A Ray of Light Could Be the Answer to How the Brain Recovers From an Insult

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Imagine one day while you are at a restaurant,in front of your favorite dish and suddenly, you are unable to pick the fork using your fingers.You feel confused, you are unable to speak and convey your plight; this is exactly how an individual having a stroke would feel like. Stroke is not a medical jargon anymore and almost everyone knows someone or the other who may have been affected by it at some point in time. Globally, stroke is the second most common cause for death. Within India itself, it was found that 1.8 million people suffer from stroke every year. To describe the disease very simply, it is a brain attack or an insult that causes cell death in the brain due to lack of blood flow. Thisis caused mainly due to a blockage in blood supply (ischemic stroke) or due to bleeding (hemorrhage). This severely limits the amount of oxygen the cells in the brain receiveand within no time, causes brain damage in the affected regions. Due to the complications that stroke causes within seconds of its onset, quick hospitalization, timely diagnosis, rapid treatment and thorough medical intervention are necessary for effective recovery.

The victims from stroke are prone to have varied impairments which seriously affect one's quality of life if necessary rehabilitative measures are not taken. Post-stroke recovery is an area of utmost significance in clinical neurology as it helps promote the growth of new connections in the surviving neurons, or in a broader sense helps brain to relearn its lost functions. Understandingthis phenomenon in the brain is of great importance to enhance the speedy recovery of the patients.

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To study brain functions, generally, the medical community relies on the functional MRI (fMRI) for brain scans. The difference between an MRI and fMRI is that, in the latter specific tasks are administered which are performed during the scan. So, there is a prerequisite to be able to perform such movement tasks(motor) of the hands and legs(this seldom happens in case of stroke patients as lesion in the motor cortex leads to paralysis in the limbs). The whole scan procedure may be a tiresome experience for the stroke survivor. So, it was contemplated on whether there is a possibility to simplify this procedure and get the best out of the patients? This led to the search for something new and a new imaging modality called functional near infrared spectroscopy (fNIRS) came into focus. This instrument, which utilizes optics, has the ability to detect brain signals while performing the motor tasks. It uses near infrared light of specific wavelength to probe the brain and when tasks are performed the change in blood, flowing through specific areas in brain, is detected from the light returning from the intracellular regions of the brain. Though the deeper brain regions are not intrigued upon, peripheral cortical brain areas are well lit up with fNIRS and signals are collected with good quality. This makes it a pertinent and useful tool for analysing the motor cortex of the brain that are targeted disruption sites of motor aphasia.

With this in mind, the area that I focused on in my research puts stress on understanding the post-stroke recovery, particularly to study the inter- and intra-functional connections within the motor cortex. For the identification of the affected areas, I decided to utilize fNIRS. The choice of modality for the research was taken after some considerations being:

It reduced the trauma certain patients faced while they were asked to lie down inside the MRI machine (claustrophobic patients, etc.)

It reduced the errors caused in the image due to head movement either voluntarily or involuntarily produced

Being highly portable, the device could be moved depending on the needs of the patients (geriatric patients, ICU, etc.)

Being non-invasive.

When NIR light is made to illuminate the brain, it penetrates the skull owing to its wavelength range and reaches the brain tissue.The task performed during the scan is reflected in the brain tissue of respective regions and, in turn, the metabolic demand of the region is increased. To cater to this demand, the flow of blood to this region is increased and more oxygen is supplied. The amount of oxygen in the blood changes its optical properties and this can be reflected in the NIR light coming back or reflecting from the brain tissue. The principle of spectroscopy is utilized here: themeasuring and interpreting of electromagnetic radiation (here it is light)that is absorbed or emitted by atoms of the samplebeing used (sample here is blood). This absorption or emission happens when the atoms of the sample move from one energy state to another in the presence of light. To state more simply, it is a science to study how light interacts with matter.Spectroscopy is used here to quantify the relative change in the oxygenated and deoxygenated haemoglobin during the task from the steady state.

In a normal individual who is right-handed, it was observed that the study yielded true findings to the fact that motor cortex in the left hemisphere of the brain is activated when the

person moves the righthand and vice-verse. But, stroke can alter this pattern and with the advent of modern imaging modalities, researchers have come out with multimodality approaches like functional Magnetic Resonance Imaging (fMRI), Electroencephalogram (EEG), Trans-cranial Magnetic Stimulation (TMS), Diffusion Tensor Imaging(DTI), etc. to apprehend the mechanism behind it.

Though we have been taught from childhood that the brain stops growing/learning after an age, this understanding has become quaint in the recent years with the theory of plasticity.This applies to the case of stroke recovery as well where the brain tries to relearn the lost functions with the help of different intervention strategies.Also, the concept of functional connectivity explains that the activities in the brain are a result of the integration of different brain regions which form networks through their correlated actions. Thus, a hypothesis could be made that there will be new functional network connections (plasticity of brain) involved in the recovery phase after stroke. Twenty healthy volunteers and twenty stroke patients were recruited for this study. The research team included radiologists and neurologists specialized in stroke treatment.

The whole idea of studying the brain network connections during stroke recovery is to aid bigger initiative of patient-specific interventions. Brain Computer Interfaces (BCI) is one such intervention. BCI, also known asmind-machine interface, facilitates direct communication between brain and an external device. The application of BCI could help in the recovery and rehab of the survivors. For example, the Functional Electrical Stimulation (FES), as a tool can be used as a rehabilitation technique to restore lost or damaged functions. This is the prime obsession which motivated me to address the challenges in relatively less studied area of post-stroke aphasia. The promising outcome from the study as well as thepotential of BCI clubbed with the effectiveness of the tool keeps on fuelling me to contribute further in the domain through active research interventions. The potential of the tool/technique is massive; a stroke survivor with a paretic arm can be trained using a technique in which the brain can relearn to use the arm by externally triggering muscle stimulation. This could bedone by initiating neuro feedback mechanism with the help of fNIRS-based BCI, where the fNIRS detects brain signals corresponding to limb movement. This classified signal can be sent back to the body in the form of muscle stimulation from FES. Through further research, it may eventually lead to the discovery that a ray of light could truly be the answer to all our questions.