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Accademia Musicale Studio Musica
Michele Della Ventura, *editor*

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Michele Della Ventura
Editor

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Preface

This volume of proceedings from the conference provides an opportunity for readers to engage with a selection of refereed papers that were presented during the International Conference on New Music Concepts, Inspired Education and New Computer Science Generation. The reader will sample here reports of research on topics ranging from a diverse set of disciplines, including mathematical models in music, computer science, learning and conceptual change; teaching strategies, e-learning and innovative learning, neuroscience, engineering and machine learning.

This conference intended to provide a platform for those researchers in music, education, computer science and educational technology to share experiences of effectively applying cutting-edge technologies to learning and to further spark brightening prospects. It is hoped that the findings of each work presented at the conference have enlightened relevant researchers or education practitioners to create more effective learning environments.

This year we received 57 papers from 19 countries worldwide. After a rigorous review process, 24 paper were accepted for presentation or poster display at the conference, yelling an acceptance rate of 42%. All the submissions were reviewed on the basis of their significance, novelty, technical quality, and practical impact.

The Conferece featured three keynote speakers: Prof. **Giuditta Alessandrini** (Università degli Studi Roma TRE, Italy), Prof. **Renee Timmers** (The University of Sheffield, UK) and Prof. **Axel Roebel** (IRCAM Paris, France).

I would like to thank the Organizing Committee for their efforts and time spent to ensure the success of the conference. I would also like to express my gratitude to the program Committee members for their timely and helpful reviews. Last but not least, I would like to thank all the authors for they contribution in maintaining a high-quality conference and I hope in your continued support in playing a significant role in the Innovative Technologies and Learning community in the future.

March 2020

Michele Della Ventura

Conference Chair

Michele Della Ventura, Accademia Musicale Studio Musica, Treviso, Italy

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Renee Timmers, The University of Sheffield, UK
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Music and the Brain: Composing with Electroencephalogram

Rachel Horrell

Interdisciplinary Centre for Computer Music Research, University of Plymouth, UK.
rachel.horrell@students.plymouth.ac.uk

Abstract. This paper proposes a novel approach to composing music using the brain-computer music interface (BCMI). In particular, the system developed for this paper focuses on making the compositional process inclusive to non-musicians and those with motor disabilities, in addition to providing a new method of composing for composers. This paper references and compares two BCMI systems that have been developed for compositional purposes, and draws upon these ideas to form the proposed system in this paper. Such system would aid the compositional process based on note velocity, chords and key changes.

Keywords. Brain-computer music interface (BCMI), Composition, Electroencephalogram (EEG).

1 Introduction

Imagine a world where we could create a melody in our head and have a computer compose it as we think. Unfortunately, this idea is rather far-fetched and technology has a long way to go before this becomes a reality as opposed to merely an idea. However, technology such as the brain-computer music interface (BCMI) is the initial move towards such a technological development. The BCMI comes from a cross disciplinary field that combines methodologies from the field of Neuroscience and Computer Music. The BCMI branches from the brain-computer interface (BCI), a system that allows for communication or control of a computer using human brainwaves. During the 1920s, psychiatrist Hans Berger discovered the electroencephalogram (EEG), a method of recording brain signals [1]. This subsequently led to the discovery of the alpha and beta waves, two very prominent frequency waves in the human brain. While the EEG became a widely used tool within the medical domain, it had also made its way into applications such as virtual reality (VR), mouse control and musical control [2].
The idea of using brainwaves for musical purposes began in 1965, when composer Alvin Lucier used the EEG to amplify his alpha wave through a number of loudspeakers

that were attached to a variety of percussion instruments, thus creating a musical recording [3]. Notably, this became known as the first musical piece to be composed using brain waves. Further to his work, composers such as David Rosenboom and Richard Teitelbaum began experimenting with the concept of using bio-signals such as the heart rate and breathing sounds to create an electronic texture composition [3]. Although the term brain-computer music interface (BCMI) was not coined until 2006 [1], it is widely accepted across the literature in this field that these experimental composers are the first pioneers of the BCMI.

Recently, researchers in this field have been focusing on developing BCMI systems for assistive neurotechnology; to help those with physical disabilities to be able to control musical instruments for composing or performing [2]. Although this is quite obviously groundbreaking work, it appears that researchers are focusing more on the technical side of the BCMI, as opposed to the musical side. Of course, there is no doubt that the technological developments are incredibly important, however, for a BCMI to be used as a compositional tool, it is just as important to focus on the musical aspects.

In this paper I present a BCMI system that not only enhances the creative practice of composing music, but also allows for the inclusivity of non-musicians and those with physical disabilities to compose music. The proposed system will use the alpha and beta waves of a user, retrieved from their EEG data, for the purpose of control over musical parameters within a pre-composed composition.

2 Composing music with the BCMI

Technological advances, such as the BCMI, have expanded the scope of how we can compose music. The traditional process of composing music by hand using a pen and paper can be seen as a very time-consuming task, especially when we compare it to the music notation software that is available to us now. This software, such as MuseScore and Sibelius, provides all the tools required to create, edit and play back a composition. These applications allow for one to input almost every performance direction and musical symbol, however, this also requires the user to have musical theory knowledge and the ability to input commands using a keyboard and mouse.

Miranda *et al.,* [2] developed a BCMI system to be used by those with severe physical disabilities. This BCMI incorporated an eye-gazing technique that required the user to select a pre-composed musical phrase by gazing at the flashing light that is next to the phrase. A downside to this technique is that it requires training to be undertaken by the user, which can be time consuming. Essentially, the user is only controlling the structure of the phrases as opposed to any compositional changes such as the dynamics or note values. If we compare this to this authors [4] BCMI system that allows for the control of the dynamics over two tracks, then the level of musical control is significantly low. Miranda and Soucaret's [4] system uses the amplitude of the alpha and beta waves to control the volume of two tracks. The first track is an electric guitar solo, which increases in volume when the alpha wave becomes prominent, and reduces in volume when the beta wave became more prominent than the alpha. The second track is a piano solo that would increase in volume when the beta wave is prominent. Despite the fact that this system only allows for control over one musical parameter, musically it offers more for the user change compared to these authors [2] BCMI system. Although this would not be a sufficient amount of parameters for a user to successfully control and edit a composition, the author stated that the system was accurate and that the user was able to successfully gain control in a matter of minutes. This gives optimism that the inclusion of more musical parameters could lead to a BCMI suitable for both non-musicians and those with physical disabilities.

3 Description of my proposed system

The proposed system expands on the work of Miranda's [4] BCMI system to include more musical parameters for the user to compose with, whilst also taking inspiration from this authors [2] system in terms of making it accessible for those with motor disabilities. The musical parameters included in this system are note velocity, chord changes and key changes from major to minor.

Technical Aspects of the System

The system uses a g.tec Sahara day electrodes and a g.MOBilab+ analogue-to-digital convertor for the EEG measurement. The electrodes are positioned according to the international 10-20 electrode placement system. Nacin [5] states that the most recently developed part of the human brain is the frontal cortex, where the majority of consciousness occurs. Due to this, it was decided to position the electrodes at F3, F4 and the ground electrode at Fpz, with F meaning frontal. The reference electrode was clipped onto the earlobe.

The EEG signals are received via Bluetooth and sent to OpenVibe, a program that provides a convenient interface between the EEG headset and the programming software, making it easy to control. In OpenVibe, a time-based epoch object was used to allow for a one-second-time window to be extracted from the continuous EEG signal. To extract the alpha and beta waves from this signal, a band-pass filter was required. Although there is much controversy to the exact frequency band of both the alpha and beta wave, the majority of literature in this field uses between 8 Hz to 13 Hz for the alpha wave and 14 Hz to 30 Hz for the beta wave [6]-[9]. Therefore, these frequency bands were used for the band-pass filter. This data was then sent across to a Mac OS running the visual programming software Max/MSP via Open Sound Control (OSC). OSC is simply a protocol for communication over networks that allow data to be sent from an EEG headset to programming software.

Max/MSP is the musical engine for this system, which was chosen due to the fact it does not adopt text-based coding, therefore making it suitable and less daunting for someone with little to no experience in programming. The incoming alpha and beta waves are associated with the musical parameters used in this system. The amplitude of the alpha wave is responsible for controlling the velocity of the melody and the chords. The amplitude of the beta wave is responsible for controlling the velocity of the harmony, choosing the chords and the chord templates (how many milliseconds are between the notes of the chord). Both the alpha and beta wave controls whether the composition changes from major to minor.

Compositional Aspects of the Composition

The pre-composed composition consists of 96 bars, which form three sections in the ternary form (A, B, A). The composition is formed of a main melody that is written for flute and a harmony that is written for Bb clarinet. The different instruments will make it easier to differentiate between the changes that the alpha and beta wave are contributing to. Composed in Bb major, the user has the option to change the composition to the parallel minor – Bb minor – simply by opening their eyes and focusing on a mental task, prompting the beta wave to become prominent. To change the composition back to Bb major, the user will have to close their eyes and relax to prompt the alpha wave. The chords that are included in this composition are the tonic, dominant and leading note chords of the Bb major scale in root position, first inversion and second inversion. This provides enough choice so the chords wont become repetitive, but also keeps it simple enough for someone with no musical knowledge to be able to understand. In relation to the chords, the user will be able to control how they are played, i.e. the milliseconds between each note of the chord, from a pre-defined list that is scaled to the users alpha wave. The user will be able to control the velocity of the main melody, harmony and the chords through their alpha wave. The velocity of each will be scaled appropriately in Max/MSP. For example, the velocity of the chords will not go as high as the velocity of the melody, as it is musically known that chords are used as an accompaniment to a melody and is therefore dynamically quieter.

4 System testing and results

The setup of this system took approximately 10 minutes. This included placing the headset onto the scalp, connecting it to OpenVibe and obtaining satisfactory contact between the electrodes and the scalp. The user was required to sit still for the entirety of this test to avoid any interference from muscle movement that may cause inaccurate results. The lack of movement that is required to use this system makes it appropriate to be used by those with motor disabilities, as they will not need to use a keyboard or mouse to make any changes to the composition. The user placed the g.tec Sahara box and g.MOBilab+ onto their lap for a sense of grounding, which instantly improved the signal quality. When the composition began to playback, the user relaxed and closed their eyes to provoke their alpha wave. This resulted in the composition to stay in the major key, produce chords and alter the chord and melody velocity. After a few minutes, the user opened their eyes and began focusing their mind on a mental task. This resulted in the composition changing to the parallel minor and the increase of the velocity in the harmony. The user was able to successfully control the musical parameters that altered the outcome of a pre-composed composition.

5 Concluding remarks and future work

In this paper I presented a BCMI system that provided a new and exciting approach to composing music. This system draws upon the technological advances that have previously been developed and expands the possibilities that can be achieved with such technology. Future work will explore the potential of controlling all aspects of this system purely from the users brainwaves, allowing them to play and stop during real-time playback. Further to this, the possibility of using this system in a performance setting will also be explored.

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This book presents a collection of selected papers that present the current variety of all aspect of the research at a high level, in the fields of music, education and computer science. The book meets the growing demand of practitioners, researchers, scientists, educators and students for a comprehensive introduction to key topics in these fields. The volume focuses on easy-to-understand examples and a guide to additional literature.

Michele Della Ventura, editor

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