SYNESTHETIC: COMPOSING WORKS FOR MARIMBA AND AUTOMATED LIGHTING

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ABSTRACT

This paper describes a series of explorations aimed at developing new modes of performance using percussion and computer controlled lighting, linked by electronic sensing technology. Music and colour are often imagined to be related and parallels have been drawn between the colour spectrum and keyboard. Some people experience a condition, chromesthesia (a type of synesthesia), where experiences of colour and sound are linked in the brain. In our work, we sought to explore such links and render them on stage as part of a musical performance. Over the course of this project, tools and strategies were developed to create a performance work consisting of five short movements, each emphasising a different interactive strategy between the performer, lights, and composition. In this paper, we describe the tools created to support this work: a custom wearable lighting and sensing system, and microcontroller based OSC to DMX lighting controller. We discuss each composition and how the interactions reflect ideas about synesthesia.

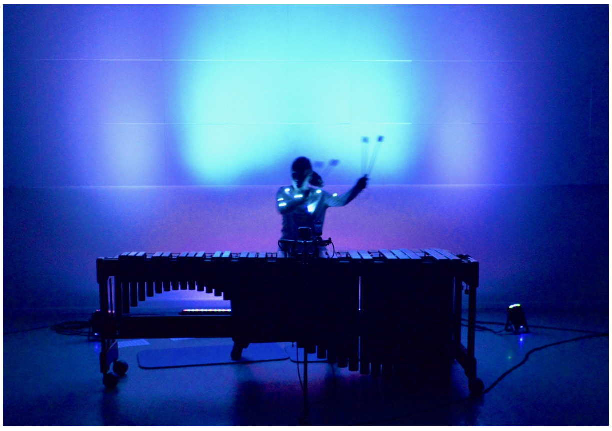

Figure 1. The performer playing one of the works in *Synesthetic*. The stage was dark except for computer controlled lighting on the rear wall and a wearable lighting system on the performer's shirt. Videos of this performance can be found here: https://doi.org/10.5281/zenodo.3402419

1. INTRODUCTION

Music has long been associated with colour (Peacock 1988). The word "colour" is commonly used to describe multiple aspects of music–the tone quality, the mood of a piece, the type of instrumentation. Artists often attempt to depict their experience of music in their visual works (McNamara 2009). Synesthesia is a neurological condition in which stimuli trigger one or more additional senses (Hubbard and Ramachandran 2005). These experiences can affect any sense, for example, in lexical-gustatory synesthesia words stimulate taste responses (Banissy et al. 2014). Some individuals with synesthesia experience colours when they hear sounds; this is known as chromesthesia (Rogers 1987). Since this phenomenon became recognised it has been of interest to composers, leading to the development of a "clavier à lumières" (colour organ) by Alexander Scriabin in 1915 (Peacock 1988) which projects light onto walls when its notes are played. In 1919, German film director Walter Ruttmann predicted that technological advances would increase the amount of connections between sound and images in art, resulting in a "constant state of being swamped with material" (McDonnell 2007). While this has not occurred, we have seen several modern attempts at integrating sound and visual material, such as the interactive installation LINE, a three dimensional interface that emits sound and corresponding light (Kobori et al. 2006).

This project, called *Synesthetic*, focused on chromesthesia. The French composer Olivier Messiaen "suffered" from chromesthesia, as Messiaen explained to the French critic Claude Samuel in 1988: "I see colours when I hear sounds, but I don't see colours with my eyes. I see colours intellectually, in my head." (Ballard et al. 2017). While few synesthetes experience the same correlations between sound and colour, individuals have consistent associations in their own experiences (Sacks 2007). One synesthete has described his music-triggered colour experiences as having "... a sort of transparent, luminous brilliance... like a screen before him" (Sacks 2007). To imitate this experience, we experimented with new modes of performance and composition for percussion, coloured lights, and sensing (shown in Figure 1). The senses of hearing and vision are inextricably linked for synesthetes, and so we wished to create a connection between sound and visuals that was aesthetically pleasant and not jarring; a matching that was complementary rather than just added-on.

For this project, we created a system where instead of

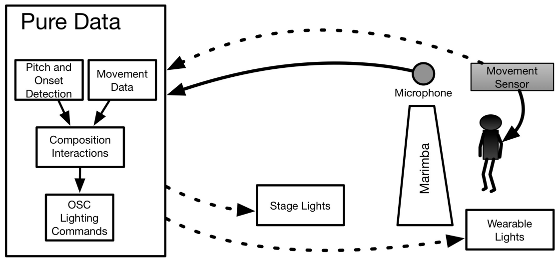

Figure 2. Our performance system included wearable and stage lighting, a motion sensor, and audio tracking of the marimba sound.

automatic projection of light when a key is pressed (as in the colour organ), we used a Pure Data patch on a computer to listen to the notes on an acoustic marimba, recognise pitches and note onsets, and then respond appropriately with a coloured LED light. Percussion performance has been defined by the gestures percussionists use to create sound (Schick 2006, p. 5) and the ancillary movements that do not affect sound, but nevertheless shape how it is perceived (Schutz and Manning 2012). With respect to this, we also used motion sensing to create a connection between the movement of striking the marimba, sound and light.

We created five interaction environments in which the lights would respond differently to the sound of the marimba and the movement of the performer. Our composer wrote five short pieces that demonstrate and explore each interaction. We developed this work during a five-day artistic residency, creating one new interaction environment each day, and a composition on each of the first four days. We performed these four pieces and one improvisation to a small audience who were able to give feedback after the performance.

2. SYSTEM DESIGN

In this section we describe the design of our performance system. This consisted of wearable lights, sensors, and our computer controlled stage lighting system. These systems were coordinated by a laptop running Pure Data, where we were able to experiment with different interactions during development. Our Pure Data program also ran pitch tracking and onset detection on the marimba sound, which was used for different interactions in our compositions. There were no electronic sounds in our project. A summary of our system design in shown in Figure 2. Source code and parts lists for our setup are available on our GitHub repository: https://doi.org/10.5281/zenodo.3392870.

2.1 Wearable Lighting

Our wearable lights and sensors used Wemos D1 Mini Lite systems, internet of things (IoT) prototyping boards based on the Espressif ESP8285 microcontroller. These small and inexpensive boards can be powered by a USB battery and include WiFi connectivity, and programming capabilities similar to an Arduino microcontroller. This prototyping platform is comparable to those used in previous research using the ESP8266 module (Ferguson et al. 2017) and XBee wireless system (Baalman 2017).

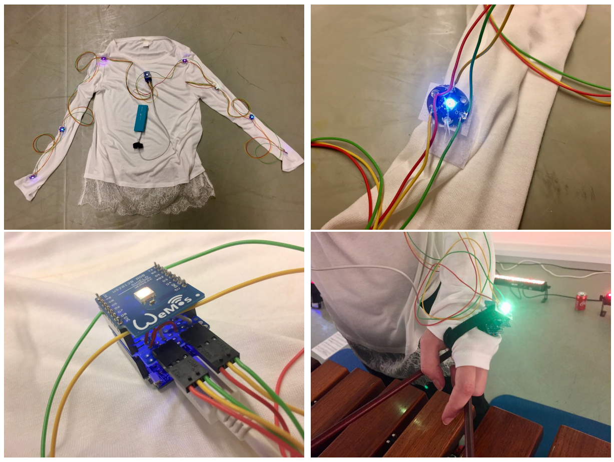

Figure 3. Detail of our wearable lighting system installed on the performer's costume (top and bottom left). Motion sensor attached to the performer's hand (bottom right). The RGB LED modules were controlled by a Wemos D1 Mini Lite microcontroller board.

The wearable lights included one Wemos D1 Mini on the performer's chest (see Figure 3) connected to nine RGB LED modules (WS2812 breakout boards a.k.a. "neopixels"). The LED modules were backed with velcro and could be attached in various ways to the performer's costume during our project development. The costume consisted of a plain white long-sleeved t-shirt, altered to have thumb holes to keep the sleeves more secure. Velcro loop squares were hand sewn to the shirt to accommodate the LEDs and microcontroller module. The lights were positioned at the upper wrists, elbows, upper arms, shoulders, and one attached to the microcontroller in the centre of the chest. A USB battery to power the microcontroller was held in the performer's pocket.

2.2 Movement Sensor

Another Wemos D1 Mini Lite was used as a wearable movement sensor. A small accelerometer breakout board (ADXL345), was attached to the microcontroller, and this system attached to the performer's hand with velcro strips to sense percussive gestures (see Figure 3). For our work, we experimented with using the accelerometer readings as well as the simple "tap" gesture, recognised on the accelerometer chip, to drive aspects of the sound/light interactions.

2.3 Lighting Controller

For project development and our initial performance we used a set of low-cost RGB LED lighting bars and developed a custom solution for controlling them via their DMX interface. We were inspired by an Arduino-based lighting controller[1], which included a wired network connection for input, DMX output, and a 3D-printed enclosure.

[1]https://github.com/alfo/artnet

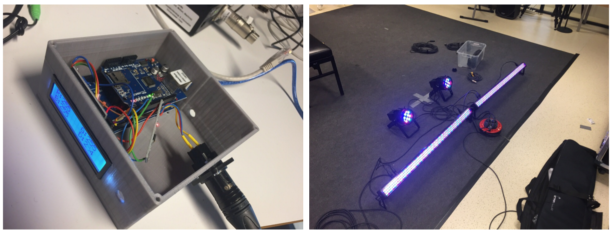

Figure 4. Our OSC to DMX lighting controller (left) and our experimental stage lighting rig (right).

For our project, we used a similar controller design, using an Arduino, Ethernet shield, and a MAX485 breakout board for interfacing via DMX (see Figure 4). We developed firmware for our use-case that could respond to OSC messages and used an edited version of the 3D-printed enclosure. In future, this controller could be replaced by a more refined system that communicates over WiFi rather than wired Ethernet.

2.4 Stage Setup

Our stage for the premiere performance was a large dance studio with white walls. We positioned the marimba approximately 1.5m away from a wall, facing into the centre of the room. The lights were positioned on the floor so that they shone onto the wall behind the performer. The performer was able to see some of the ambient light reflected on the marimba in concert lighting conditions. Our computers were set up to the side, out of the direct line of sight of the audience and performer. There was no additional stage lighting.

3. COMPOSITION

After developing our wearable and stage lighting systems, we developed five sketch compositions for Synesthetic during an intensive five-day workshop. Each of these sketches explored different interactions between lighting and sound and featured contrasting musical material. The following sections describe each of these works.

Videos of each work can be found online at https://doi.org/10.5281/zenodo.3402419.

3.1 Connecting Sound to Colour

In the first session, our aim was to use a simple sound-to-light interaction in a composition. We divided the colours red, green and blue across the entire range of the marimba. The lowest pitched notes of the marimba were mapped in Pure Data to trigger blue lights, the middle range mapped to green and the highest mapped to red. The colours blended when notes were played between these pure colours, blending red with green in the upper middle register and blending green with blue in the lower middle register. The composition written for this session made use of this blending and changing of colours. This led to some unusual jumps between very high and very low notes (see Figure 5). The lowest octave of the marimba has strong, clear overtones, and we found that these led to misclassification in our pitch tracking patch and caused the lights to flash between red and blue. We attempted to eliminate this flashing effect by adjusting the position of

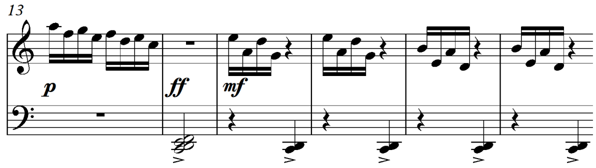

Figure 5. An excerpt from the score of session 1 showing the marimba jumping from the high range to the low range of the marimba.

microphone and changing to softer mallets. Softer mallets did produce more of the fundamental tone, but can be too soft to properly play the higher notes. In our performance, we compromised on a medium-soft mallet which made the high notes audible when played with some force, and did not produce too many interfering overtones in the lower register.

3.2 Designing a Twelve-Tone Colour-Scale

For this composition we focused on connecting pitch classes to individual colours. Some have attempted to assign each tone to a colour, matching frequencies to positions in the colour wheel, Well's work is one example (Wells 1980). However Wells' proposal is not the experience of most synesthetes. Instead of using this kind of ordered rainbow approach, our tone-to-colour mappings was borrowed from Scriabin's 1910 work *Prometheus: The Poem of Fire* (Op. 60) where the score indicates how certain colours should fill the stage. Although Scriabin was probably not a synesthete in the clinical sense (Galeyev and Vanechkina 2001), he felt strong connections between colour and sound. Our attempts to replicate Scriabin's mapping were frustrated by the colour reproduction ability of our LED stage lights; however, we were able to find a set of twelve similar colours such that the contrast between each tone was discernible.

This composition is a twelve-tone work, where the tonal material comes from the first 8 bars of the development section of the fourth movement of W.A. Mozart's Symphony No.40 in G minor, K.550.

3.3 Communicating from Colour-Scale to Performer

Sacks describes a synesthete who sees a pane of yellow glass and is reminded of the key of B flat major (Sacks 2007). This indicates that synesthesia can go both ways—from music to colour and the reverse. For session three, we intended to use Scriabin's colour-tone association from the previous session in an inverse manner: to communicate instructions to the performer. We programmed a series of colours to illuminate the costume, to instruct the performer which note to play using the 12-tone colour scale. This required the performer to memorise the series of colours in the scale (see Figure 6). In practice, we found that it was almost impossible to discern several of the colours when trying to "read" them in this way. In particular, the lights did not make clear greys or browns. We attempted to overcome this problem by changing several note colours to be more easily distinguishable. It was necessary for the composition to be monophonic and slow to allow the performer to discern the colour, find the correct

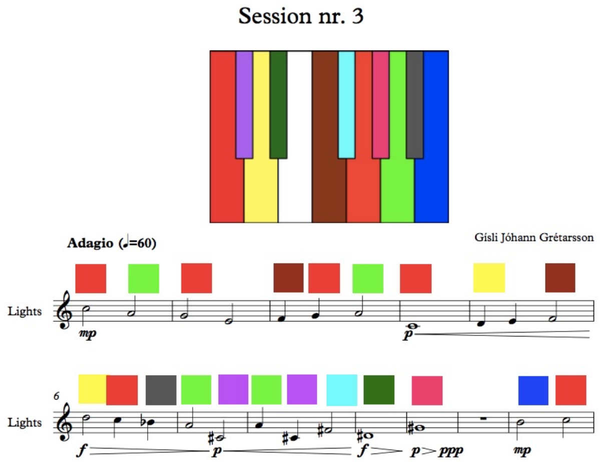

Figure 6. An excerpt of the score for session 3 (not shown to the performer), showing the notation as well as the associated colour. Also shown is our modified 12-tone colour association keyboard

note, and play.

To add an extra dimension to the challenge of this work, the wearable lights were set to indicate the score to the performer, and the background lights react to show the actual notes played. The audience watching could then tell if the performer played a wrong note by seeing a difference between the colour on the costume and the colour on the background wall. It was still very difficult for the performer to correctly discern some of the the notes based on the lights on the costume. For instance, blue and purple, and dark green and light green, were easily confused. This limitation could be due to the colour reproduction of our lighting setup and we hope that further experimentation with different stage lights may lead to more reliable communication. Despite the limitations of the setup in the performance, audience members enjoyed this piece due to the clear and visible interaction between performer, composition, sound, and light.

3.4 Indicating Tonality with Colour

One synesthete has described seeing colours associated with keys, chords, and tonalities rather than individual notes (Sacks 2007). The person had over 24 different colour associations with the different keys and modes. To mirror this association, a composition was created that had several distinct key changes throughout. During the performance of the piece, a matching sequence of colours was displayed on the stage lights at the key changes (see Figure 7). This lighting change was triggered manually by the composer. The lights on the costume corresponded to the notes actually being performed, using the tone-colour keyboard we designed in the previous session. Although this session was the simplest in terms of interaction, feedback from audience members suggested that they found this piece to be relaxing and interesting.

3.5 Connecting Motion to Light

Percussion can be defined by performance gestures, the motion of striking an object, rather than any particular instrument (Schick 2006). In the fifth session we experimented with connecting data from our motion sensor to light. We were able to develop a simple method for inferring strike gestures by detecting high aggregated acceleration of the performer's hand. We used such strike events to temporarily light up the performer's costume with a white light which subsequently faded to mirror the marimba's sound envelope. This connection was quite compelling as the costume lights flashed in rhythm with the percussionist's left hand. As this was the final session, a composition was not completed in time to receive feedback at the open rehearsal evening. Instead, a short improvisation was performed which adequately demonstrated the interaction between movement and light.

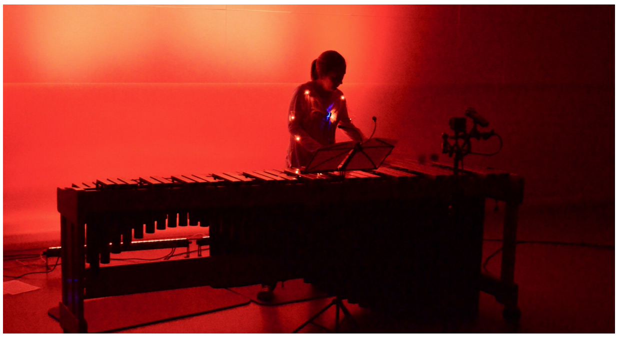

Figure 7. An image from Session 4, where tonality was connected to colour.

4. CONCLUSIONS AND FUTURE WORK

The aim of this project has been to explore real-time connections between sound and light in marimba performance, inspired by real and imagined concepts of "synesthesia". In this paper, we have described the interactive music systems we developed to explore such connections. These included wearable lighting and motion sensing systems, a custom DMX lighting controller, and audio analysis Pure Data patches. We have also described a series of five interactive environments using this setup, and compositions written to explore these environments. These systems, compositions and interaction studies allowed us to play with the connection between sound, light and marimba gesture, and could serve as a basis for future performance setups and compositions.

Our development process uncovered some issues that complicate the goal of directly connecting sound and light. In the first two sessions, inaccuracies in pitch tracking led to a lack of stability in light colours. It may have been more accurate to use a MIDI instrument to map the notes to certain lights and vice versa; however, it could be that the confusing overtones of the marimba and flashing effects is what a synesthete might experience. We do hear those overtones, and they define the timbre of the note. We feel that such interactions between sound and light imitate what some synesthetes may experience when listening to music, although it was not possible to provide a fully immersive experience with our limited setup. While the connections we have made make artistic sense, we suspect that it may be jarring for actual synesthetes to view our performance, as the projected lights may not match their own experience of synesthesia. In future, we aim to expand this project to a concert-length program of composed music and lighting interactions, or expanding the artistic goals by adding more musicians or a dancer.

Acknowledgements

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