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Sound in Color

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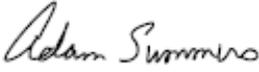in partial fulfillment of the requirements for the degree

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I. Introduction

"Sound in Color" is an interactive audio-visual experience designed to explore the relationship between sound, color, and emotions. Taking place on the Massey Concert Hall stage, the project is inspired by synesthesia and incorporates research on color psychology. Participants are invited to select an emotion and color. As the user hums into a microphone, they hear their emotions expressed through sound in their headphones and watch as the lights on stage respond to their vocal cues.

Whenever I have an emotional response to music, I see vivid color landscapes. From the very beginning of my thesis project journey, I wanted to create something that would express this visual experience I have with music. By merging the artistic realms of audio and visual media, I wished to explore the idea that our emotions act as a constant and fundamental tie between our senses.

This paper will begin by outlining the research performed on synesthesia, interactive aural augmented reality media, and color theory. Then, the methodology of the creative process and completion of the project will be described. Next, the paper will lay out the technical details of programming audio in Ableton Live, lighting on the grandMA2, and control data in Touch OSC. Finally, there will be a reflection on the completed project describing how people responded to the experience, ways in which this project may be used commercially, and what may be done to improve the project in the future.

II. Research

<u>*Synesthesia – "The Man Who Tasted Shapes" by Richard E. Cytowic*</u>

The Man Who Tasted Shapes is a book written by Richard E. Cytowic detailing the neurologist's journey of findings regarding synesthesia, a neurological phenomenon that causes multiple senses to be linked together.

Cytowic introduced the idea that synesthesia is above all an emotional experience. In the book, Cytowic writes of when he performed brain scans on synesthetes to discover what happens to their brains whenever they are having synesthetic experiences. The author found that the limbic side of the brain – the emotional core of the nervous system – lights up in activity while the rest of the brain goes dark. This finding reveals that synesthesia is not merely about neurons firing in random directions but is about having a profoundly emotional experience. This theory lines up with how many synesthetes describe their experiences in Maureen Seaburg's *Tasting the Universe.* Synesthetic experiences are often recounted as being deeply emotional in Seaburg's interviews with synesthetes, some going so far as to compare the experience to a spiritual enlightenment (Seaburg 88). Cytowic goes on to propose that synesthesia is within all of us. From the neurologist's perspective, synesthesia is actually a normal brain function that has simply been lost from the consciousness of most people. He dubbed synesthetes as "cognitive fossils" that have simply retained this cognitive function in their consciousness (167). Synesthesia can be simply thought of as an "ability to understand something directly without knowing how you understand it" (116). Emotion is the link that gives us this noetic, tacit understanding in multisensory experiences, "[giving] us our intuitive sense of what is correct and what goes together" (192).

This point is illustrated beautifully by the painter Georgia O'Keefe, who sought to capture express and capture her emotions through her artwork. She stated:

> "I know I cannot paint a flower…but maybe in terms of paint color I convey to you my experience of the flower or the experience that makes the flower of significance to me at that particular time" (qtd. by Cytowic 116).

In other words, O'Keefe used color to convey the emotions she felt while experiencing looking at the flower. She hoped the paint colors would draw the emotions of whoever looked at her paintings and allow them to experience the flower as she did.

Reading *The Man Who Tasted Shapes* inspired me to draw out peoples' inert ability to make multisensory connections by appealing to their emotions through color.

<u>*Interactive Media – Aural Augmented Reality*</u>

Augmented Reality (AR) integrates a layer of a virtual reality to the real-world environment. It can be defined as a medium that "combines real and virtual," "is interactive in real time," and "is registered in three dimensions" (Azuma 356). Aural Augmented Reality (AAR) manipulates the sound of the real world by layering a virtual sonic environment with the

real sonic environment of the user. Traditionally AR technologies have focused on visual applications, but the rise of interest in VR immersive experiences have inspired technological development in the audio realm (Kostek 1096).

Aural augmented reality experiences are designed to help the user see their reality in a new light. Rather than displacing the user from reality (virtual reality), augmented reality enhances the real-world environment of the user. After performing research on various AAR applications, I decided to incorporate a live audio input rather than a recording in my thesis so that the user may remain grounded in the reality of their own voice. Rather than displacing the user from reality, I wanted the user to hear their own voice expressed in a new light so that they may have a more personal and interactive experience.

Color Psychology

My final preparation for this project was research on color psychology. Although people's responses to color are somewhat subjective, there are common patterns in relation to certain colors. I specifically researched the colors: pink, red, orange, yellow, green, blue, violet, and black. Notes on the psychology and complexity of emotions associated with these colors are outlined below (see Table 1).

Table 1: Color Psychology Chart

Color	Psychology	Emotions	Helps you feel	Characteristics
Pink	-Calmness, romance, kindness, nurturing -Love, femininity -Joyful, creative, vibrant -Euphoric, refreshing	-Compassionate -Admiring -Sweet -Immature -Playful	-Energetic -Motivated -Fascinated -Creative	-Sensitivity -Tenderness, nurturing -Sense of safety and vulnerability -Tranquility
Red	-Oppositional: love and passion, anger and power -Instantly grabs people's attention -Linked with danger	-Excited -Energetic -Strong -Passionate -Emotional	-Stimulated -A sense of urgency -Attentive -Cautioned -Encouraged	-Passion and drama -Associated with strong emotions such as love and anger -Vibrant and exciting
Orange	-Energy, enthusiasm, attention, happiness -Excitement, warmth, compassion -Refreshing (citrus)	-Optimistic -Confident -Adventurous -Sociable -Creative	-Stimulated -Attentive -Free -Fascinated -Fun	-Extroverted -Encouragement -Exudes happiness and joy -Appealing to young people -Releasing inhibitions
Yellow	-Warmth, brightness -Energy -Attention -Frustration	-Happy -Enthusiastic -Spontaneous -Positive	-Stimulated -Relaxed -Awoken -Uplift mood	-Optimistic -Youthful, fresh energy -Uplifting and illuminating -Success and confidence
Green	-Nature, safety -Luck, envy -Refreshing and tranquil -Optimistic and relaxing	-Fresh -Balanced -Reliable -Harmonious	-Relaxed -Revitalized, healed -In nature -Refreshed, peaceful	-Growth and health -Abundance, plentiful environment -Restful and secure
Blue	-Calmness, stability, productivity -Sadness -Feelings of calmness and serenity	-Trusting -Loyal -Competent -Serene -Peaceful	-Reduce stress -Create calm -Relax -Secure -Create order	-Instils trust and confidence -Induces calm and conveys serenity and peace -Feelings of loyalty, integrity, and responsibility
Violet	-Mystery, imagination -Wealth, royalty -Sensual, lush -Tactile, musky aromatic	-Imaginative -Spiritual -Compassionate -Sensitive	-Luxurious -Royal -Creative, inspired -Wise, ambitious	-Spirituality, introverted -Inspires reflection and self-awareness
Black	-Mystery, boldness, power -Evokes feelings of anger, aggression, and fear -Sadness, unhappiness	-Powerful -Controlled -Elegant -Secure	-Dramatic, intimidating -Feared, with authority -Mysterious -Hide feelings	-Formal, sophisticated -Covers and hides, mystery -Strong and powerful -Fear and evil, pessimism

III. Methodology

Step 1: learning Ableton Live and grandMA2 lighting console

My approach to completing my project was to take it step-by-step. I was not familiar with the grandMA2 lighting console or the Ableton Live digital audio workstation prior to this project. I also did not yet know how I was going to connect the whole system together when I started working on my thesis. With this in mind, my goal at the start of the project was to work in patience. I would tackle one thing at a time, slowly but surely.

I started in the area I was most unfamiliar with – programming lights. I spent a couple of weeks over winter break watching grandMA2 video tutorials, scouring the grandMA2 help pages, and doing some hand-on training at the board in Massey Performing Arts Center. Over several sessions in the concert hall, I got more comfortable programming and created some basic color-themed lighting cues. Then, I started training myself in Ableton Live. I did some basic tutorials in the DAW and read up on the plugins available in Max for Live to learn the capabilities of the system.

Step 2: Connecting audio and lighting

After getting familiar with using Ableton Live and the grandMA2, I started working on how to connect them together. I was particularly curious in the "pitch tracker" Max for Live plugin that tracked the pitch of an audio input and outputted midi note data of the pitch. I wondered if I could send this midi note data to the grandMA2 so that every pitch would trigger a corresponding color cue. I connected by laptop to my interface, and my interface to the lighting console via a midi cable. After reading through the midi remote control section of the grandMA2 help pages, I went through a process of trial and error on the console until I reached success. I cannot begin to describe how excited I was when I played an A4 into the microphone and the lights turned red.

Next, I connected the audio output of my interface to the sound input on the grandMA2 console. I read up on the sound input triggers section of the grandMA2 help pages and learned that audio input peaks may trigger cues within an executor and that the BPM of the audio is tracked by the console. I created a simple executor named "dim" that simply increased the dim value or brightness of the color washes when it sensed a peak in audio. I also experimented with various lighting effects, looking at pan/tilt movements and dim ramp effects to see how fast and how well they reacted to the audio input's changing BPM value. I found that the BPM tracker was a bit slow in responding to the audio input, so I decided to keep its influence subtle on the effects.

Step 3: Programming lighting cue stacks and audio plugin chains

As the spring semester started, I scheduled time to program in Massey Concert Hall three times a week in 3hr time slots. I created eight basic lighting cue stacks named: PINK, RED, ORANGE, YELLOW, GREEN, BLUE, VIOLET, and BLACK. Every stack started with a 'home' cue: a color-themed look with no movement. Then, I added a 'movement' cue that introduced some lighting effects triggered by the sound input. For some executor stacks, I added an extra cue triggered by time that took the movement cue back to the home cue.

When I got to a good place with lighting, I began working on the audio portion of the project. At this point, I had done research on color psychology and had come up with how these feelings may translate sonically for each color. I created 8 audio tracks in Ableton Live labelled: PINK, RED, ORANGE, YELLOW, GREEN, BLUE, VIOLET, and BLACK. I put on my headphones, bypassed the "RED" channel, and started experimenting with plugins. After about 30 minutes to an hour, I had created something that sounded more like the color black to me. So I renamed the "RED" channel "BLACK." Then, I went back to the black lighting cue. Listening to my audio effects, I adjusted my lighting effects to better reflect what I had created sonically. Then I curated the fade and attack times of the lighting cues to best respond to the onset and decay of the sound.

I went through this same process of creating an audio plugin chain and readdressing the corresponding lighting cue over multiple weeks. Typically, I would finish one audio/lighting combo per work session. It was not uncommon that I would start working on the audio with one color in mind and then feel it sounded more like another color halfway through my work. The second audio track I tackled was "ORANGE," which turned out to be "PINK;" and what started out as "BLUE" became "VIOLET." One-by-one, I went through the colors and started to bring the project together.

Step 4: Configuring a control midi system

As I was making way on programming the audio and lighting for the project, I began thinking about how best to configure the system for user control. First, I tried connecting everything with a midi keyboard borrowed from my thesis director, Dr. Ko. I created an excel sheet detailing all the midi mapping, with each note corresponding to a semitone and audio/lighting function. I programmed each key of the midi keyboard to either turn a lighting color cue on or off, writing in the grandMA2 midi remote page the commands "Fader 7.6 at 100" or "Fader 7.6 at 0." Then I programmed launch pads to toggle the record enable button for each audio channel in Ableton Live.

This method worked, but I soon realized this could not be the final solution. Using a midi keyboard worked great for me to control the system as long as I was working in the lighting booth, but I needed a way to control everything from the stage. At first, I was thinking I could have the keyboard, laptop, and interface on stage, then connect a long midi cable from my interface to the lighting console. But the maximum length for a midi cable is 50 ft, and the stage is over 100ft from the lighting booth. Then, I began to look into wireless midi options, hoping that there may be a way to wirelessly connect the keyboard on stage to my laptop at the lighting booth. I only found Bluetooth options that would be too risky to perform at that distance and only worked with certain midi keyboard models.

Then I began looking into iOS applications that could act as an Ableton Live controller from my iPad. My thesis director recommended TouchOSC, an app created by Hexler that allows one to send and receive MIDI and OSC messages to their DAW over Wifi. I downloaded the Touch OSC app on my iPad and the editor on my laptop. I configured some toggle buttons to send the same midi notes that I had previously programmed on the keyboard. It worked, but it was clunky. The midi message only sent when toggled on and did nothing when it was toggled off. I could not figure out how to fix the issue, so I changed the toggle buttons to a push buttons.

I created one "sound" page with 8 push buttons labelled with feeling words and a second "color" page with 16 push buttons labeled "color ON/OFF."

Step 5: Adding Midi tracks

At this point in my thesis work, a snowy winter storm hit Nashville and I was forced to stay home for about a week. I still had some audio and lighting scenes to work on and was disappointed I couldn't go in to MCH to work on lights. But working from home gave me the opportunity to really focus on the audio portion of the project. With what felt like an abundance of time to work in Ableton, I began to get a bit bored and impulsively started adding midi tracks to some of the audio scenes. I found samples of nature sounds and added rain and bird tracks to "GREEN." I created a shepherd's tone and some low-end beats for "RED." I found an icy swelling pad for "BLUE" and light strings for "YELLOW." I even experimented with adding an E Piano pad and some harp sounds to "VIOLET" but ended up scratching it.

As I was nearing the finish line with the audio work, Ableton Live started crashing incessantly. It kept giving the error message, "A serious program error has occurred. Live will shut down after this message box is closed." It turns out there were too many plugins active in the session at one time and my computer was experiencing CPU overload. Because this error would occur immediately when the session was opened, I had to open an old backup file to troubleshoot. I resolved the issue by bypassing all of the plugins and programming Touch OSC to un-bypass all the plugins on the channel when it was active.

Step 6: Making final improvements

When I completed my work on the project, I had committee members Dr. Ko and Mr. Summers use my thesis in Massey Concert Hall to get their feedback. My main takeaway from their initial use of the system was that the GUI needed improvement. The cues needed to be deactivated in order for the system to run properly, but the interface did not show which buttons were currently active. It was also ineffective to have the sound functions and lighting functions on different pages, as it was hard to tell which audio and lighting cues were supposed to go together.

I went back to the Touch OSC editor, put all of the buttons on one page, and sat down to figure out how to make the toggle buttons work. After reading through the sparse info on the Touch OSC website, I went through a process of trial and error between the app and Ableton Live. Eventually, I found that changing the midi "type" from note to control change solved the issue for triggering audio cues. I simply used different CC numbers instead of different midi notes to differentiate audio triggers. Now, toggling off effectively un-bypassed the plugins and channels on that audio cue.

This solution, however, would not work for lighting – the grandMA2 midi remotes only followed midi note values. I had to find a way to program differently in the grandMA2 rather than in Touch OSC. In the MIDI Remotes page, I changed the trigger type from command (CMD) to executor (Exec). Then, I set the button to be controlled to "Fader." So instead of having the midi note trigger a command line such as "Fader 7.7 at 0," I had the midi note select executor 7 directly and control its fader. So now, toggling on in Touch OSC put the fader at 100 and toggling off put the fader at 0. After making these final improvements, my work on my thesis was done.

IV. Technical Specs

Audio (Ableton Live)

Channel:	Sonic Goals:	Plugins Used*:	Midi Tracks:	Notes:
Pink (Playful)	Warm timbre, silly and playful delay effects Subtle and simple (pure and childlike)	Antares Auto-tune EFX, Baby Audio Magic Switch, Grain Delay (Bubbles), Waves H-Delay, Waves RVerb, Waves AR TG Mastering Live	N/A	
Red (Passionate)	Strong, distorted sound Loud, instantly grab your attention Shepherd's tone	Simple Pitch Shift, Waves GTR Stomp, iZotope Vocal Doubler, Convolution Reverb (ALBCR Air 1), Waves REQ4	Shepherd's Tone, Rhyt Mo 5	
Orange (Energetic)	Light sounding, misty reverb Pinging percussive delays bouncing around the space	Antares AVOX WARM, Waves H-Delay, Convolution Reverb (EDSP7500 Magic Echo), Waves Abbey Road Plates Reverb, Waves AR TG Mastering Live	N/A	Multiple H-Delays routed through Waves Studio Rack
Yellow (Optimistic)	Chorus effects, plate reverb "imprints" Light strings A bright, yet warm sound	Waves Q1, Baby Audio Magic Switch, Waves H-Delay, Chorus, Harmony Engine, Convolution Reverb (ABLCR Chord String), Waves Abbey Road Plates Reverb, Warm Up Highs, Waves AR TG Mastering Live	Off-World Strings	Harmony key of C major high octave
Green (Refreshed)	Sounds of nature: rain, birds chirping Harmonizer, wide stereo image, hall reverb A full, balanced sound	iZotope Vocal Doubler, Antares Harmony Engine, Valhalla Space Modulator, Waves Scheps 73	ADM Mode Bird Synth, ADM Mode 80's VHS Rain Synth	Harmony key of G major, space mod used as delay/reverb
Blue (Serene)	Ambient, washy pad "waves" of sound Quiet, soft timbre with reduced high end	Convolution Reverb Pro (01 Real Plates), Waves AR TG Mastering Live	EM_Onsen O	
Violet (Reflective)	Deep, luscious sound with suppressed high end Minor-chord harmonizer, hall reverb	Remove, Warm Tube, A Bit Warmer, Antares Harmony Engine, Waves MondoMod, Convolution Reverb (ABLCR Chord String), Waves Abbey Road Plates, Scheps 73	N/A	Harmony key of D natural minor
Black (Mysterious)	Indistinct disorienting background noises Distorted, screeching noises, low octave pitch shift Whispery vocal sound	iZotope Vocal Doubler, Low Tone Flutter, Wide and Dirty, Large Space Chorus, Waves AR TG Mastering Live, Brainworx bx_subfilter, Convolution Reverb Pro (Arundel Neve)	N/A	

*all plugin chains began with the Waves C1 comp as an expander to reduce noise (the lights/hazer were very loud on stage).

IV. Technical Specs (contd.)

Lighting (grandMA2)

Executor:	Lighting Goals:	Cues (trig, trig time, fade)*:	Effects**:	Notes:
Pink (Playful)	Deep pink wash Wanted spots to spin almost like a little girl spinning in a dress Fast dim effects to reflect audio delay effect	Cue 1: Time, 2, 0 MOVEMENT: Sound, All, 0 Cue 3: Time, 2, 2	R2 P/T Cross, R2W Circle, RQ7 Dim Ramp, ZW DIM, All LED DIM RAMP	Spinning gobos Fast dim effect Back and forth L/R movement with R2s
Red (Passionate)	Fiery red wash Yellow/orange rays in front of user Dramatic dim and movement effects	Cue 1: Time, 1.5, 0 MOVEMENT: Sound, All, 0.25 Cue 3: Time, 1, 1.75	ZW DIM, All LED DIM RAMP, R2 P/T Cross, R2 Spot Dim, R2W dim all	Fast dim ramp: all LEDs R2W movement
Orange (Energetic)	Citrus orange wash Lights to flash from left to right with audio ping delay Soft spotlights	Cue 1: Time, 2.25, 0 MOVEMENT: Sound, All, 0.25 Cue 3: Time, 1, 2.23	ZW Front/Back dim, R2 Spot dim, ZW tilt sym, RQ7 dim ramp	LED washes dimming L and R with ping delay Washes positioned slightly more US during dim effect Slower spot dim effect
Yellow (Optimistic)	Sunlight yellow wash Twinkling spots Small, slow movements, sunbeam texture	Cue 1: Go, -, 0 MOVEMENT: Sound, All, 1.5	R2 spot slow dim, R2 slow cross	Subtle wash movement Twinkling spots with slow movement
Green (Refreshed)	Forest green color wash Spots yellow like sunrays through trees Small textural movements	Cue 1: Go, -, 0 MOVEMENT: Sound, All, 1.2	R2 P/T Cross, ZW Slow Tilt	Slow spot movement crossing position of user Some subtle movement with LED washes
Blue (Serene)	Icey blue color White spots skating across the floor	Cue 1: Go, -, 0 MOVEMENT: Sound, All, 10	R2 P/T Cross, ZW dim/tilt out, R2 spot dim	Spots slowly moving across the floor LED wash subtle movement
Violet (Reflective)	Deep, dark violet wash Simple and subtle, eliminating distraction	Cue 1: Go, -, 0 MOVEMENT: Sound, All, 1.5	Slow R2 P/T cross, ZW out	Very subtle LED movement
Black (Mysterious)	Dimly light with white spotlights on user Dramatic dim ramp effects	Spot 1: Time, 1, 0.5 HOME FLASH: Sound, All, 0	All LED dim ramp	Spots on chair All LED move into home position with dim ramp effect

*trig times and fade times given in seconds
**all effects tied to BPM of live sound input

IV. Technical Specs (contd.)

Control (Touch OSC)

Label:	Function:	Type:	Number:	Note:	Receive Notes:
Playful	Toggle Sound	Control Change	0	N/A	Record enable channel, bypass plugins
Passionate	Toggle Sound	Control Change	1	N/A	Record enable channel, bypass plugins, trigger midi clip playback, turn on midi channel
Energetic	Toggle Sound	Control Change	2	N/A	Record enable channel, bypass plugins
Optimistic	Toggle Sound	Control Change	3	N/A	Record enable channel, bypass plugins, trigger midi clip playback, turn on midi channel
Refreshed	Toggle Sound	Control Change	4	N/A	Record enable channel, bypass plugins, trigger midi clip playback, turn on midi channel
Serene	Toggle Sound	Control Change	5	N/A	Record enable channel, bypass plugins, trigger midi clip playback, turn on midi channel
Reflective	Toggle Sound	Control Change	6	N/A	Record enable channel, bypass plugins
Mysterious	Toggle Sound	Control Change	7	N/A	Record enable channel, bypass plugins
Pink	Toggle Color	Note	N/A	84	84, All, Exec, Current, 6, Fader*
Red	Toggle Color	Note	N/A	88	88, All, Exec, Current, 7, Fader*
Orange	Toggle Color	Note	N/A	91	91, All, Exec, Current, 8, Fader*
Yellow	Toggle Color	Note	N/A	95	95, All, Exec, Current, 9, Fader*
Green	Toggle Color	Note	N/A	98	98, All, Exec, Current, 14, Fader*
Blue	Toggle Color	Note	N/A	101	101, All, Exec, Current, 11, Fader*
Violet	Toggle Color	Note	N/A	105	105, All, Exec, Current, 12, Fader*
Black	Toggle Color	Note	N/A	107	107, All, Exec, Current, 13, Fader*

*grandMA2 midi remote settings: Note, Channel, Type, Page, Executor, Button

V. Reflection

On April 2nd-5th, I was able to showcase my project to friends, family, and professors. It was informative and fun to see how different people interacted with the project. Some people were in and out in 5 minutes, while others used the system for over 30 minutes. Some of my musician friends unabashedly sang into the microphone, while others had to be coaxed into saying a few words. Some people took it at a slow pace, thoughtfully picking out colors and sounds to experience. Others raced through the scenes and tried pairing every emotion with every color theme. Most people would interact by humming, speaking, or simply listening to the audio scenes with midi tracks while observing the lights respond around them.

I was able to talk briefly with those who demoed my project about their experience, and I noticed a few common themes. Many people expressed that they felt like they were on a different planet while they were on stage. The experience took them to a new reality. Most said that the feeling words and audio connected well with the color it was intended for, but "didn't work" with the other colors. A few users preferred some feeling words with other colors. Some described ways in which combining a sound to different color themes (or vice versa) made them respond to the same sound (or lighting cue) with a different emotion. But there were some common threads: several users said verbatim that they felt as if they were "floating" while they were experiencing the "Optimistic"/yellow scene. Many people felt as if they could sit and reflect in the "Serene"/blue and "Refreshed"/green scenes forever, and some did for about 15 minutes. Of those who used the system for over 10 minutes, many said they felt a sense of calm afterwards. I am happy with the feedback I received from people about the project, as I feel this shows how the system prompted people to explore the connection between their feelings, colors, and sound.

I would love for a project like this to be featured in a modern art museum, or perhaps be a travelling exhibit. Some improvements would have to take place before this went public, however. First, the system would have to be made more "fool proof." The system does not work as intended if more than one audio or lighting cue is active. With how my GUI was set up, however, it was possible for the user to "break the rules" and activate as many buttons as they wanted. To remedy this, there would have to be an automatic "toggle off" function that deactivated all other buttons whenever the user toggles on any button. Secondly, every audio cue should have some ambient recorded sounds or midi clips looping in the background to help the experience connect with more people. I noticed that some were more inclined to listen before they spoke into the microphone and were shy about interacting with the system if greeted by silence. Finally, I would improve the project by linking each feeling scene to certain lighting effects so that different color themes would connect more effectively with each audio cue. Then, if a user selected a different color, it would only change the colors and not how the lights responded to their voice. Since the lighting effects were programmed specifically to match what was happening with the audio, some lighting cues did not go so well with some audio cues.

VI. Conclusion

This paper began by describing the emotional core to multisensory experiences, the definition and goals of interactive augmented reality experiences, and the complexity of emotion associated with color psychology. Next, my creative methods and the process of completing the project was outlined in detail. Technical specifications were then given for audio, lighting, and control data programming in Ableton Live, grandMA2, and Touch OSC. Finally, the paper reflected on the response of friends and family to the project and judged what should be done to improve the audio/visual experience before it may be released commercially.

My thesis journey has been a long one. The project has greatly evolved from my original idea sophomore year[1], but the central theme has stayed the same: exploring the relationship between sound, color, and emotion. I am grateful for every friend, classmate, and professor who encouraged me to pursue a project that sounded so big and intimidating to me at the start. I would like to thank my thesis director Dr. Doyuen Ko and my committee member Adam Summers for trusting me enough to commit themselves to my project when I was a sophomore, and for their helpful advice in my work this semester. I would also like give a special thanks to Bret Bell, Rusty King, and Teresa Driver at MPAC for allowing me so many hours of access to Massey Concert Hall to complete my project, which I am very grateful for.

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[1] I submitted my prospectus a year early in order to study abroad the spring of my junior year.

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