

Vestibular information is insufficient for reliably encoding head position

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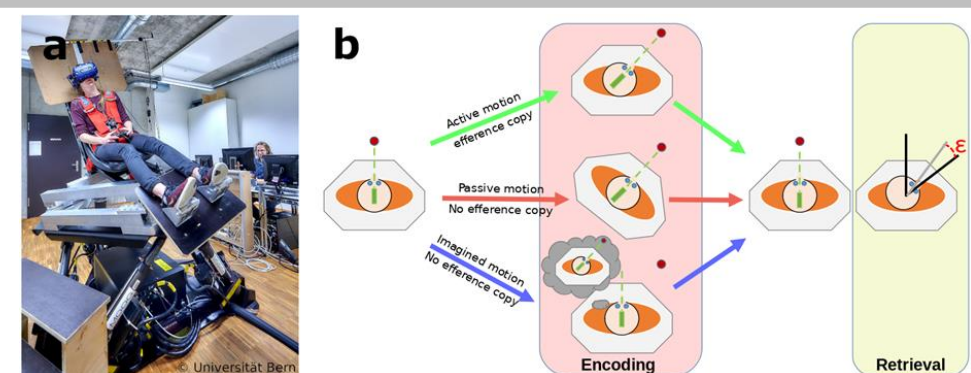
Background

The term spatial memory refers to stored information regarding the location of objects or the self in three-dimensional space. Vestibular input is widely disregarded despite compelling evidence for its important contribution in spatial memory [1,2]. It is known that efference copies, elicited by a self-caused action, can increase performance in spatial memory tasks. A recent study on motor imagery and touch suggested a functional equivalence between imagined and executed movements and proposed that efference copies are also created during motor imagery [3].

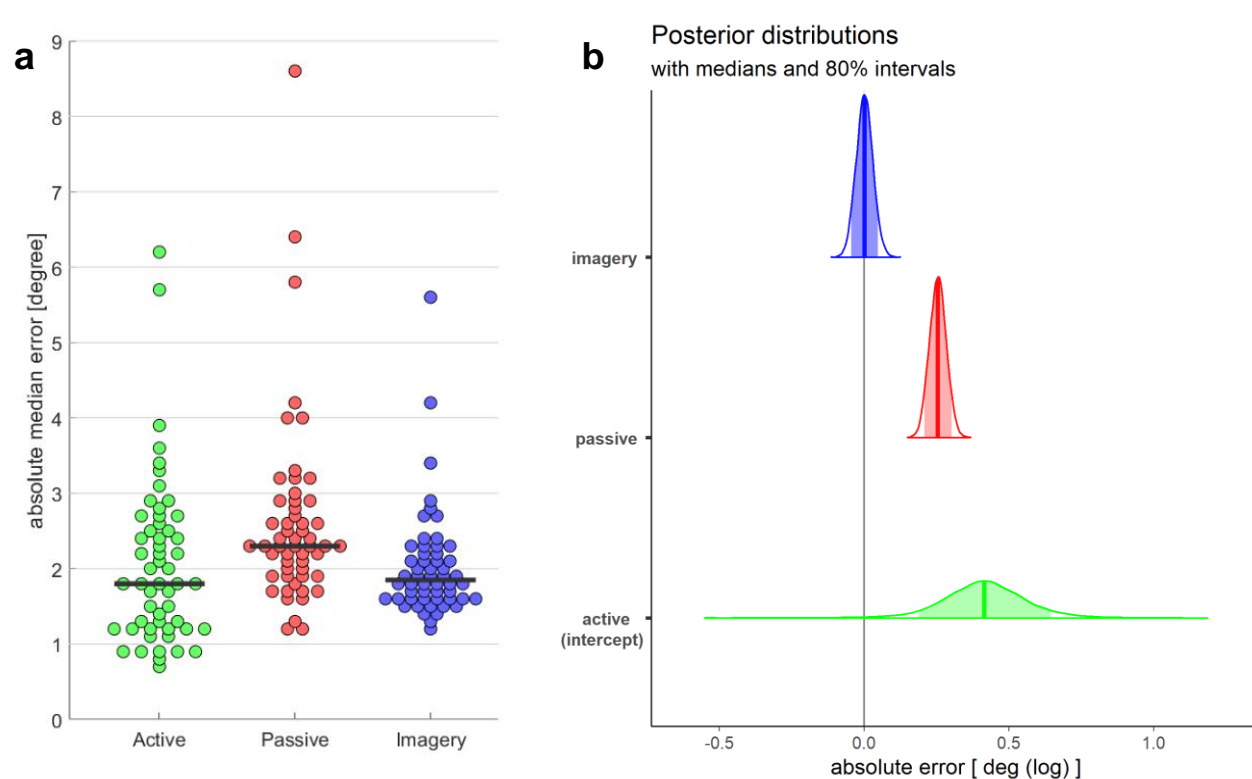
Methods

55 participants (39 female, 16 male, mean age: 22.4 years, SD: 3.4 years) were included in the study. Visual stimuli were presented via a VR-headset, equipped with accelerometers. Passive motions in the yaw plane were performed by a motion platform (a). Participants were asked to encode a target position in three different encoding conditions (*active*, *passive*, and *imagery*). The retrieval was always performed by an active head rotation and the positioning error was measured (b).

The experiment was implemented using PlatformCommander [4] and data were analyzed by Bayesian regression models.

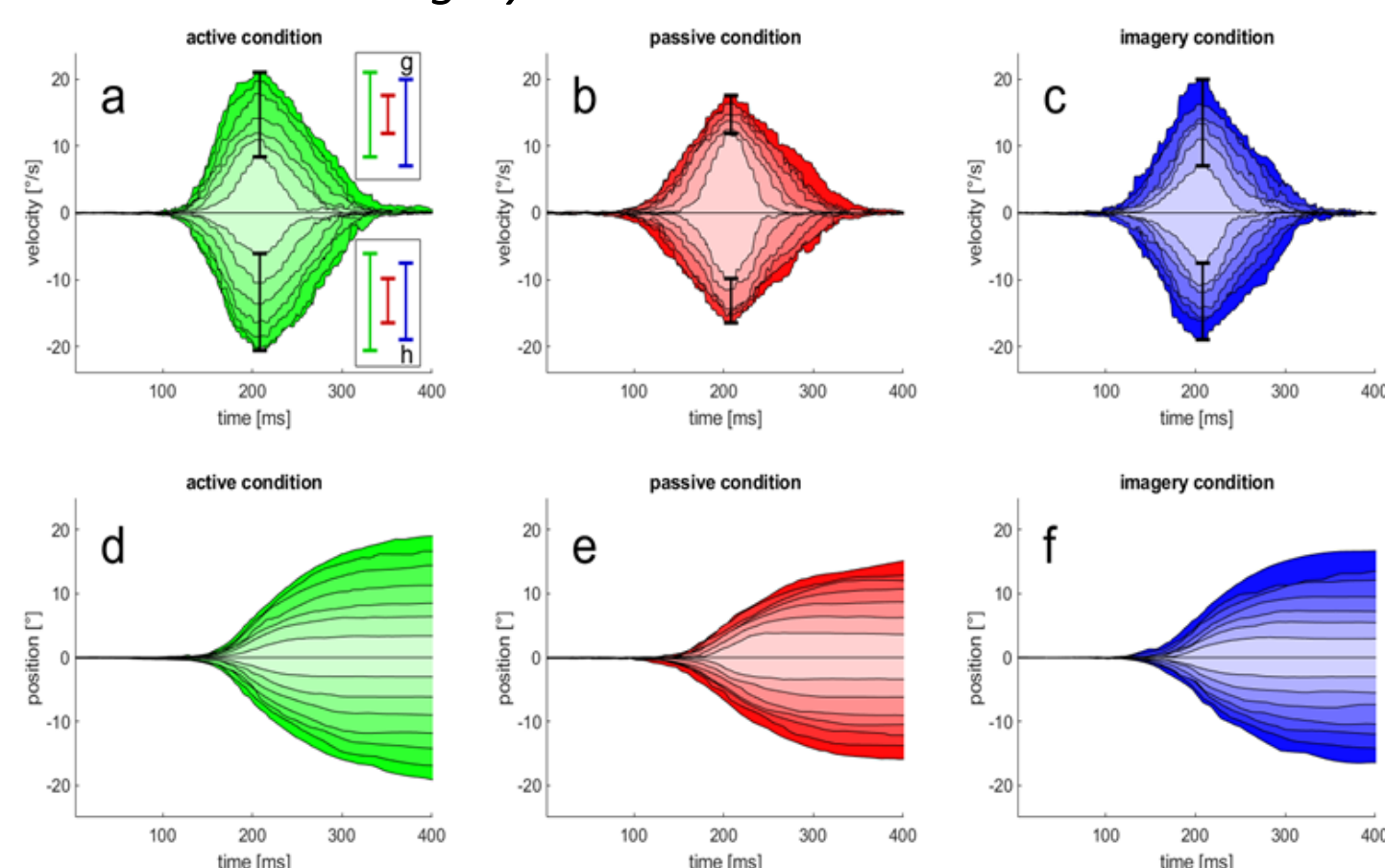


Results



Visualization of the absolute errors per condition (a). Each dot represents the average error of one participant. (b) Result of the Bayesian regression model. The 95% credible interval of the *passive* condition does not contain zero, indicating a meaningful difference compared to the *imagery* and *active* conditions.

Visualization of the head velocity (a-c) and the head position (d-f) over time. Peak velocities showed a reduced range (g,h) with larger peak velocities for small angles but smaller peak velocities for large target angles in the *passive* compared to the *active* and *imagery* condition.



Discussion

We have found that imagining a head rotation, without performing it during encoding, leads to similar performance as an actively performed head rotation and to better performance compared to the *passive* condition. In the *passive* condition, no motor commands are prepared and conveyed to the muscles, hence no efference copy is generated, and vestibular information is the only information related to self-motion. It has been theorized that during imagery sensory information is simulated internally by means of corollary discharge [4]. Our study provides first empirical evidence of a specific influence of corollary discharge on spatial memory. The most plausible explanation for the smaller variance in peak accelerations in *passive* condition is that the participants incorporated the velocity properties into their head rotations.

In a next step, we plan to study patients with vestibular disorders, which should show a more pronounced difference between passive and active states due to reduced or absent vestibular information.

References

- [1] F. W. Mast, N. Preuss, M. Hartmann, und L. Grabherr, „Spatial cognition, body representation and affective processes: the role of vestibular information beyond ocular reflexes and control of posture“, *Frontiers in Integrative Neuroscience*, Bd. 8, Nr. May, S. 1–14, 2014, doi: 10.3389/fnint.2014.00044 [2] T. Brandt, M. Strupp, und M. Dieterich, „Towards a concept of disorders of “higher vestibular function”“, *Frontiers in integrative neuroscience*, Bd. 8, Nr. June, S. 1–8, 2014, doi: 10.3389/fnint.2014.00047. [3] K. Kiltner, B. J. Andersson, C. Houborg, und H. H. Ehrsson, „Motor imagery involves predicting the sensory consequences of the imagined movement“, *Nat Commun*, Bd. 9, Nr. 1, S. 1617, 24 2018, doi: 10.1038/s41467-018-03989-0. [4] M. Ertl, C. Prell, D. C. Fitze, G. Wyssen, und F. W. Mast, „PlatformCommander — An open source software for an easy integration of motion platforms in research laboratories“, *SoftwareX*, Bd. 17, S. 100945, Jan. 2022, doi: 10.1016/j.softx.2021.100945. [5] D. Subramanian, A. Alers, und M. A. Sommer, „Corollary Discharge for Action and Cognition“, *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging*, S. 1–9, 2019, doi: 10.1016/j.bpsc.2019.05.010.

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