Outline of Proposed Research

Brain-computer interfaces (BCIs) transform human brain signals into direct communication using an external electrical device. BCIs have the potential to change the way humans interact with the world around them. The goal of the proposed project is to continue my Master's research in order to asses the potential of a music-based BCI to detect the contents of a participant's imagination using only the recorded electroencephalography (EEG) signal. Significant first steps have been made to create similar devices which give patients with severe motor deficits a simple method of communicating with the world. For example, researchers were able to successfully distinguish whether a vegetative patient was imagining playing tennis or imagining walking through their home[1] and the patient could use this technique to answer yes or no questions. However, this was done with functional magnetic resonance imaging (fMRI), an expensive and cumbersome technique. In contrast, EEG is portable and inexpensive, making it widely accessible and a good candidate for future BCIs. EEG-based interfaces have been successfully used in individuals with severe motor deficits, enabling them to move a cursor on a screen by controlling their brain signals in the 8-12 Hz range[2]. Further work was done in which three different brain states were reliably differentiated when subjects purposefully modulated their own EEG signal[3]. However, these techniques were only able to distinguish large scale changes in brain state, severely limiting the number of responses the BCI could make.

Recent advances in EEG signal processing have made it possible to distinguish increasingly subtle differences in brain activity. These advances will enable researchers to differentiate many brain states, allowing a communication device to handle more than simple yes or no questions. Music is especially suited to an EEG-based BCI since music unfolds over time and EEG has high temporal precision. As noted in the thesis summary my previous work showed that heard and imagined pieces of music can be classified at a statistically significant level. Although statistically significant these accuracy rates are not robust enough to be used for a BCI.

I would like to continue this line of research in order to create a more robust system. During my

Master's research I investigated the effects of the musical time-signature on classification. The next step is to determine what other salient aspects of music can be used for classification (e.g. presence of lyrics, rhythmic patterns etc.). Rhythmic patterns show promise as *perceived*[4] drum rhythms can be classified from EEG. In a separate experiment simple rhythm *imagination* has also been classified from EEG[5]. In this experiment participants were asked to imagine a single speech syllable in a particular rhythmic pattern. However, imagining a meaningless pattern of sounds (drums or syllables) may be difficult for participants to do accurately and a more salient stimulus may be necessary. Speech is something that is inherently rhythmic and meaningful words and phrases are likely easier for participants to imagine than single syllables. I propose that differentiating rhythmic patterns may provide a more robust BCI than the previous work done with differentiating music. In order to induce rhythmic patterns in a participant's EEG signal I would like to use short, rhythmic, repetitive phrases. If this proves to be a successful way to detect what a participant is imagining then the next step will be to integrate other musical features (for example melody or pitch) to determine whether this increases our ability to robustly classify the contents of a participant's imagination. This will allow us to build a powerful music-based brain-computer interface.

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