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# Application of Neurofeedback on Gilles de la Tourette Syndrome

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## ABSTRACT

Tourette's syndrome is a neurological disorder which comprises of vocal and motor tics and adversely affect a patient's quality of life. It has no known cure. Neurofeedback is a process in which patients are able to see data from their brain and respectively manipulate their actions to achieve the desired output. As success has been shown in using neurofeedback to manage symptoms of other neurological disorders, we chose to conduct research, outlined in this review, on its application in Tourette's. Using MATLAB, we created a neurofeedback system that chose data from certain electrodes in the patient's brain, filtered it and displayed it back to the patient in a comprehensible and visually appealing manner. We hope that this will provide a basis for clinicians to adopt this treatment in a widespread manner to help increase the quality of life in patients with Tourette's.

## Introduction

Tourette's syndrome (TS) or Gilles de la Tourette syndrome is a neuropsychiatric disorder which affects the nervous system and causes unwanted and involuntary movements and sounds known as 'tics' which are extremely difficult to control. (1) This condition affects nearly 1.4 million people in the United States alone, and about 1 in 50 children in the world. (2) The tics or symptoms of the disorder typically appear at around ages 5 through 17 and are more prominent in men than women. (3) There are two types of tics, motor and vocal, both of which could be either simple or complex. These tics are debilitating to a person's life. From childhood, people with this condition face extreme bullying and discrimination which can destabilize their lives. They have less access to opportunities and their condition doesn't make them an ideal candidate for basic life milestones such as going to college or getting job (4).

Neurofeedback is a noninvasive approach that teaches the self-control of brain functions to people by measuring their brainwaves and giving the patient feedback about how their brain works. This is not a new approach, and it has been used to study other neurological disorders such as Attention-Deficit/ Hyperactivity Disorder (ADHD), Autism Spectrum Disorders, Insomnia, drug addiction, schizophrenia and more. In most cases, the electroencephalography (EEG) of a patient is recorded through the treatment and its components are shown to the patient so that the patient can learn to manipulate their behaviors based on the data. The components can be extracted and shown in many different forms. (5)

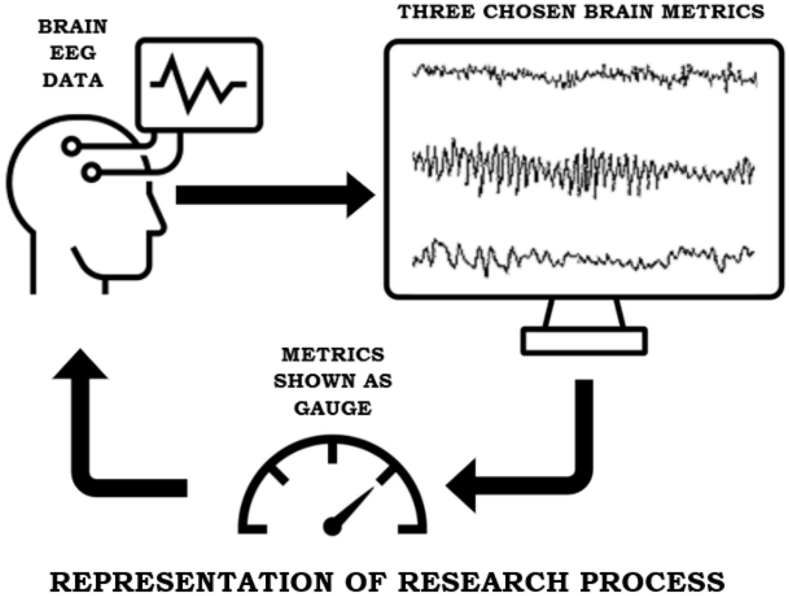


**Figure 1.** Pictorial representation of research process. The toolbox extracts EG signals from adequately positioned electrodes to extract three known brain signals. It extracts metrics and recombines them into one signal with variable contribution of the three and represents that.

As neurofeedback can be used to reduce symptoms of anxiety or mediate symptoms of other neurological or psychological disorders, it can also be applied to diagnose, treat, and make the lives of people with Tourette's easier. Studies have investigated the effectiveness of neurofeedback systems for the treatment of Tourette's. More specifically, they have investigated the use of the theta-beta ratio for the treatment. Preliminary work indicates this could be valuable, however calibrating these components can be difficult and their effectiveness in isolation is very limited. Combinatorial approaches have not been thoroughly explored in neurofeedback systems to date but could benefit a condition such as Tourette's where several feedback components seem to have an impact. We sought to develop a toolbox able to extract and calculate the components from the EEG data and deliver them in an easy to control way as a neurofeedback system.

## Methods

The idea of this research sprung forth from my interest in neuroscience, specifically Tourette's syndrome and computer science. Tourette's has no known cure like many neuropsychological disorders such as ADHD or anxiety. As neurofeedback has helped make lives of these patients more bearable, one for patients with Tourette's would be beneficial.

To create a functioning neurofeedback system, we used MATLAB, a programming language, to develop the code and output for this system. First, we imported electroencephalogram (EEG) data from a patient in the likely range for developing symptoms of Tourette's because we did not have access to one with Tourette's. We wanted our system to be as accurate as possible. In this case, we used a fourteen-year-old male and imported the data in script form into MATLAB.

Based off other studies, we chose two electrodes, Cz and C3. These traces were filtered with a fourth order Butterworth bandpass filter from MATLAB at specific Hertz values corresponding to each band (Slow Cortical Potential (SCP) – 0.1-30, Beta – 12-30, Theta – 4-8, Sensorimotor Rhythm (SMR) – 0.5-45) so that the different frequency bands which impact Tourette's syndrome, theta, beta, SMR and SCP could be isolated. SCP, beta, theta and SMR were then plotted on four separate amplitude (voltage) over time (data points) graphs with the original trace in the background.

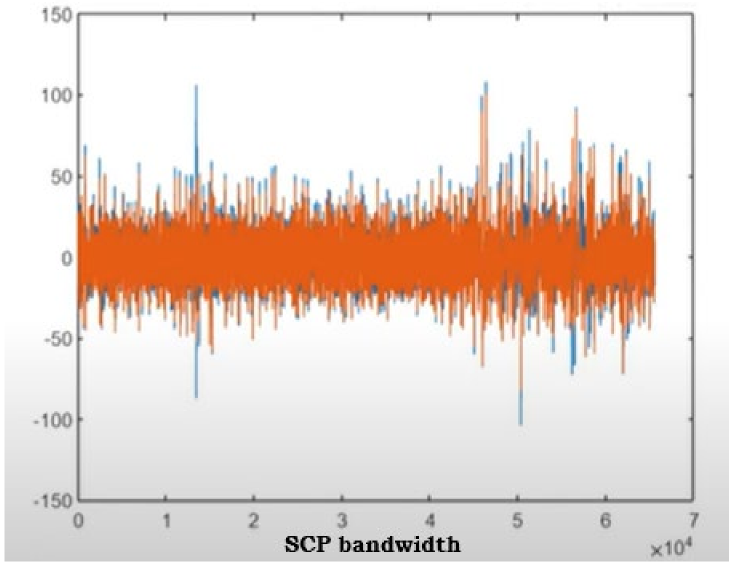


**Figure 2.** SCP bandwidth plotted over original trace. The orange data is the amplitude (voltage) over time (data points) of SCP and the blue data behind gives an idea of how the data changed after filtration. Same was done for theta, beta and SMR.

To make each value positive and get the average, we found the root mean square (RMS) of each value and took the rolling average of it to plot. The high values indicate lots of activity whereas lower values indicate more of a resting state. This data is plotted in graphs of amplitude (voltage) over time (seconds) throughout the process to see the progress being made as the neurofeedback system runs.

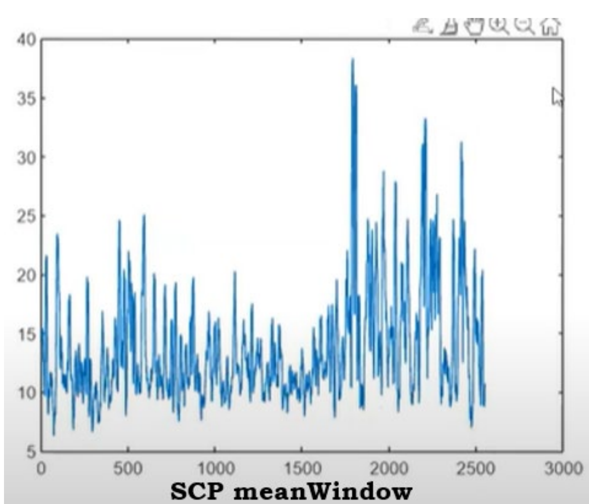


**Figure 3.** A plot which portrays the average of RMS values in amplitude over time. The higher values depict more activity in the brain while lower values represent less activity. Same is done for the SMR, theta and beta.

## Results

To provide the information in a format that would be easier for the clinician to read, we first needed to combine each of the components into one plot. In order to do so, we needed to normalize the data to make one plot.

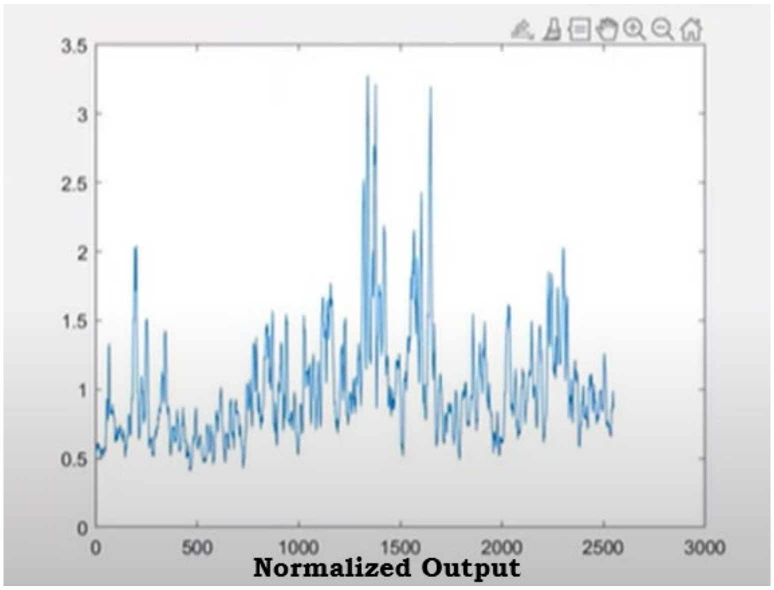


**Fig 4.** A graph of each of the bandwidths normalized and combined using the sample dataset.

Using the MATLAB gauge documentation, the previous data plot was transferred to an easy-to-read gauge for the patient to understand what the neurological effect of their actions was. In this scenario, a marker in the red signifies setback or a negative effect due to the patient's actions while the green portrays the opposite- a positive result. The values in the combined, normalized graph are converted into a value that will fluctuate on the gauge component. Based on watching this gauge, the patient can learn to manipulate their actions and behaviors to keep the hand of the gauge in the green zone.

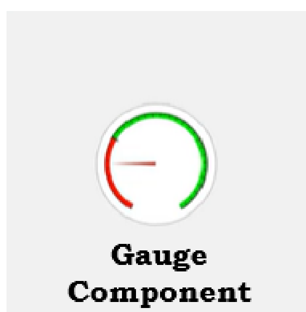


**Fig 5.** The sample gauge shows the marker in the red zone which indicates a negative result. The patient will then try to change their behaviors in order to move the marker back into the green zone.

## Discussion

In this work, we chose to use three different metrics to run our neurofeedback system: theta-beta ratio, SMR, and SCP. These different signals are extracted from different frequency bands from different electrodes. Their functional role remains unknown but they have been shown to have a useful correlation with brain function, in particular, in neurofeedback systems. They have been used in Tourette's neurofeedback systems as well as neurofeedback systems for ADHD, anxiety and depression. (6) Our approach to combine all of them in a variable format in an effort to provide greater flexibility for clinicians to tailor the therapy to individual patients is novel. Such a combinatorial approach has never been developed or tested in Tourette's or in the context of Tourette's but it has been tested in ADHD and other conditions which is why we chose this approach.

Our neurofeedback system, unlike others, is meant to be versatile and easy to understand. Our neurofeedback system gives the clinician the ability to input and modify values in order to provide a specialized therapy session for each individual patient. This allows a clinician to provide accurate feedback to many different patients based on the patient's brain rhythms. In addition, because Tourette's typically develops in childhood and adolescence (3), the results from the neurofeedback system are shown in an easy-to-read form, simple for these patients to understand- a gauge. The system allows for more personalized and effective treatment as it is tailored towards the target audience.

Although data was not extracted from an actual Tourette's patient, we chose data from a patient who would be most likely to develop the disorder. As Tourette's is mostly commonly developed in the male gender, aged 2-15 (3), we chose to extract data from a male patient at the age of fourteen-y ears-old. This ensures that the brain rhythms chosen would be accurate to most Tourette's patients.

## Conclusion

In this paper, we have developed a software tool to address symptoms of Tourette's syndrome via Neurofeedback. Neurofeedback has been shown to help negate the symptoms of other neuropsychological disorders in patients. Thus, the purpose of this work was to develop a similar system for Tourette's syndrome as the disorder is currently uncurable and the symptoms can cripple people for life. Our neurofeedback system takes EEG data from the patient's brain and feeds it back to them in the form of a gauge so that the patient can see the result of their involuntary behaviors. This, like other neurofeedback systems, will allow the patient to attempt to reduce the impacts of the disorder on their lives.

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