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Inter-hemispheric control of vestibular thresholds

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Inter-hemispheric competition

Dear Editor,

Neural mechanisms underpinning vestibular-cortical control are suggested to be subject to inter-hemispheric interactions, which can subsequently influence both low and higher-order vestibular functions [1]. However, it remains unknown whether inter-hemispheric interactions can influence either vestibulo-ocular (VO) or vestibulo-perceptual (VP) thresholds. Accordingly, to investigate whether individual differences in hemispheric dominance influence VO and VP thresholds, we correlated an objective biomarker of hemispheric dominance with the degree of change exerted over VO and VP thresholds following alterations in cortical excitability. Quantification of the hemispheric dominance required calculation of the degree of vestibular-nystagmus suppression in response to targeted application of trans-cranial Direct Current Stimulation (tDCS) over the posterior parietal cortex (PPC) [2], a key area implicated in vestibular-cortical processing [3,4].

Thirty four right-handed subjects (17 male, mean age 24.7, range 19–33) were recruited, following screening for any brain-stimulation contraindications or any neurologic, ophthalmological, psychiatric and otological disorder. Subjects provided informed, written consent. Stimulation was applied with a direct-current of 1.5mA for 15min using a battery-driven stimulator (neuroConn GMBH, Ilmenau, Germany) with a ramp-up time and a fade-out period of 10s. Seventeen subjects received cathodal stimulation (test group), whilst the remaining seventeen received anodal stimulation (control condition). Stimulation was always applied over the left PPC (P3 international 10–20 EEG system, Electrode Size 25cm^2), with the reference electrode always placed over the ipsilateral deltoid muscle [5–7].

To determine hemispheric dominance, we implemented our validated, objective biomarker, which involves applying cathodal tDCS to the left PPC, and assessing it's effect upon vestibular nystagmus suppression in response to cold-water(30 °C) caloric irrigations [2]. For vestibular stimulation, subjects lay supine on a couch, with their head angled up at 30° to allow maximum activation of the horizontal semi-circular canals. Irrigations were performed in each ear for 40 seconds with a flow-rate of 500 ml/min (CHARTR VNG; ICS medical). Resulting eye movements were recorded for 2 minutes using a head-mounted infra-red binocular video-oculography system. Eye movements were automatically analysed to determine the peak slow-phase velocity (SPV) of the resultant vestibular-nystagmus. Calculation of the percentage change in peak SPV following stimulation provides the Nystagmus Suppression Index (NSI), with larger suppression reflecting greater right hemisphere dominance [2].

We assessed vestibular thresholds by seating participants on a motorised, vibration-free, rotating chair (Contravez Goerz, Pittsburgh, Pennsylvania, USA) (Fig. 1A). Rotations commenced with an initial velocity of 0.3°/s and accelerated incrementally by 0.3°/s^2 until participants perceived the rotation. 6 randomised rotations (left and right) were performed in complete darkness, whilst white masking-noise was amplified through speakers [8]. A 1 minute break with the light switched on was provided following each rotation to eliminate any carry-over effects from the previous rotation. Each participant was given a button press, in which the right and left button corresponded to the respective direction of rotation. Participants were instructed to push the appropriate button as soon as they perceived the rotation-direction. Time taken from the onset of chair rotation to the participant's button press provided the VP thresholds. We simultaneously recorded eye movements using electro-oculography (Sampling Rate 250Hz). VO Thresholds were calculated by identifying the first nystagmic beat following the onset of chair rotation using in-house Software (Analysis-Mr. D. Buckwell). Thresholds were measured before and after tDCS [8].

Firstly, we observed that cathodal stimulation over the left PPC suppressed vestibular nystagmus following both right and left-ear cold irrigations (ANOVA, $F[1,16]=19.8$, $p < 0.001$). Anodal stimulation, as expected, did not induce any significant change ($p > 0.05$). With respect to vestibular thresholds, VO thresholds

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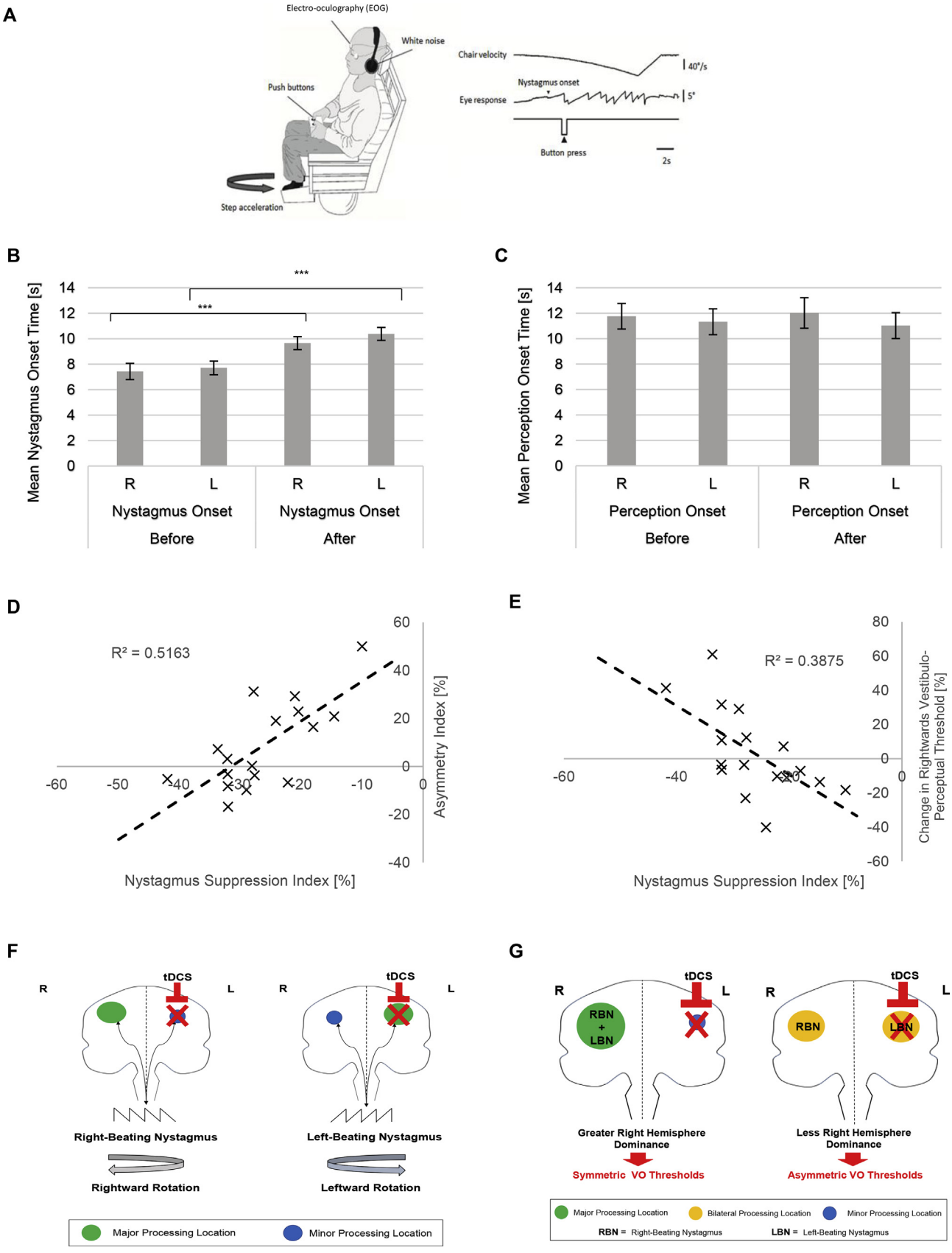

Fig. 1. A: Methodology and associated Analysis. Left panel illustrates a participant seated in the motorised, vibration-free, rotating chair fitted with a button press and Electro-oculography (EOG). Speakers delivered amplified white noise. Rotations occurred in both right and leftwards directions in complete darkness. Right Panel shows analysis of both VO and VP Thresholds. VO thresholds reflect the time taken from the beginning of chair rotation to the first nystagmic beat, whilst VP thresholds reflect the time taken until the participant pressed the direction-corresponding button.