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Brain-computer music interfacing for continuous control of musical tempo

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Abstract

A Brain-computer music interface (BCMI) is developed to allow for continuous modification of the tempo of dynamically generated music. Six out of seven participants are able to control the BCMI at significant accuracies and their performance is observed to increase over time.

Keywords Brain-computer music interface, Music generation, EEG, Online continuous control

1 Introduction

Brain-computer music interfaces (BCMIs) are devices that allow control over, or interaction with, music via brain activity and without activation of the efferent nervous system [6]. BCMIs therefore allow individuals to interact with, create, or modify music in situations where this would not otherwise be possible. For example, individuals with severe movement restrictions may benefit from use of a BCMI for recreation or as a therapeutic device.

Previous studies have presented BCMIs for passive modification of musical properties, such as beat and loudness, via measurements of complexity of different frequency bands in the electroencephalogram (EEG) [5]. They have also demonstrated selection from a discrete set of two-tone bass frequency drone sounds via emotional imagery [3] and selection from a discrete set of musical scores via steady-state visual evoked potentials (SSVEPs) [4].

Thus, BCMIs have been shown to allow active control of music generation via selection from a discrete set of instructions or passive interaction with music. However, there is an opportunity to further investigate whether BCMI users can wilfully modify musical properties on a continuous scale during a period of online music control.

Therefore, a BCMI is constructed to allow users to modulate the tempo of a piece of music dynamically via intentional control. Specifically, users are able to increase the tempo of the music via kinaesthetic motor imagery (MI) [7] and decrease the tempo via relaxation. Music tempo is mapped to the strength of the users motor imagery allowing them to move the tempo continuously across a specified range.

2 Methods

2.1 Participants

Seven healthy right-handed individuals (median age=23; SD=2.9; 6 males) voluntarily participated in the experiment. All participants gave informed consent, and the study was approved as per the University of Reading guidelines for ethics.

4 Discussion

Music can be actively controlled via 6 out of our 7 BCMI users with significant accuracy in one or more sessions. It may be argued that multiple comparison correction is needed. However, sessions are not independent, thus Bonferroni correction on a per session basis is not appropriate. Instead, Bonferroni correction is applied to mean accuracies per participant, revealing 3 participants to be able to control the BCMI at significant accuracies.

There is considerable variability and for some sessions participants were not able to control the BCMI at significant accuracies. Nonetheless, our results demonstrate that music tempo can be understood and utilised as a feedback mechanism by the majority of BCMI users.

These results open up the possibility of allowing users a greater level of control of music than previously explored [4, 3]. The performance increase over sessions visible in figure 1 is also encouraging as it suggests that users can, through increased experience, improve their ability to control tempo. We also note, however, that in the final sessions our users displayed a performance reduction. This may be due to fatigue, but further exploration is required.

Future work will seek to compare users' ability to learn to control properties of a piece of music with feedback modalities more traditionally used in BCI control (for example, visual feedback). We will also explore the effects of more advanced computational methods on the performance of the BCI. Additionally, the interaction of music and emotion is an interesting research angle and it would be very interesting to extend the work presented in [3] to allow continuous emotional imagery based control of musical features such as tempo, mode, or timbre. Therefore, future work will also look at extending our BCMI to continuously detect emotions.

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