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Effect of vestibular stimulation by rotation on motor activity rhythm

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Background

The vestibular system is responsible for detection of angular and linear head accelerations/decelerations. It is strongly stimulated during periods of motor activity. Recent literature raises the hypothesis that vestibular afferents could influence the circadian timing system.

Anatomical evidence was provided in rodents (Horowitz et al., 2004; 2005). The loss of vestibular functions in animals and in humans with bilateral vestibular loss also caused circadian rhythms changes (Martin et al., 2015; 2016).

In humans, vestibular stimulation by swinging in a rocking bed demonstrated an accelerated effect in the wake/sleep transition and highlighted sleep consolidation during napping (Bayer et al. 2011).

The present study test the impact of vestibular stimulation induced by a rotatory chair on the motor activity rhythm in human.

Discussion

The main results demonstrated a decrease of the average activity level measured after vestibular stimulation comparing to the SHAM condition. We assume that the relaxing effect of vestibular stimulation could explain the decrease of activity level following the stimulation. The increased symptoms of motion sickness caused by vestibular stimulation represent an alternative explanation to the decrease of activity level.

In addition, it revealed a significant phase advance on the second day after the vestibular stimulation session has been done.

The marked phase advance following late afternoon vestibular stimulation supports the hypothesis about the potential effect of vestibular stimulation on circadian rhythms and its implication in the modulation of circadian rhythms, which can be considered as partially responsible for the effects of physical activity on biological rhythmicity (Buxton et al. 2003).

Method

34 participants were recruited. They underwent two experimental sessions (SHAM, STIMULATION) in a counterbalanced order. During the SHAM session the rotatory chair didn't move and was not tilted to avoid any vestibular stimulation. Parameters of the stimulation session on the rotatory chair are presented in the Figure 1.

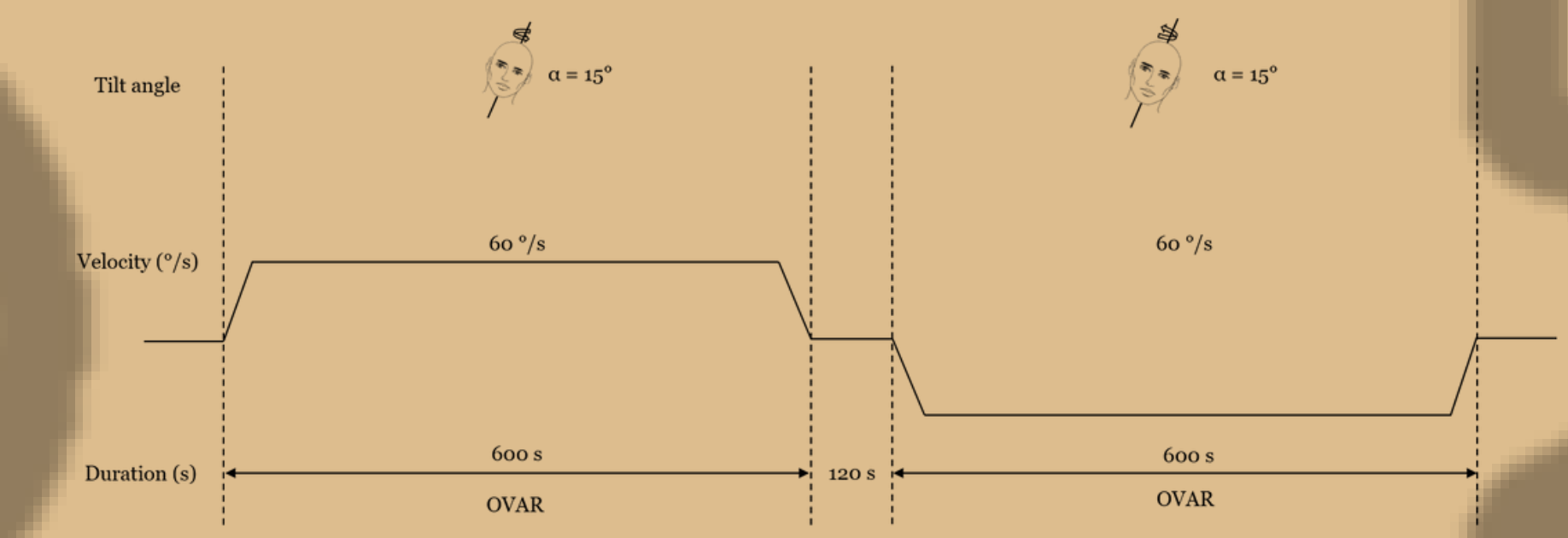


Figure 1: Parameters of the Off Vertical Axis Rotation during the vestibular stimulation.

Actigraphy was measured continuously one week before the first session (BASELINE), the week between the first and second sessions, and one week after the second session. Each subject completed a Graybiel scale (Graybiel et al., 1968) before (pre-tests) and after (post-tests) each session to evaluate motion sickness symptoms. Measures were repeated at post-tests +1h, +2h, +24h, +48h.

Statistical analysis
 We performed multifactorial non-parametric analyses of variance for repeated measures. Concerning the rest/activity rhythm a cosinor analysis was executed.

Objective

- 1) Assess the tolerability of the stimulation protocol in relation to the level of motion sickness symptoms.
- 2) Evaluate the impact of the stimulation on the rest/activity rhythm.



Result

Motor activity

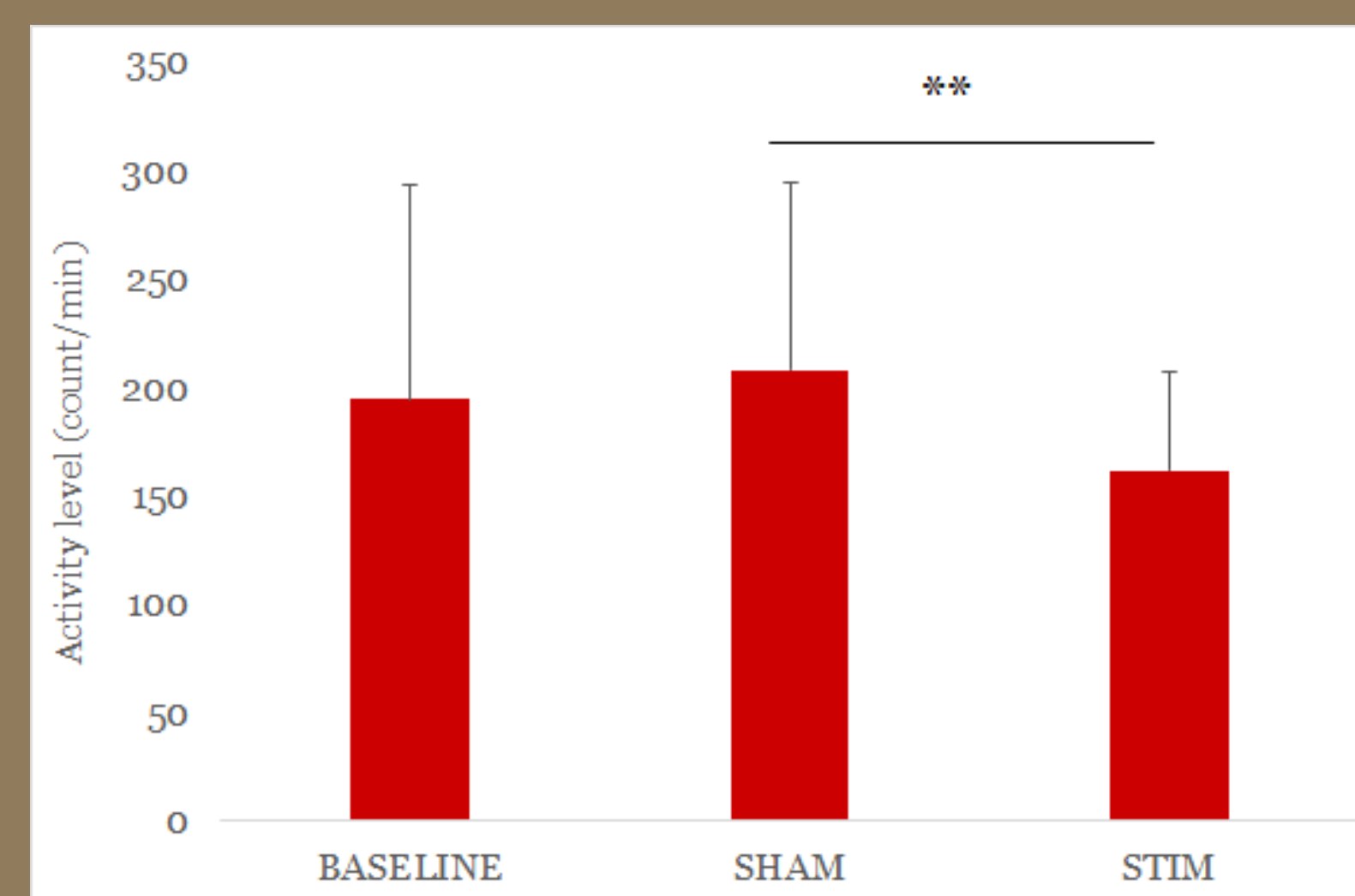


Figure 2: Average activity level (score ± SD) for the three conditions (BASELINE, SHAM, STIM). ** p < 0.01.

→ Decrease of motor activity

Cosinor

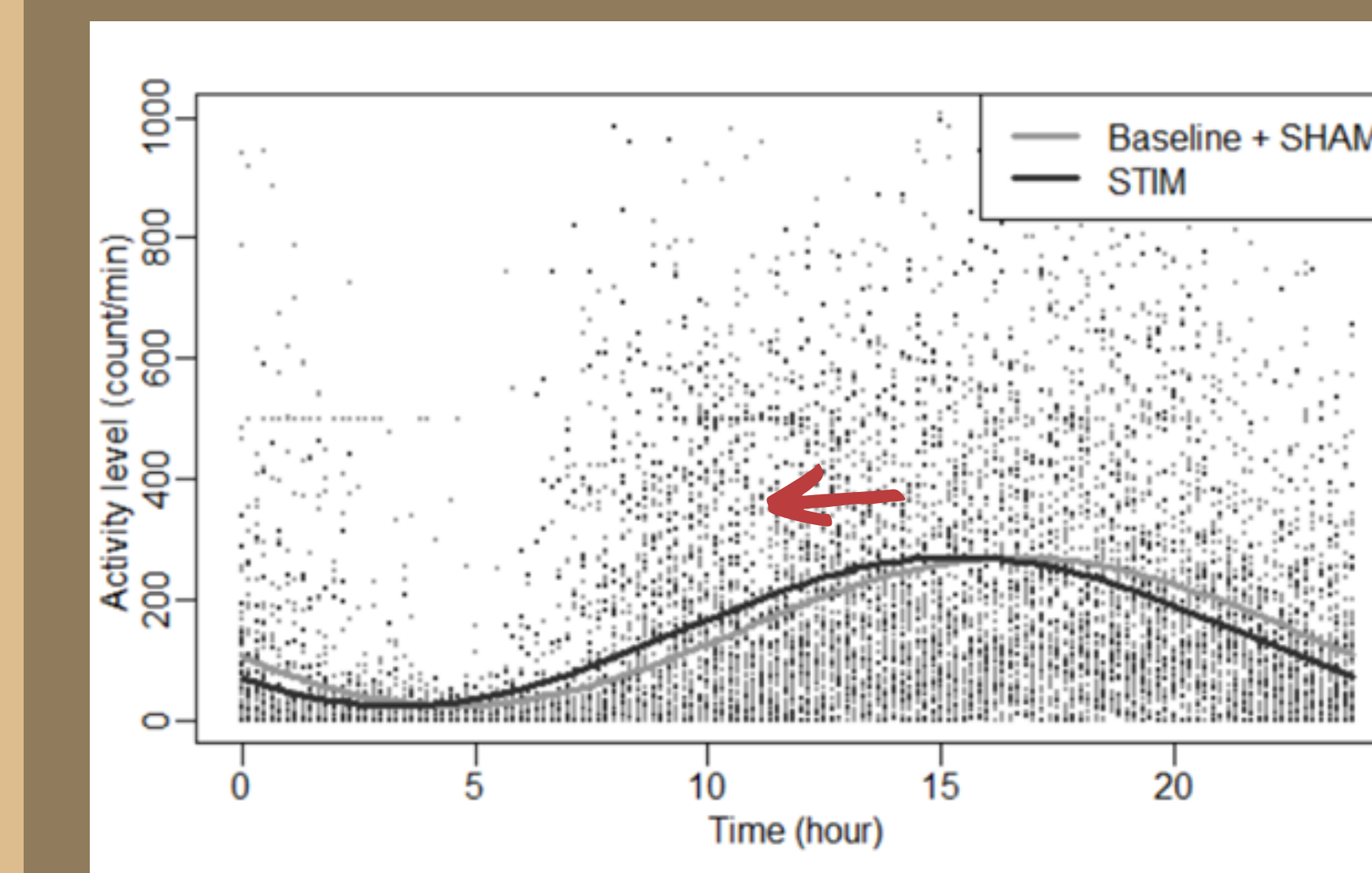


Figure 3: Rest/activity cosinor curves for STIM (black) and (BASELINE + SHAM) (grey) conditions. A significant phase advance (1.15 h) is observed in the STIM condition (3:22 p.m.), compared to (BASELINE + SHAM) (4:37 p.m.). Mesor (146.59 ± 3.89) and amplitude (123.31 ± 5.48) did not differ in the three conditions.

→ Advanced phase effect

Motion sickness symptoms

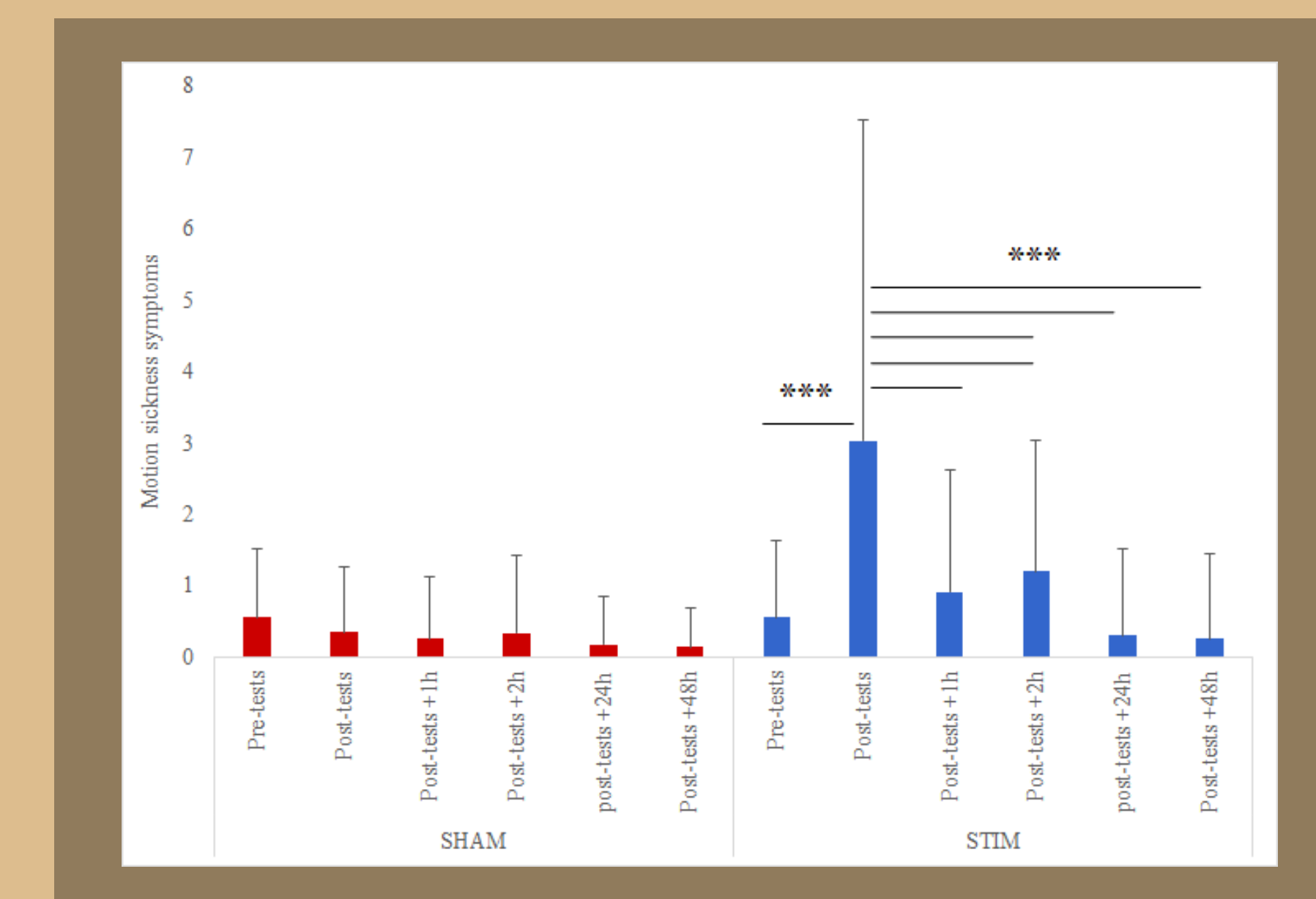


Figure 4: Mean motion sickness level (score ± SD) for SHAM and STIM sessions for pre-tests, and post-tests (+1h, +2h, +24h, +48h) measures. *** p < 0.001.

→ Increase of motion sickness symptoms