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Viva Contemporary! Mobile Music Laboratory

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ABSTRACT

The mobile music laboratory is an installation for interactive music listening and research on embodied cognition, with focus on contemporary classical music (CCM). CCM is often less familiar to listeners than other types of music, but its success is essential for composers pioneering musical and cultural developments. This installation gives listeners of any background a way to actively engage with CCM. It enables users to interactively control the temporal expression of CCM through intuitive conducting-tapping gestures while traces of their cognitive and physiological processes are recorded for subsequent analysis. The mobile music laboratory system is comprised of a real-time controller with MIDI playback and a data acquisition system. As the user controls the music, Lab Streaming Layer synchronously records gesture timing and audio as well as neural and cardiac signals. The installation is designed to engender purposeful music engagement with CCM while simultaneously serving as a mobile laboratory for studying embodied CCM listening experiences, thus enabling ecologically valid music cognition research outside of auditory psychology labs.

CCS CONCEPTS

• **Applied computing** → **Sound and music computing**; • **Human-centered computing** → *Gestural input*.

KEYWORDS

Interactive art, contemporary classical music, embodied cognition

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1 INTRODUCTION

We present an installation which implements and tests the idea that expectation and embodied cognition, or cognition influenced by physical movement, plays a central role in music listening and

*EG/EC planned and EG implemented project. CP customized software for project.

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appreciation [2, 4]. We focus especially on Contemporary Classical Music (CCM) with the aim to boost engagement and emotion response to CCM. For many listeners, CCM is less accessible and less familiar than other types of music. While CCM affords many new auditory experiences, it often lacks regular rhythms and hierarchical temporal structures like beats and meter that normally orient listeners, establish temporal expectations, and lead to physical embodiment [6]. With low exposure and weak temporal expectations, regular listeners can find CCM alienating.

The mobile music laboratory installation is designed to help people generate expectations while experiencing CCM. The expectations come from interacting with the timing of the music using a controller and physical gestures to conduct the music in real time. In this way, the mobile music lab reinjects temporal expectations into CCM and harnesses embodied cognition to alter the listener's reception of the music. Crucially, by allowing listeners to interactively control the music in real time through their own motions – similar to past conducting interfaces for controlling temporal expression [1] – the listener assumes some of the role of the performer. By combining the listener and performer roles, we recruit the cognitive mechanisms related to expectation, sensorimotor integration and neural entrainment to change the listener's perception and reception of the music. Below we describe a first version of the mobile music laboratory.

2 MOBILE MUSIC LAB COMPONENTS

Here, we review technical aspects of the music preparation, the interaction with the real-time controller, the physiological sensors, and the data acquisition system for personalizing, listening, and studying embodied CCM listening experiences.

2.1 MIDI Preparation

To prepare MIDI files of CCM compositions for interactive control in the mobile music lab, we select recorded performances of solo piano music from the Star Charts dataset of the COSMOS project¹. These are expert performances that communicate clear musical structures recorded on the Cosmos reproducing piano, a Bösendorfer 280VC Enspire PRO. The reproducing piano records the timing and loudness of the human performance, and can replicate it without the presence of a human performer.

To permit interactive control for the current installation, described in Section 2.2, the underlying composition must contain a single tactus, or pulse, throughout. No further constraints are placed on the meters or rhythms contained in the CCM works for

¹<http://cosmos.ircam.fr>

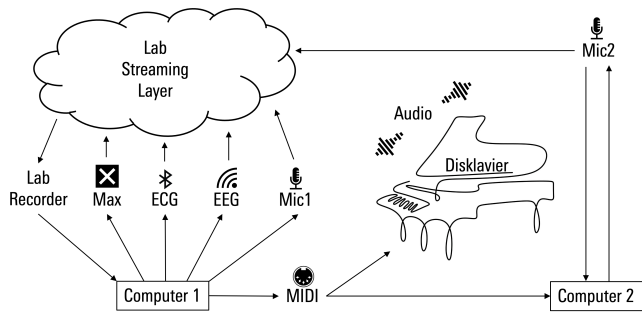


Figure 1: Mobile data acquisition system - LSL applications on two computers are used to broadcast music-related and physiological data. Computer 1 records all available LSL streams. Computer 2 additionally records audio and MIDI.

the mobile music lab. The MIDI velocity of each note is extracted from the recorded performance and applied to a clean MIDI file to give it realistic dynamics during the interactive playback. A bespoke Max patch reads the MIDI and controls the tempo at which MIDI data is sent out for synthesis/replay based on user input through a Roli Lightpad Block M touch interface.

2.2 Interaction

For tempo control of the MIDI, users tap and push into the Roli Lightpad Block M at the level of the tactus. The full surface of the Roli is programmed to operate as an extended Max toggle object. Tap rate and push depth are registered by Max and used to predict tempo and control playback at the tick level. Each tap is tightly synchronized to the onset of a tactus, however the speed of the MIDI ticks also changes within a tactus according to the latest tempo and the duration of the most recent push gesture. I.e., Shorter and longer push gestures are mapped to an increasing or decreasing intratactus tick rate, respectively, to arrive at an estimated new tempo by the end of each tactus. This method balances tight and loose synchronization strategies for a smoother-sounding performance controlled by the user with minimal delay, i.e. with a single gesture.

2.3 Mobile physiological sensors

While the users interactively control the music, mobile electrocardiography (ECG) and electroencephalography (EEG) sensors measure electrical heart and brain activity, respectively. A bluetooth Polar H10 heart rate sensor, a chest strap with one electrode, is used to gather and transmit ECG at 100 samples per second. A wireless Neuroelectric Enobio Research 8 EEG is used to gather and transmit 8-channel EEG at 500 samples per second. The physiological signals, along with the audio at 44100 samples per second and tap events, are synchronized and recorded by the online data acquisition system shown in Figure 1.

2.4 Mobile data acquisition system

The mobile music lab's data acquisition system is built on Lab Streaming Layer (LSL), a network-based data streaming library [3]. Crucially, LSL can broadcast and resolve sampled and event-based

data streams which are synchronized by the network. In the mobile music lab, pre-existing LSL applications AudioCapture², PolarBand2lsl³, and NIC2⁴ broadcast the incoming audio from two microphones, ECG, and EEG data, respectively. A custom-made LSL application broadcasts event-based Max data from the Roli interface. On Computer 1, pre-existing LSL application LabRecorder² records LSL streams synchronously. Outside of LSL, the Max patch internally stores each push duration and the secondary computer records the newly performed MIDI data and audio from a secondary microphone for data validation.

3 PERSPECTIVES

The mobile music laboratory installation makes contemporary classical music interactive in order to both promote listener appreciation for the music and investigate the impact of embodied music cognition on listener experience and physiology. Participating in the mobile music lab mixes the role of listener and performer by giving the user real-time control over the temporal expression of the music. For CCM, we posit that this physical interaction may be crucial for developing internal expectations about the music and renewing perspectives on CCM through active embodiment.

From the scientific perspective, the mobile music laboratory provides a platform for studying music cognition and behavior relating to CCM. Music cognition research is typically performed in highly constrained environments. Here, the online, synchronous data acquisition approach of the mobile lab makes it possible to investigate the physiological manifestations of CCM engagement through embodied interaction in an installation setting. Moreover, the mobile music lab is flexible and its MIDI playback can be realised through a disklavier, computer synth, or mobile phone browser [5], thus providing an avenue for music listening studies in other ecologically valid settings outside of the lab.

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²<https://github.com/orgs/labstreaminglayer/repositories>

³<https://github.com/markspan/PolarBand2lsl>

⁴<https://www.neuroelectrics.com/resources/software>