# Personalized frequency-modulated noninvasive brain stimulation for associative memory improvement

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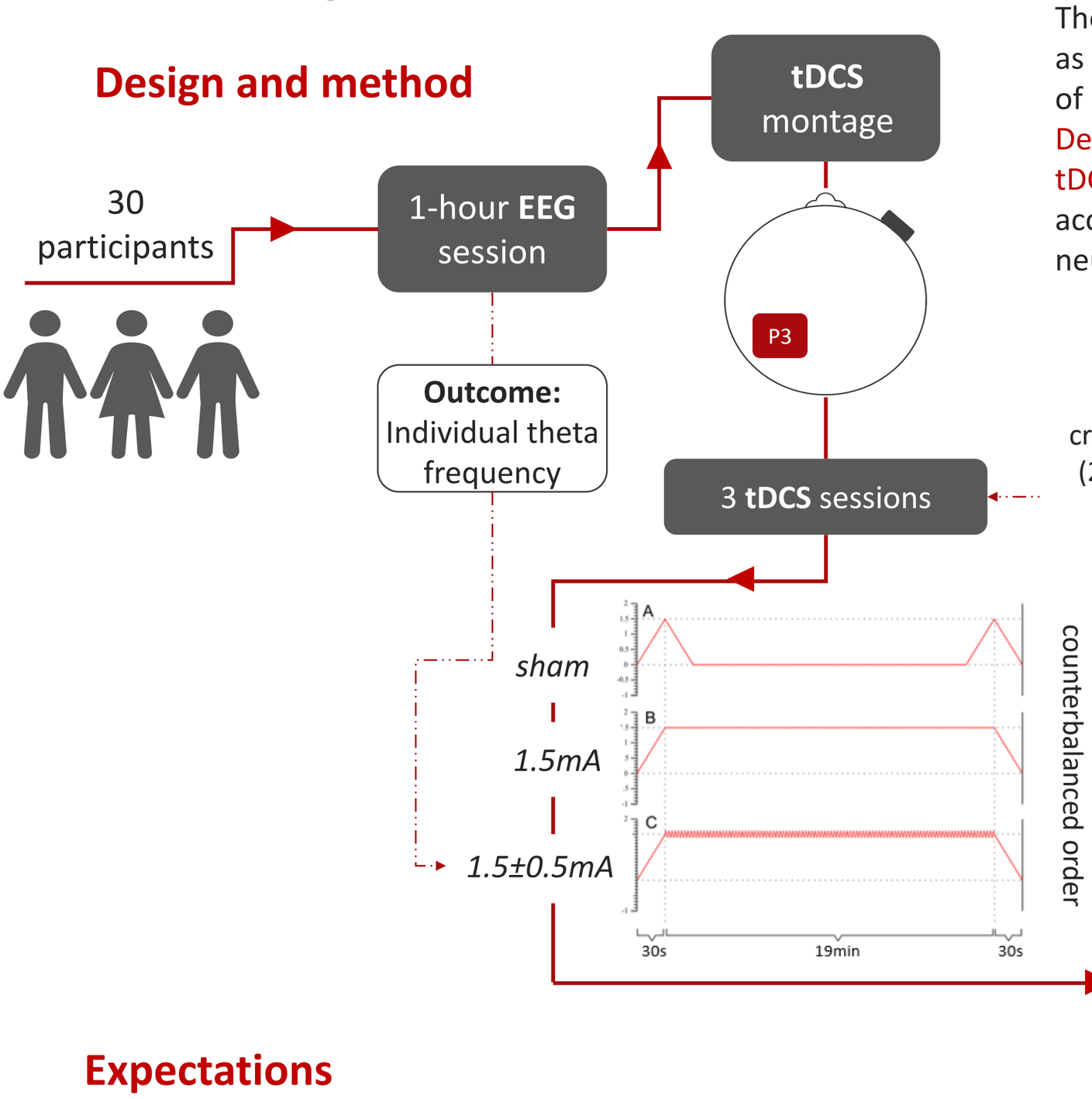
Memory plays a central role in everyday functioning as it enables us to remember information about people and places, recall past events, learn new facts and skills, as well as to make judgments and decisions. Associative memory (AM) represents one's ability to bind multiple pieces of information and encode them as a distinct unit. As all complex cognitive abilities, AM deteriorates with aging and due to various pathological states. Application of a constant anodal tDCS above targeted brain areas turned out to be a promising way to boost AM and potentially postpone or slow cognitive decline. Even though majority of previous studies showed positive effects of stimulation on different behavioral measures of AM, the ones that did not opened a debate on weather the further customization of the tDCS protocols could result in more targeted and robust effects.

## Design and method




## Aims and rationale

### Promote theta waves with theta oscillatory tDCS

Activity of the hippocampus relayed neural network is consider to be neurophysiological underpin of the memory. Contrasting the effects of the anodal theta oscillatory tDCS protocol with the standard tDCS can provide an insight in weather the modeling of stimulation protocols to natural brain firing (i.e. theta rhythm) amplifies facilitatory tDCS effects.

### Reduce the noise by personalization

The momentary level of individual cortical excitability as well as the individual structural and default functional organization of the brain may contribute to inconsistent tDCS effects. Determining individual theta frequency prior to administering tDCS and adjusting protocol frequency accordingly could account for individual differences in frequency of natural neural firing, and thus provide more reliable effects.

## Expectations

- Both constant anodal and theta oscillatory tDCS protocols will enhance associative memory performance
- Theta oscillatory tDCS with individualized frequency will show greater impact on AM performance than standard anodal tDCS
- The ratio of responders to non-responders will be more favorable following the theta oscillatory tDCS, i.e. the personalization of the frequency will minimize the effect of individual differences in responsiveness to tDCS therefore ensuring more reliable effects in the individual level.

## Related research

Vulić, K. Bjekic, J., Paunovic, D., Jovanovic, M., Milanović, S. & Filipović, SR. Improving associative memory: Exploring the effects of theta oscillatory transcranial stimulation and transcranial direct current stimulation over posterior parietal cortex (in press)

Bjekić, J., Vulić, K., Živanović, M., Vujičić, J., Ljubisavljević, M., & Filipović, S. R. (2019). The immediate and delayed effects of single tDCS session over posterior parietal cortex on face-word associative memory. *Behavioural brain research*, *366*, 88-95.

Bjekić, J., Čolić, M. V., Živanović, M., Milanović, S. D., & Filipović, S. R. (2019). Transcranial direct current stimulation (tDCS) over parietal cortex improves associative memory. *Neurobiology of Learning and Memory, 157, 114-120.*

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This research was supported by the Science Fund of the Republic of Serbia, PROMIS, #6058808, MEMORYST

Science Fund of the Republic of Serbia