Ganesh Arvapalli

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Dr. Russell Taylor, Ehsan Azimi

Seminar Paper Critical Review - Transcranial Magnetic Stimulation (TMS) of the Supramarginal Gyrus: A Window to Perception of Upright

Project Overview:

Transcranial Magnetic Stimulation (TMS) can be used for the inhibition of cortical brain activity for a variety of experimental setups. An example of TMS usage is in the case of assessment of the subjective visual vertical (SVV). Cortical supramarginal gyrus (SMGp) inhibition through TMS has been proposed as a way of measuring the impact this area of the brain has on eye torsion, however this can be a labor-intensive process. This project aims to automate TMS for specified regions of the brain using a robotic tool in hopes that mapping brain activity will be simplified. The project will include a force-feedback component to prevent TMS application from causing injury to subjects and integrate a visualization environment to help track the experiment in real-time.

Paper Selection:

The paper, "Transcranial Magnetic Stimulation (TMS) of the Supramarginal Gyrus: A Window to Perception of Upright," was chosen for its relevancy towards all foundational aspects of this experiment. A citation for the paper is provided in the references at the end of this review. [1] A description of TMS procedures, the SVV, and the SMGp are all presented in an understandable format as well as an outline for the need of a robotic tool to automate TMS application. Consequently, the durations of TMS application as well as the specific sites being studied are discussed in the paper, which is useful towards the implementation of this project.

Problem and Key Results:

Perception of what is considered "upright" depends on a multitude of factors but is primarily related to vestibular feedback, concerning balance and the relationship of the head to ground. These factors affect our spatial orientation significantly, which is measured through a test called the subjective visual vertical (SVV). SVV assessment methods vary but one cortical region of importance is the supramarginal gyrus (SMGp). The pathway behind SVV perception and the SMGp is in the process of being elucidated, but there may potentially be a link between the SMGp and eye torsion, which is known to affect SVV. The primary results of this experiment were the fact that the SMGp was significantly linked to changed SVV, with a left head tilt causing a $+2.7^{o}$ deviation to the right and a right head tilt causing a deviation of -3.6^{o} to the left. This suggests that our spatial reference frames rely on the integration of several vestibular and visual inputs that can be altered through TMS.

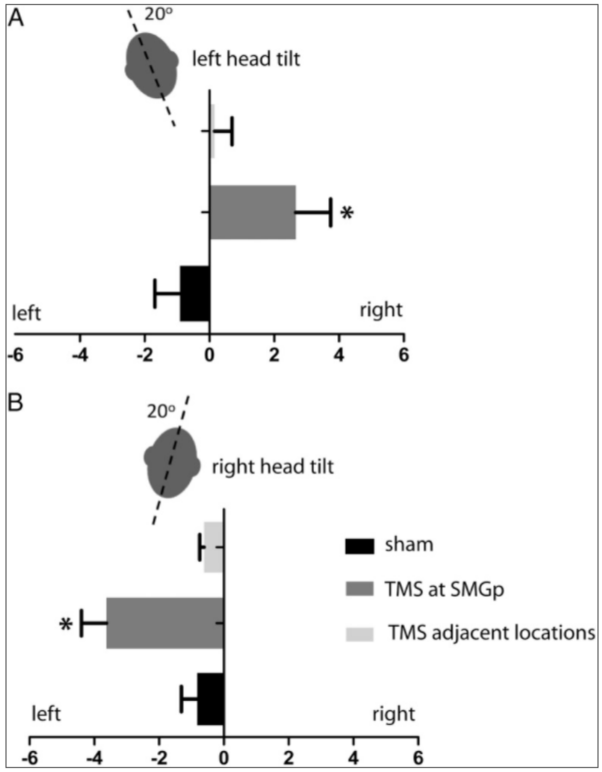

Figure 1. The two graphs show the significance of the impact of TMS application on the SVV for different head tilts

Background:

Spatial orientation and navigation are highly dependent on vestibular inputs alongside visual information. Vestibular input integration appears to be linked to regions in the right hemisphere of the brain, including the superior temporal gyrus and the inferior parietal lobule. One specific area of the latter, the supramarginal gyrus (SMGp) has been studied regarding its relationship to vestibular feedback through functional neuroimaging studies and behavior analysis following cortical lesions in the area. However, not all functional roles in the aforementioned regions are known nor how information is processed in and between these areas. To assess the impact of changes in these regions, a test called the subjective visual vertical (SVV) is employed. SVV testing involves a subject identifying what they consider to be perpendicular to the ground ("earth vertical"). This vertical normally very stable, known as “orientation constancy,” but can be affected by the vestibular system, proprioception (determining relative head and body positions), and vision. Acknowledging this as the case, the activation or inhibition of related cortical regions is currently being explored to induce a measurable impact on vestibular feedback. One approach is transcranial magnetic stimulation (TMS), in which magnetic fields are induced in targeted area, thereby stimulating or inhibiting parts of the brain. The specific method used in this study was continuous theta burst stimulation (cTBS), which is designed to decrease cortical activity. Thus, TMS was used to mimic lesions in the SMGp and the effects of its inhibition were investigated with regards to impact on the SVV.

Experiment and Methods:

There were two parts to this experiment that each required their own setup: SVV and TMS. The SVV setup involved projecting a laser against a screen approximately 1 meter away from subjects, whose heads were immobilized with bite bars. The laser was about 35 cm long and rotated between $\pm 16^o$ around the true earth vertical in 2^o increments. Subjects were presented with a dial through which they could judge the alignment of the laser by turning it match orientations. The degree to which the dial was to the right was weighted on a scale from 0 to 1, with 0.5 corresponding to perfectly straight. The experiment was presented as two sets of two blocks: one set before TMS was applied and one after with the two blocks going left to right and right to left. For the control group (called "sham"), no TMS was applied, but the procedure was simulated with a wooden block in between. This was repeated with the head tilted at various angles.

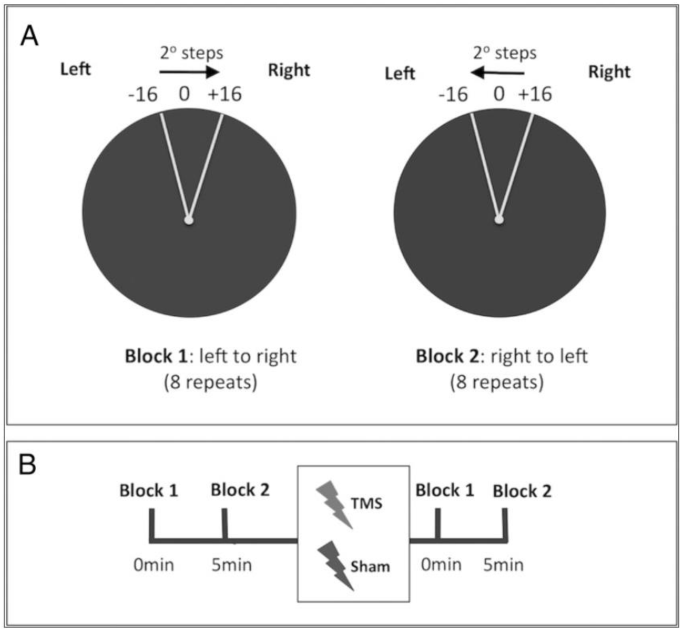

Figure 2. The experimental setup described in the paper involved two blocks before and after stimulation, each of which moved the laser either left to right or right to left.

The TMS procedure was performed with a MagStim Rapid2 figure-eight coil place tangent to the head at the area of interest. The method of cTBS was presented as 200 bursts of 3 pulses at 50 Hz over 40 seconds. To avoid discomfort from noise, subjects were given ear plugs. Data collected was analyzed for the head tilt conditions using a one-way ANOVA test.

Assessment:

The paper successfully demonstrated the usefulness of TMS in studying the impact of inhibition of vestibular pathway cortical elements on SVV. The SMGp was related to eye torsion, a feature that could be investigated in future experiments and will be investigated in this project. The paper provided useful information on experimental setup, including the necessity of the coil being tangent to the head, the coil model used, and the procedure of TMS application. A few drawbacks of the paper were that there were too few subjects and that the method of zeroing the pre-TMS SVV was not explicitly stated. There are could have been a little more data analysis and graphs, another aspect that could be automated in the future. On the other hand, the paper provided a clear description of the experimental setup, which was useful to this project and the effects of SMGp inhibition were clearly demonstrated. The vestibular information processing pathway was well researched and explained in such a way that someone with very little experience in the field could understand it. The paper mentioned that future experiments could potentially produce a functional map of the SMGp and track eye torsion to account for it. These procedures could also be repeated on the left cerebral hemisphere.

References:

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3. Pereira, C. B., Kanashiro, A. K., Maia, F. M., & Barbosa, E. R. (2014). Correlation of impaired subjective visual vertical and postural instability in Parkinson's disease. Journal of the Neurological Sciences, 346(1–2), 60–65. https://doi.org/10.1016/j.jns.2014.07.057