Quantifying the influence of magnetic vestibular stimulation on spatial tasks

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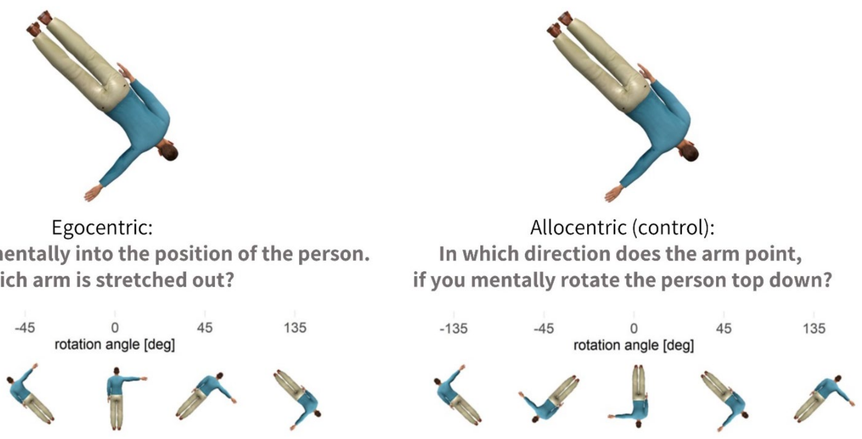
Background

- Strong magnetic fields induce dizziness, vertigo, and nystagmus due to Lorentz forces acting on the cupula in the semi-circular canals [1]. This effect is called **magnetic vestibular stimulation** (MVS).
- Altered vestibular information can influence performance in cognitive tasks with spatial components, this has been shown in studies using passive motion, galvanic or caloric vestibular stimulation, microgravity and in patients with vestibular dysfunction [2]. Specifically, mental body rotations using a strategy relying on the own body reference are affected (i.e., egocentric strategies). MVS can also affect spatial attention [3].
- In this study we investigated, if MVS in a 7 Tesla MRI scanner (Magnetom Terra, Siemens) influences **mental body rotation** (for experimental set up see [4]).

Methods

30 healthy participants solved a mental body rotation task with egocentric and allocentric strategy, both in supine and in tilted position.

Spatial task: Mental body rotation with two strategies

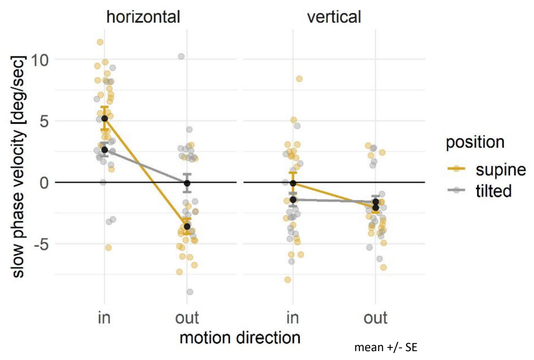


Egocentric body rotation strategy relies on own body position (influenced specifically by vestibular information), whereas allocentric strategy served as control condition (control for unspecific effects such as distraction, changes in vision, working memory).

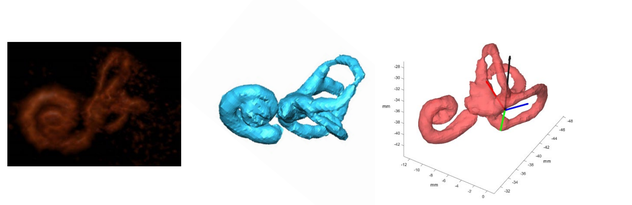
Manipulating MVS strength (within-subject)

- Stronger MVS in supine position:

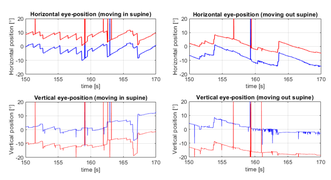
- Weaker MVS in tilted position:



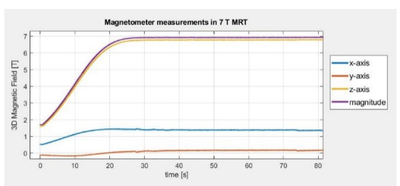
Measuring MVS strength



Extracting orientation of inner ear structures from MRI



Eyetracking (nystagmus)



3D Magnetometer (field strength)

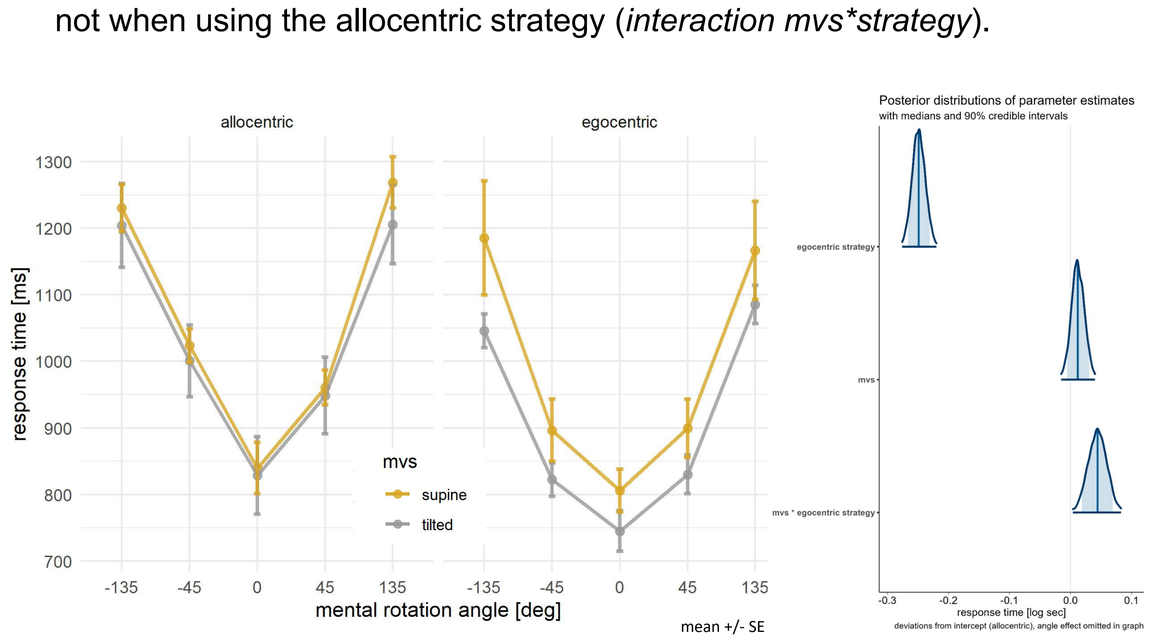
Subjective self-motion perception

Results

Group level analysis

Bayesian multilevel model : *response time ~ angle + mvs * strategy + (1 | id)*
using a shifted log-normal distribution, with correct responses above 0.1 seconds

- Participants showed increase of response time with increasing angles and slower response times in allocentric compared to egocentric strategy.
- Participants were **slower under stronger** (supine position) **than under weaker** (tilted position) **MVS only when using the egocentric strategy** but not when using the allocentric strategy (*interaction mvs*strategy*).



Exploratory analyses

– No predictive value of slow phase velocity or reported self-motion perception strength for the individual *mvs*strategy interaction*.

Conclusion

- Magnetic vestibular stimulation can influence performance in spatial tasks relying on own body position, such as egocentric mental body rotation. Thus, it could serve as a tool to investigate the interrelation of vestibular information and spatial cognition.
- The inter-subject variability of the MVS effect is substantial, and cannot fully be explained by individual strength of magnetic vestibular stimulation (measured by nystagmus or reported self-motion perception).
- Studies using fMRI to investigate spatial cognition or investigating vestibular patients should be aware of confounding effects of magnetic vestibular stimulation [5].

References

[1] Roberts et al. (2011). *Curr Biol. 21*(19), 1635-1640. [2] Falconer & Mast (2012). *Exp Psychol. 59*(6):332-9. [3] Lindner et al. (2021). *eLife. 10,* 71076. [4] Wyssen et al. (2023). *JoVE. 193,* e64022. [5] Boegle et al. (2020). *J Neurol. 267*, 91-103.

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