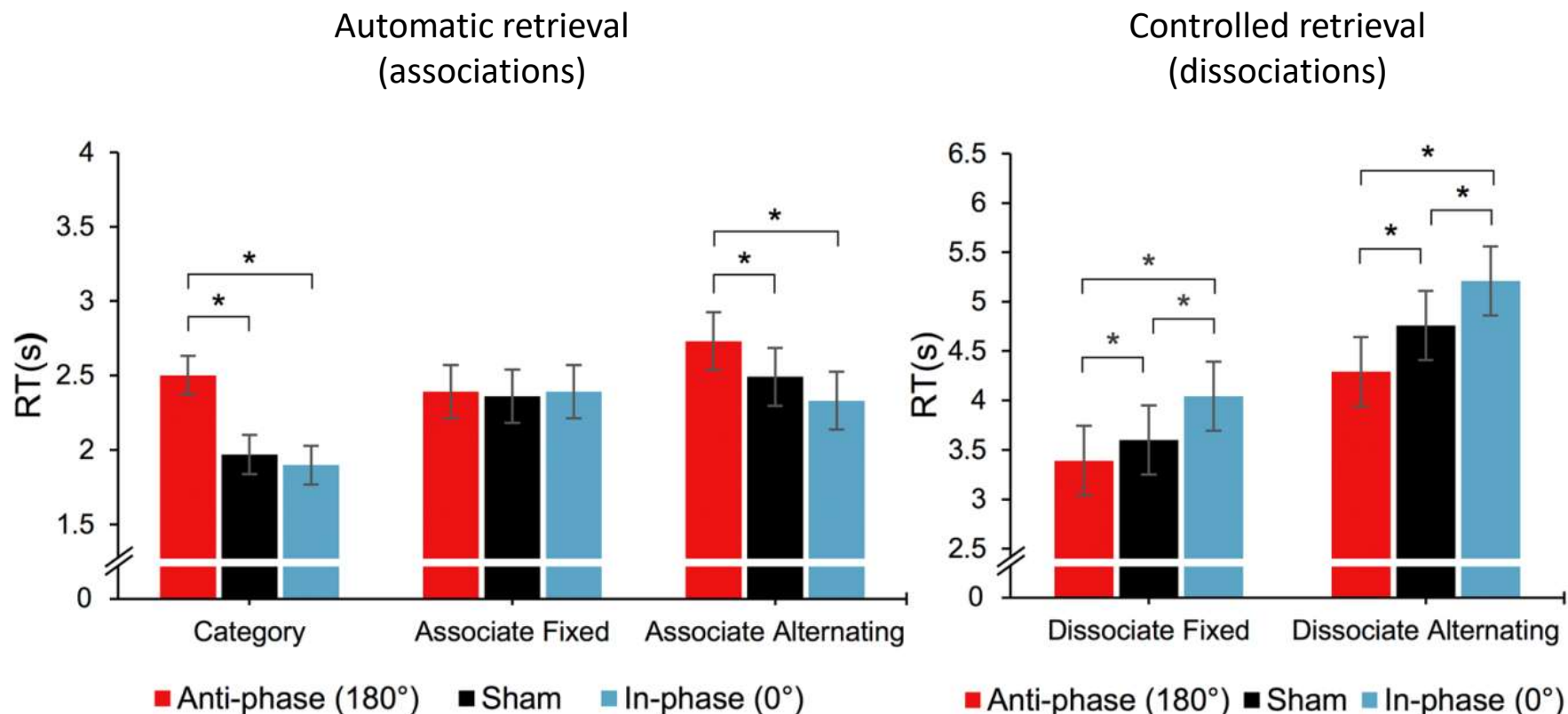


Remote associates test: An empirical proof of concept

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■ Results



Retrieval of semantically related words (automatic retrieval)

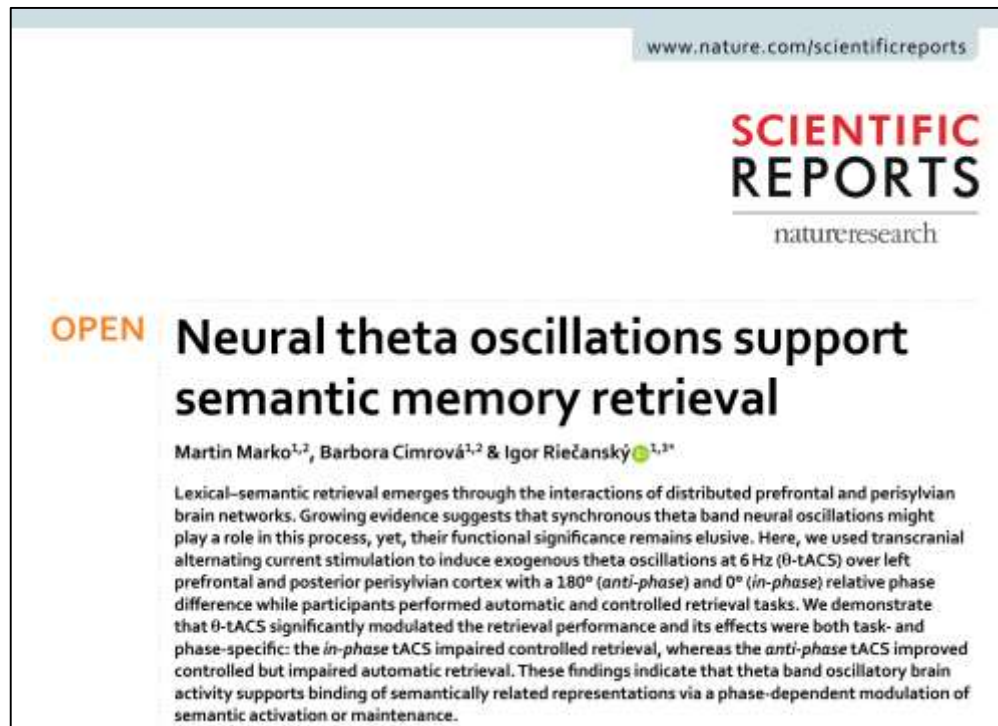
- impaired by anti-phase θ -tACS

Retrieval of semantically unrelated words (controlled retrieval)

- facilitated by anti-phase θ -tACS
- impaired by in-phase θ -tACS

■ Conclusions

- Theta-tACS significantly modulated semantic retrieval:
 - In-phase tACS, increasing long-range theta synchrony, impaired controlled retrieval
 - Anti-phase tACS, decreasing long-range theta synchrony, improved controlled but impaired automatic retrieval
- **Theta oscillations support binding of semantically related representations**



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