Precision with neuromodulation in neuropsychiatric disorder

Sagarika Bhattacharje

Department of Neurophysiology, National Institute of Mental Health & Neurosciences NIMHANS, Bengaluru 560029, India

ABSTRACT

With the advancement of newer techniques of neuromodulation and neuroimaging, interindividual variability in the treatment response has surfaced as a major challenge. The present presentation will discuss how neuroimaging and mathematical modelling can help us solve such puzzles. For, complex problems like selective stimulation of dorsal and ventral network of cognitive behavior like reading that exist in close vicinity can be addressed by prior computational simulation. Structural T1 scans can be utilized to simulate the optimal electrode positions of brain stimulation technique like transcranial direct current stimulation (tDCS). This is published as a toolbox to be used by the scientific community named "SATA". Using the SATA customized montages in an experiment, it was found that network specific improvement in reading behavior is possible following brain stimulation. However, the improvement dependents on an individual's baseline proficiency and there is significant inter-individual variability in the magnitude of improvement. Such variability could be result of interindividual variability in brain morphometry thereby causing variable current reaching the target region. Publicly available neuroimaging big data set was used to investigate this hypothesis. It was found that as the person ages, gender plays an important role in determining the spread of current at the desired brain region, and this is primarily mediated by degree of brain atrophy and shift in midline torque. So, the existing strategy of using same dosage for all individual or a "one size fits all" strategy of might not be adequate. To obtain an optimal benefit, there is an increasing demand for customizing brain stimulation parameters according to individual needs. So again, a toolbox was developed so that adequate dosage and electrode positions could be determined based on individual anatomy of an individual. Using neuroimaging, it was also shown that the location of CSF pockets in the brain relative to the placement of tDCS electrodes on the scalp influences the focality of tDCS current in the target region.-CSF pockets that are in the path between target and reference electrodes, and that are close to the target, tend to direct current into the target region, so individuals with greater amounts of CSF in those pockets show greater tDCS focality in the target region. In contrast, CSF pockets that are closer to the reference electrode and farther from the target will flux most of the current towards the distant reference electrode, so individuals with greater amounts of CSF in those pockets show reduced tDCS focality in the target region. Such findings are beneficial in designing any treatment protocol for patients using neuromodulation. Neuroimaging guided neuromodulation can be very helpful in not only identifying brain networks underlying the disease process but also the compensatory ways by which neuroplasticity could be leveraged to benefit cognitive impairment in patient. The stimulation of functionally intact network might fetch more results where there is room for improvement, rather than stimulating a damaged network. Inspired by this, a collaborative project shows that when the frontostriatial network is dissociated in OCD patients, a compensatory occipital-cerebellar network is developed that correlate with the disease severity score. Such networks could be the potential targets for brain stimulation and decreasing the disease severity. Such works with neuroimaging are especially important to direct the clinicians in exploring different neuromodulation sites and parameter so that the desired benefits could be achieved for the patient.