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Comparing the Focality across Non-Invasive Brain Stimulation Techniques

Non-Invasive Brain Stimulation (NIBS) can become a powerful and widely used tool in the clinic, research labs, and homes due to its safety and ease-of-use; also with the Transcranial Electrical Stimulation (TES) types being inexpensive. These techniques are important to study because we are manipulating the most fundamental element of the brain. We have the possibility to treat virtually every neurological disease or mental illness. However, there are many types of NIBS, with each one's advantages being unclear due to the poorly understood underlying mechanisms. We simulated NIBS with computational physic solvers in reconstructed head model to study the resultant electric fields, which is what neurons are sensitive to. To select the best type of NIBS, we compared between the conventional transcranial Electrical Stimulation (tES), which uses one pair of electrodes, injecting current directly over the region of interest with a return electrode a distance away; Temporal Interference(TI) Stimulation, which uses two pairs of electrodes, one injects current of slightly higher frequency than the other that causes a maximum of the frequency difference (beat) near the midline of the two pairs; and Transcranial Magnetic Stimulation(TMS), which uses alternating magnetic fields generated from superconducting coils to induce electric fields via eddy currents underneath the coils. We measured the parameters Dhalf, Vhalf, and Spread. Dhalf is the distance from the electrode surface at which the electric field is half it's maximum. Vhalf is the volume of stimulated medium that contains an electric field that is larger than half the maximum electric field. Spread is Vhalf divided by Dhalf. Therefore, to find the most focal NIBS, we want the technique with the smallest Spread and largest Dhalf. We show the conventional TES approach is significantly less focal than the other two methods. Also, for large Dhalfs, TI outperforms over TMS. However, the required current that's necessary for TI may be a limitation. This study shows that TI may have the greatest potential to target brain regions with the most precision both near the surface and deep in the brain.