MusEEGk: Design of a BCMI

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ABSTRACT
We present a novel integration of a brain-computer interface (BCI) with a music step sequencer. Previous BCIs that utilize EEG data to form music provide users little control over the final composition or do not provide enough feedback. Our interface allows a user to create and modify a melody in real time and provides continuous aural and visual feedback to the user, thus affording a controllable means to achieve creative expression.

Keywords
Brain-Computer Interface, P300 Evoked Potential, Music composition

ACM Classification Keywords
H5.5. Information interfaces and presentation (e.g., HCI): Sound and Music Computing

General Terms
Design, Experimentation

INTRODUCTION
A brain-computer interface (BCI) is a tool that translates neural signals into a digital output. This output can allow users to control an interface or objects in their environment. BCIs for creative expression include using BCIs to paint images [6] or draw shapes [3]. Following in that vein of creativity, we designed and implemented a BCI that can be used for musical composition and performance.

Brain Computer Musical Interface (BCMI) research has been lacking in real-time user control. So far, BCMIs have produced devices where the music output is one of two things: a modulation of a pre-recorded piece or an algorithmically generated composition. There has been only one study that the authors are aware of that allows the user direct control over the output (discussed below), and none of the interfaces allow for real-time composition with continuous visual and aural feedback. Creating a reliable musical BCI will be an important step, not only for the community of musicians, but also for the realm of assistive technology.

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BACKGROUND AND RELATED WORK
The most common method of measurement used by researchers looking at BCIs is electroencephalography (EEG). EEG measures electric fields produced by neurons through the use of electrodes that are placed on the scalp.

One method that researchers can employ to control a BCI combines EEG with Hjorth analysis and results in a system that is able to derive a musical piece by using a subject's brainwaves [5]. However, because this study attempts to "guess" at a musical piece, the subject has little control over the final piece that is produced. Another method used in BCI research– and the method used in this paper - is based on the P300 response. The P300 is an event-related potential (ERP) – a brain signal that occurs in response to an external stimuli. In a pilot study, researchers attempted to create a BCMI by using the P300 response to choose sequential notes from a matrix [1].

Affording the user discrete selection of individual notes is a concrete step toward building a flexible BCMI, but can be cumbersome if an individual has to compose a song by only selecting one note at a time and stringing them all together at the end. Additionally, audio feedback in this experiment was given when a note was selected and at the end of the experiment. The individual would not hear the melody of the song until after the composition was over.

P300 Based Music Composition
Our aim for MusEEGk is to create a composition program that has both a low threshold and a high ceiling. This phrase, sometimes used to describe a property of new musical interfaces or instruments, means to have a low entry/learning curve for beginners while at the same time having a high ceiling for mastery. With that in mind, we designed MusEEGk with the goal of having a system that was expressive, transparent, and flexible.

Expressive
One of our goals when designing MusEEGk was to allow for a freeform composition interface that provides constant as well as consistent feedback to the user. To do this we decided to use a traditional musical step sequencer. A step sequencer was chosen as the composition mechanism because, since selection is slow compared to a mouse click, having a system that loops allows the composition to feel

longer and more complete. MusEEGk functions exactly like a traditional step sequencer, only on a slightly smaller scale. The bottom row is designated Middle C, with each successive row one note above the previous row's note until the top row (exactly one octave above Middle C).

Transparent

The issue of interface comprehensibility revolves around the ability of the user to understand what is happening in the system and how they go about influencing the system. Users must be able to see all available actions and interpret whether or not the action taken had the desired effect. Figure 1 shows the display that our participants see. The left matrix is used for note selection and the right matrix displays and plays the selected notes. Notes that are selected are highlighted in pink and available notes are the default blue color. The selected notes remain highlighted in pink until either the session ends or the user decides to deselect that note. There is a 1:1 mapping of notes between the selection matrix and the sequencer matrix, and each note on both matrices are labeled for faster recognition.

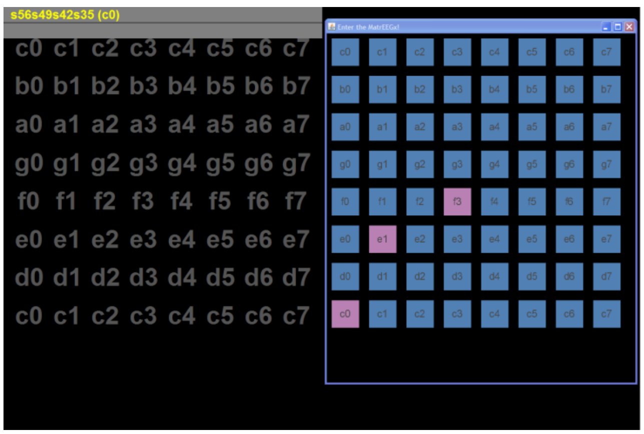

Figure 1: The left matrix (BCI2000) is used for selection of notes while the right matrix (Clojure) displays notes selected.

Flexible

Unlike in traditional interfaces, BCIs must be much more resilient to inaccurate or unintended actions. The high occurrence of such errors might lead to multiple sequential mistakes. BCI inferences should be designed to not only limit the frequency of errors, or provide means of undoing errors, but also mitigate any frustration or user anxiety that arises from errors.

In MusEEGk, the main flexibility component is the ability to deselect notes. This function allows users to undo mistakes – unintended selections by the interface or the user – and inject variety into their compositions. Furthermore, mistakes can be undone during the start of any selection period and is independent of any actions that come before. Unlike a traditional P300 speller, users of MusEEGk can choose to ignore mistakes initially and go back to correct them at a later time without long periods of forced backtracking.

EEG & Music Processing

For real-time processing of EEG data, we used BCI2000 [7]. Audio events were handled by a SuperCollider synthesis server [4] which we control via the open source Overtone music toolkit. We render the step sequencer via a wrapper around the Processing visualization library. For sound synthesis, we used the SuperCollider synthesis engine [4]. The audio loop runs at a tempo of 110 beats per minute, allowing for approximately three loops during a single note selection. Visualizations were created using the Processing graphical library, and interaction with SuperCollider was handled by the Overtone library. MusEEGk is written in Clojure [2].

This interface was tested on twenty-one participants who were given approximately six minutes to create a composition of their choice. Post-experiment questionnaires rating the task difficulty, task enjoyment, and tune enjoyment as well as comments on the interface were collected. Results showed that the task was not difficult, that it was enjoyable, and that users generally enjoyed the tune they created. This suggests that MusEEGk is a viable design for a brain-computer music composition interface that can be used for creative expression. Future work will look at enhancing the user experience by allowing more customization of sounds and tempo as well as including the addition of a start/stop button.

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REFERENCES

1. Grierson, M. Composing with Brainwaves: Minimal Trial P300 Recognition as an Indication of Subjective Preference for the Control of a Musical Instrument. Proceedings of the ICMC, (2008).
2. Hickey, R. The Clojure programming language. ACM Press, New York, New York, USA, 2008.
3. Mappus, R., Venkatesh, G., Shastry, C., Israeli, A., and Moore, M.M. An fNIR Based BMI for Letter Construction Using Continuous Control. Extended Abstracts from the Conference on Human Factors in Computing Systems (CHI), (2009).
4. Mccartney, J. SuperCollider : a new real time synthesis language. 4-7.
5. Miranda, E.R. and Brouse, A. Toward direct brain-computer musical interfaces. New Interfaces For Musical Expression, (2005).
6. Rapoport, E.D., Nishimura, E.M., Zadra, J.R., et al. Engaging, Non-Invasive Brain-Computer Interfaces (BCIs) for Improving Training Effectiveness & Enabling Creative Expression. Human Factors and Ergonomics Society Annual Meeting Proceedings, Human Factors and Ergonomics Society, (2008).
7. Schalk, G., McFarland, D.J., Hinterberger, T., Birbaumer, N., and Wolpaw, J.R. BCI2000: a general-purpose brain-computer interface (BCI) system. IEEE transactions on bio-medical engineering 51, 6 (2004), 1034-43.