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Musical Murals - Augmented Reality Audio Experiences

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Abstract

The appearance of Pow! Wow! Worcester murals of Worcester Massachusetts have become an annual tradition in recent years. The goal of this project is for users to experience complementary audio for the murals in a walking tour around the city. The results of this project showed evidence of a psychological connection between emotions experienced while looking at certain colors and listening to certain sounds, to determine accurate pairings of audios and visuals.

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Acknowledgements

I would like to thank my project sponsors WICN Radio Station and Pow! Wow! Worcester Murals. Their enthusiasm and insight helped shape this project. I would like to thank professors Joseph Cullon and Richard Falco for their expertise in working with WICN and Pow! Wow! Worcester. I would also like to thank Professor Scott Barton as my advisor for this project. I appreciate your support during the completion of this project.

Executive Summary

Human emotion is something that can be changed and shaped as we experience different things. Every aspect of our own lives alters our own individual emotions. For my IQP, I have done research to create emotional and entertaining experiences for residents of Worcester, Massachusetts to enjoy by combining the art of Pow! Wow! and the music that complements its inspirations with augmented reality (AR).

This project used the Bose Frames, a pair of augmented reality sunglasses that have speakers on the arms (Wearables by Bose). One of the goals of this IQP is to utilize this technology to create an augmented experience for a user of the Bose Frames to enter, that will give them an augmented reality experience in the real world. Another of the goals for this IQP is to introduce a medium from WICN, this project's sponsor, that appeals to a younger generation of listeners. By using the Bose Frames and a more recent compilation of geographical information and entertainment, a younger audience could be obtained. This medium will be in the form of audio tours of the spectacular art of Pow! Wow! in Worcester. Pow! Wow! Worcester is an art festival that takes place annually in New England around the Worcester area. Artists participate by painting magnificent murals in different locations around the city. The murals are the main focus of our augmented reality audio tours. Through the interface of an online website, worcestermuraltour.com, owners of the Bose Frames will be able to listen to the musical and auditory representations of the artforms that they stand before. This website allows people to look at a mural and listen to audio that complements the artists purpose and emotional intent, thus creating an augmented reality experience for their entertainment.

This project attempts to bridge the gap between audio and visual interpretations of art. A mural the size of a building represents emotions and feelings that can also pertain to a certain song or sound. The use of the Bose Frames in this project fills the space between the paint on the wall and the person looking at it.

The phenomenon of visual and auditory cohesion is something that has been interpreted and studied differently many times. To begin to understand how music compliments color, we have to understand how color affects emotion. A study done by K. Warner Schaie in 1961, had a total of 44 subjects, each describing the colors blue and red, in terms of the emotions they felt from them (Gunn, 2002). The subjects chose to describe blue as "secure, comforting, calm, peaceful and serene", whereas red was described as, "protective, defending, powerful, strong and masterful" (Gunn, 2002). In 1964, another study was done with schizophrenic patients and drawings they made (Gunn, 2002). The subjects' drawings were analyzed and put into two groups; a warmer color group that consisted of a red color palette, and a cooler color group consisting of a blue color palette. The warmer group was composed of subjects who were more extroverted and involved in society, whereas the cooler group was composed of a more introverted and self focused sample. In terms of psychology, red was shown to stimulate the

sympathetic nervous system, associating with arousal and stress, while blue was shown to stimulate the parasympathetic nervous system, which is associated with resting and relaxation (Gunn, 2002). In other words, the color red is proven to be a color that inspires action and intensity, while blue is proven to inspire the opposite. The murals of Pow! Wow! Worcester, are all composed of entirely different color palettes, as well as art styles, shades of color, size, shapes, and overall themes in general. Given the relationship between color and mood, I wondered how the vivid color palettes of the Pow! Wow! murals inspire or affect the emotional experience of viewers.

After understanding how color can affect emotion, it is time to take it a step further and understand how music can have the same effects. Throughout history, music has been used as a method of healing, focus, inspiration and most importantly expression. Philosopher Francis Sparshott claimed that there are four different phenomena linking music and emotions (Sparshott, 1994). “People tend to value music because it expresses and induces emotions” (Juslin & Laukka, 2004). Patrick Juslin talks about the theoretical mechanisms in which music may be used to express emotions. One of these mechanisms is mood contagion, in which people may easily “catch” the emotions of others when seeing their facial expressions or hearing their vocal expressions, perhaps through primitive “motor mimicry” (Juslin & Laukka, 2004). What this means is that by listening to music, we are able to interpret the emotion given by the artist and allow it to change our mood in real time. By composing, performing and listening to songs, we are aware of them and think the same way about them as we would to any other object in our environment in relation to ourselves.

The objectives for my project were as follows:

- Create pairings of audio to the 2019 Pow! Wow! Worcester murals that complement the art in a way that inspires a certain connection to a person taking a tour. Enable the tours to be listened to using the Bose Frames.
- Create a tour on worcestermuraltour.com of the 2019 murals that use the pairings I have created.

To accomplish my first objective, data was required to help determine pairings to the murals. One of the methods I used to collect data for my research was to create a survey about selecting musical pairings for the murals. The goal of this survey is to find out what music people would pair with the murals while looking at them. Another form of data collection to accomplish my first objective was to conduct interviews with professionals in both the visual arts and auditory arts. I contacted the artists of Pow! Wow! Worcester 2019 to give me insight on their work in terms of what inspired them and what they had hoped to inspire in others.

The second objective of this project was accomplished by using design tools such as Curatescape, a web and mobile app framework for publishing location-based content using the

Omeka content management system. The tour can be created on curatescape using HTML and CSS code as well as embedding the necessary Unity build information.

The data from my survey showed some correlation between which music people connected with certain murals. For example, of the 14 responses for the mural by Aaron Powers, the majority of the responses were directed towards calmer, slower paced music and sound such as ambience, Jazz and Folk. This helps to prove the connection between color, music and mind as the colors of the mural are mostly deep blues and greens. Both of these colors also were shown to invoke a calmer and slow paced way of thinking in my research.

On the other hand, data regarding the mural done by Matt Gondek, shows how a mixture of different tones, shades and themes in color in a mural, can lead to drastically different responses in terms of musical pairings. As you can see the genres suggested include but are not limited to: hip hop, parody, horror, metal and punk rock. All of these genres are different in nature, with the exception that they mostly represent faster paced, more aggressive sounding music.

Professor Falco, of the Humanities and Arts department at WPI, runs WPI's Jazz history database as well as is a professional at finding art and music pairings from his research. I spoke with Professor Falco about each mural of the 2019 Pow! Wow! Worcester festival and had a conversation about what he might pair with them. "A painting is never static", said Falco when I asked him why he believes art can always speak to a viewer (Falco, 2020). He said that visual art has layers that need to be examined and understood by someone who is observing it. These layers are something that can make us feel something we don't even realize. In turn, the feelings we get from these layers can correlate to music. For example, the mural by Lena McCarthy, he paired with music that was more of a solo piano; something with one calming instrument to complement the blue layers in the painting. He recommended artists such as Cecil Taylor, Rufus Reid and Muhal Richard Abrams.

One of the artists, Czr-Prz, or Caesar, has been an artist since his teenage years and got involved in Pow! Wow! through personal connections. This mural of a bird and a fish morphing into one confluent animal was inspired by Caesar trying to show how two vastly different things can still be similar and work together to create something beautiful. Something important to notice in his work is that the colors of red and blue are both shown in great quantity, but are working together. Caesar's goal for this mural to inspire in his viewers was "for people to become creative and feel free". This perfectly embodies the emotions that the colors red and blue were shown to represent.

To complete my second objective, Professor Cullon cloned worcestermuraltour.com and assigned it to the domain http://bosikiqp.com. This domain is where my current prototype for the tour resides. I was able to use the curatescape framework of Omeka to design each stop on the tour as an "Item". These items each contain different fields such as: map location, site description, artist media url, image, and of course music file. The items could then be loaded into a tour and organized in any way I saw fit. I created a tour that involved 13 of the 18 murals that

were within 3.3 miles of each other. The audio embedded in each stop can be played through the users mobile device by pressing the “Play” triangle button. Volume can also be adjusted on playback. This playback can be transmitted through the Bose Frames if the listener has connected the Frames to their mobile device via Bluetooth.

One of the biggest challenges that I had encountered throughout this project was data collection. The data collection methods I used consisted of online surveys, in person interviews and phone call interviews. All of these methods had flaws in their execution, mostly relating to timing and poor communication. Another challenge I faced regarding the survey was collecting a proper amount of responses. I had posted surveys on the same sub-reddit forum r/SampleSize in the past and had gotten over 100 replies. For this survey, I had only received 14 responses. In the future, if I were to create a survey that long, I would plan to incorporate a reward for completion such as a raffle prize for all participants. Also, another way I could have gotten more responses would have been to release the survey on more than one platform. I had only gotten clearance from WPIs IRB to release the survey on this subreddit, but more input from other locations could have increased sample size.

The main conclusion from my IQP is that there is a connection between music, murals and mind. Through research and practice, I was able to determine that certain types of music are more fitting to certain types of art. My research has shown me, for example, that the color red invokes a more intense, angry emotion, while the color blue brings out the calm in an individual. This relates to my survey data in the sense that there is a correlation between the color red and intense, angry music, while blue correlates to a slow, relaxed genre.

To continue this IQP in the future, I would recommend that a researcher look into more augmented reality implementation of these findings such as working with the Bose Frames. Although my IQP will work with a Bluetooth paired set of the Frames, the hardware in the device is not used to its full extent. There are code libraries that could be further developed to create compatibility with the Bose SDK and WebGL, allowing for the use of the Frames on an online web application.

Another recommendation I have would be to utilize either WICN’s or WPI’s Jazz History Database to get a more solid selection of songs to be paired with the 2019 murals and future murals to come.

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Introduction

"Where words leave off, music begins." -Heinrich Heine

Human emotion is something that can be changed and shaped as we experience different things. We, as people, become happy at the sight of a rainbow or hurt at the loss of a loved one. Every aspect of our own lives alters our own individual emotions. Art, both visual and auditory, have proven to be huge affectors of our mood and feelings when they are in our presence. For my IQP, I have done research to create emotional and entertaining experiences for residents of Worcester, Massachusetts to enjoy by combining the art of Pow! Wow! and the music that complements its inspirations with augmented reality (AR).

This project used the Bose Frames, a pair of augmented reality sunglasses that have speakers on the arms (Wearables by Bose). The speakers, resting on the exterior of the user's ears, allow external sound to enter the ear. This provides an additive listening environment where the audio coming from outside the frames can be heard in addition to that coming from the Frames. One of the goals of this IQP is to utilize this technology to create an augmented experience for a user of the Bose Frames to enter, that will give them an augmented reality experience in the real world.

This project's sponsor, WICN's main audience is people within the age group of 50-70 and avid jazz music listeners. One of the goals for this IQP is to introduce a medium from WICN that appeals to a younger generation of listeners. By using the Bose Frames and a more recent compilation of geographical information and entertainment, a younger audience could be obtained. This medium will be in the form of audio tours of the spectacular art of Pow! Wow! in Worcester. WICN and I worked together to discuss new ideas on how we can use the Bose Frames to appeal to a younger audience.

Pow! Wow! Worcester is an art festival that takes place annually in New England around the Worcester area. Artists participate by painting magnificent murals in different locations around the city. The murals are the main focus of our augmented reality audio tours. Through the interface of an online website, worcestermuraltour.com, owners of the Bose Frames will be able to listen to the musical and auditory representations of the artforms that they stand before. This website allows people to look at a mural and listen to audio that complements the artists purpose and emotional intent, thus creating an augmented reality experience for their entertainment.

This project attempts to bridge the gap between audio and visual interpretations of art. A mural the size of a building does more than just look nice. It represents emotions and feelings that can also pertain to a certain song or sound. The use of the Bose Frames in this project will allow the augmentation of sound in a tour, thus making users hear the emotion in the art as well as see it. The bose frames fill the space between the paint on the wall and the person looking at

it. They allow for an entire third dimension to bridge the air around the mural with sound complimenting the art. Augmenting the users interpretation of the art with sound and music.

Background

This project was created and powered through the help of multiple sponsors. WICN Radio Station was a key sponsor in the creation of this project by providing the Bose Frames audio sunglasses for me to work with. They helped create the idea to work with the other sponsor Pow! Wow! Worcester to generate audio tours using the frames.

1.0 WICN Radio Station

The sponsor of this project is WICN Radio Station, a jazz radio station in New England that was founded in 1969. Their programming mainly consists of blues, classical, folk, bluegrass, jazz, rock, new age, cultural music, public affairs, and community focus shows. WICN is an NPR affiliated radio station that began in 1969 as Worcester's Inter-Collegiate Network. They joined WPI and Holy Cross with other colleges in the area, and was accredited by the Corporation for Public Broadcasting in 1987 (WICN). WICN strives to offer their listeners, both new and classic alternatives to the canned selection of playlists that media giants play for their listeners. Their mission is to preserve America's living art forms of Jazz for generations to enjoy, speaks to why they wanted to sponsor this project. The station has many show hosts and DJs that can select from a large database of historical and new jazz genres to play to the public. The main audience of WICN is people within an older age range of 50-70 years. In order to appeal to a younger audience, WICN envisioned an augmented reality audio tour of the Pow! Wow! Murals in Worcester.

2.0 Pow! Wow! Worcester

Pow! Wow! is an annual art festival that takes place in many cities all over the globe. These festivals have artists from all around come and create murals on buildings and structures to liven up the communities. Each festival of Pow! Wow! has its own mission with it's own unique group of people. "Worcester's mission is being committed to bringing great public art to the streets and making it as accessible as possible to the public.", said Lisa Drexage, the lead coordinator for Pow! Wow! Worcester (L. Drexage, personal communication, 2020). Pow! Wow! has been in Worcester since 2016, planning annual festivals since then. The 2019 festival had 18 artists, each making a mural in areas that "needed some love" according to Drexage (L. Drexage, personal communication, 2020). For example, an area of Worcester called Great Brook Valley is a community of mostly single mothers and less fortunate families. The streets of the community used to be dull and uninviting to a visitor, but Pow! Wow! wanted to change that. During the

2019 festival, artists such as Jason Naylor, Lillipore and Isabelle Ewing, got involved with the members of the community to show them the wonder of creating a mural and creating life on the side of a building.

2.1 worcestermuraltour.com

WPI Professor of Humanities and Arts Joseph Cullon has worked on projects involving Pow! Wow! in the past and was able to provide me access to his website: worcestermuraltour.com. This website was one of the projects that he had done with Pow! Wow! previously, and soon became one of my main objectives in my project. The website consisted of three main tours of the murals: from 2016 to 2018. Each tour consisted of multiple sites to see the murals painted in that year along with embedded GPS navigation and descriptions of the sites. A screen capture of one of the stops on the 2018 tour can be seen in Figure 1.

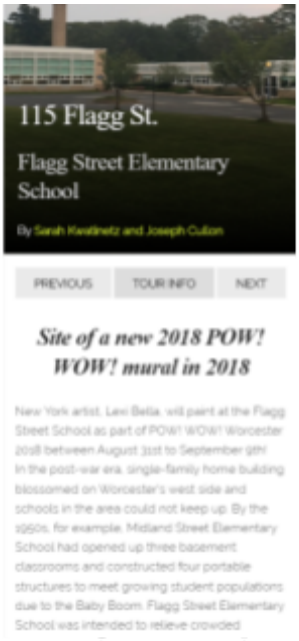

Figure 1 - Screen capture of stop on worcestermuraltour.com

3.0 Bose

The tours that I would be creating in my project were intended to be used with the Bose Frames. Bose is a company founded in 1964 by a Massachusetts Institute of Technology Professor Amar Bose (Bose, 2013). Their innovation in audio technology has lead them to release the Bose Frames, a pair of technological sunglasses with built in speakers to the arms. The use of the Bose Frames for this project was one of the main factors to sculpt the final product.

4.0 Color and Mood

To begin understanding the "how" of the project, we must first understand the "why". Why is there a need to pair audio with the art of the murals? The phenomenon of visual and auditory cohesion is something that has been interpreted and studied differently many times. Taking something that is meant to be looked at and incorporating a sound that not only matches the image but enhances the experience of looking at it, is a process that involves a lot of research. To begin to understand how music compliments color, we have to understand how color affects emotion. A study done by K. Warner Schaie in 1961, had a total of 44 subjects, each describing the colors blue and red, in terms of the emotions they felt from them (Gunn, 2002). The subjects chose to describe blue as "secure, comforting, calm, peaceful and serene", whereas red was described as, "protective, defending, powerful, strong and masterful" (Gunn, 2002). The adjectives found in 1961 not only define the emotions felt by the subjects but can relate to the psychological status of them. In 1964, another study was done with schizophrenic patients and drawings they made (Gunn, 2002).

The subjects' drawings were analyzed and put into two groups; a warmer color group that consisted of a red color palette, and a cooler color group consisting of a blue color palette. The warmer group was composed of subjects who were more extroverted and involved in society, whereas the cooler group was composed of a more introverted and self focused sample. In terms of psychology, red was shown to stimulate the sympathetic nervous system, associating with arousal and stress, while blue was shown to stimulate the parasympathetic nervous system, which is associated with resting and relaxation (Gunn, 2002). In other words, the color red is proven to be a color that inspires action and intensity, while blue is proven to inspire the opposite.

The importance of understanding how color affects mood directly relates to this IQP. The murals of Pow! Wow! Worcester, are all composed of entirely different color palettes, as well as art styles, shades of color, size, shapes, and overall themes in general. Given the relationship between color and mood, I wondered how the vivid color palettes of the Pow! Wow! murals inspire or affect the emotional experience of viewers.

5.0 Music and Mood

After understanding how color can affect emotion, it is time to take it a step further and understand how music can have the same effects. Throughout history, music has been used as a method of healing, focus, inspiration and most importantly expression. Music is a form of communication that can explain a deeper meaning or concept without even using words. Philosopher Francis Sparshott claimed that there are four different phenomena linking music and emotions (Sparshott, 1994). The first phenomena: people often have moods. People can be happy, sad, angry or anxious, in ways that affect how they feel about everything at a given moment. Second, people have reactive feelings towards events, people or things around them. Some examples are love, rage, hope and fear. These feelings are created because of an external source. Third, people classify objects based on the emotions it makes them feel. For instance, a small animal would be classified as 'cute' because of the joy it creates in a person. Fourth, the world around us directly influences our actions. Anything we do as humans is a decision that was made because of how we thought it would help (or hurt) our surroundings or ourselves. "The four kinds of phenomena may shade into each other, and in their most distinct manifestations may be both causally and semantically related to each other" (Sparshott, 1994). The reason this all relates to music is that we experience music as an object, affecting our surroundings. "People tend to value music because it expresses and induces emotions" (Juslin & Laukka, 2004). Patrick Juslin talks about the theoretical mechanisms in which music may be used to express emotions. One of these mechanisms is mood contagion, in which people may easily "catch" the emotions of others when seeing their facial expressions or hearing their vocal expressions, perhaps through primitive "motor mimicry" (Juslin & Laukka, 2004). What this means is that by

listening to music, we are able to interpret the emotion given by the artist and allow it to change our mood in real time. By composing, performing and listening to songs, we are aware of them and think the same way about them as we would to any other object in our environment in relation to ourselves.

6.0 What is Augmented Reality?

Augmented reality, or AR, is a new age form of human-computer interaction that creates elements in the form of visuals or audio to alter their current real-world surroundings, thus, augmenting their reality. This is different from virtual reality in the sense that virtual reality causes a user to be immersed in a fictitious or otherwise alternate location by use of a headset that covers the eyes and sometimes ears of the user. This shuts out the user's real surrounding environment from their senses, creating the immersive illusion of being in another reality. Augmented reality does the opposite, in the sense that it brings the fictitious or alternate elements to the user's real environment, adding onto reality instead of subtracting from it.

6.1 What makes sound 3D

Traditional 2-channel stereophonic playback systems are incapable of producing what is referred to as Binaural Audio, 'bi' meaning two, and 'aural' referring to your ears, or 3D sound (Feret 2017). This is because of something called "Crosstalk", which means the system relays sound to both ears at the same time (How 3D Audio Works, 2017). The problem being that when a person turns their head, the sound coming into their ears follows the movement instead of staying virtually within the same space. 3D sound is accomplished by using head related transfer functions or HRTFs, simulated audio reflections and reverberations that change depending on parameters such as room size (Choueiri, 2010). All of these would have to be done in real time which would normally be too complex in normal AR applications. However, there exist tools to handle these processing feats called software development kits or SDKs.

6.2 AR Use Examples

AR can be presented in many different unique ways because of its general definition. For example, one of the more popular AR mobile applications of the previous decade was "Pokemon GO" (Wingfield, 2016). This open world game uses the camera on a user's smartphone, to augment Pokemon to look as though they are within the real world in front of the player. The phone's GPS and gyroscope are used by the application to determine where the 3D rendered Pokemon should appear in relation to the player. As the player moves their phone around, the Pokemon appears to stay in place on the ground.

A European funded audio-augmented environment platform called LISTEN is a project that was meant to be a medium for users to coordinate their movements with sound and space (Zhou, 2004). A person wearing motion tracked headphones would be immersed in a digital

sound environment, hearing things such as a phone ringing. The headphone was equipped with two microphones that picked up sound in a 360 degree range from both sides. This would create an illusion of fake sound in addition to the real sound of the users surroundings. This is an example of augmented reality. The technology of this concept has since advanced and I am able to use it in my project in the form of The Bose Frames.

A study by the University of Singapore showed that there is a direct correlation between users being able to confidently identify the location of objects in space based on the three dimensional changing audio in a sound space (Zhou, 2004). The experiment had subjects move through a virtual space using augmented reality glasses that displayed objects in the space. The objects produced a sound that the subject could use to locate them. The subjects were to identify the location of the objects by using the sound. They first did this with a 2-dimensional sound that had a consistent volume in both ears of the subject. Then, a 3-dimensional virtual soundscape was used to simulate the proximity of the objects to the subject. Something to note is that the sound used in the virtual soundscape was exaggerated drastically to account for the small space of the test area. This is because normally, sound will not make a noticable volume change in a small area, so the test wouldn't be as useful. The results showed that the subjects were able to confidently identify the location of the objects significantly more when using 3D sound.

7.0 The Bose Frames

AR is used in more than just visuals. Auditory augmented reality is becoming more prevalent in today's world. Newer forms of technology allow us to experience audio in ways that we never could before. Bose, a sound hardware company, recently came out with their newest innovation in augmentation of sound: The Frames (Bose). The Bose Frames are sunglasses equipped with discrete and compact sound speakers that reside within the arms of the frame. The speakers rest on the exterior of the user's ear, thus transferring sound directly into the ear. The speakers do not obstruct the listeners ear canal in any way. This allows for all sound in the listeners real surroundings to freely enter, opposed to earbuds or headphones occluding or stopping sound from entering. This use of a non-invasive audio device, augments the user's perception of audio by adding sound to the already existing noise in the environment, making it a very useful form of AR.

7.1 Bose Developer SDK

For this project, I will be using the Bose developer SDK to allow Unity, a real-time simulation and development platform, to communicate with the Bose Frames (Bose Developer Portal). Unity has the capability to simulate a virtual environment that can be manipulated and sent to the Frames. One of the SDKs that could be used to help simulate spatial audio is the Google Resonance Audio SDK. This SDK includes components including 'ResonanceAudioSoundfield' which represents a full 360 degree spatial audio by encoding sound waves on a virtual sphere

around a listener, ‘ResonanceAudioRoom’ which simulates room effects for a particular space by introducing dynamic early reflections and late reverberation as well as using the transform properties of objects in Unity, and many other features. It also has the capability to simulate audio occlusion which happens when an object is in between a person and a sound source. The Resonance SDK offers a lot of potential in the simulation of virtual sound that could be used in the process of creating this project. Other SDKs such as OpenAL and FMOD can be used.

The Bose Developer SDK is a development tool that can interact with platforms such as iOS, Android, Windows and Mac. It can be integrated into Unity such that a developer can interact with Bose products’ functionality. The available hardware that the SDK can interact with includes the rotation of the device, the accelerometer and gyroscope, as well as gestures such as tapping and head movement. The SDK allows for BLE pairing to enforce a secure device connection.

8.0 Finding the Gap

Using the knowledge that visual art can have a direct impact on human emotion as well as listening to music can affect mood, we can see that there can be a connection between music and art. The issue that needs to be addressed is that the Pow! Wow! Worcester murals of 2019 can be improved by associating music to each art piece. This can be accomplished digitally using the Bose frames as a tool of augmentation to allow a person to look at the murals and listen to complementing music.

Methodology

1.0 Objectives

The objectives for my project were as follows:

- Create pairings of audio to the 2019 Pow! Wow! Worcester murals that complement the art in a way that inspires a certain connection to a person taking a tour. Enable the tours to be listened to using the Bose Frames.
- Create a tour on worcestermuraltour.com of the 2019 murals that use the pairings I have created.

2.0 Survey

To accomplish my first objective, data was required to help determine pairings to the murals. One of the methods I used to collect data for my research was to create a survey about selecting musical pairings for the murals. The goal of this survey is to find out what music people would pair with the murals while looking at them. The survey was structured on a Google form that had

only open ended answer boxes for participants to fill in. The survey was 18 questions, one for each mural and asked participants to name music that they felt was best fitting for each mural. They were also asked to say why they chose that music for each mural. I posted the survey on reddit.com/r/SampleSize, a subreddit dedicated for public surveys, to collect information on the opinions of the community. This particular subreddit has a population upwards of 120 thousand users that actively post and take surveys. I had used this subreddit to post a survey in the past and had received over 180 responses. The survey was anonymous and does not ask anything personal of the participants besides age. Participants were not required to put an answer for every question if they could not come up with one. Participants must put N/A if they could not answer a question.

3.0 Interviews

Another form of data collection to accomplish my first objective was to conduct interviews with professionals in both the visual arts and auditory arts. I contacted the artists of Pow! Wow! Worcester 2019 to give me insight on their work in terms of what inspired them and what they had hoped to inspire in others. I created a script that I sent to each artist that I would change certain values of, such as their name and mural location. Some of the questions that I had asked included: “What energy do you want your work to give or what do you feel it gives?”, “What audio (music, sound effects, environment) would you say your work pairs with or represents?”, and “What effect do you want your work to have on a viewer/ listener?”. I found artist contact information by searching their social media and online portfolios, and emailed all of the 2019 artists within the first two weeks.

I also scheduled interviews with various professors and professionals at WPI and WICN in order to aid my research and gain information on the topic. These interviews helped more to accomplish my second objective to give me more information about aspects such as technological development.

4.0 Website

The second objective of this project was accomplished by using the website’s built in design tools such as Curatescape, a web and mobile app framework for publishing location-based content using the Omeka content management system. The tour can be created on curatescape using HTML and CSS code as well as embedding the necessary Unity build information. The website’s backend handles the styling of the titles and descriptions as well as the included images. I am able to manually style my own audio elements to play music by incorporating my own code. In Figure 7, I show an example of one of the pages for a mural on the website. Included on the page is an element to host the audio source file, followed by an element that credits the artist and links to their online portfolio.

```
<div style="margin: auto; text-align: center;">
    <p style="font-size: 20px; margin: auto; padding: 20px;">Audio Pairing</p>
    <audio controls="controls">
        <source src="0ea9ca9a5232ced267a21ce2703fae8b.mp3" type="audio/mpeg" />
        Your browser doe's not support the audio tag.
    </audio>
    <p style="font-size: 20px; margin: auto; padding: 20px;">Website Portfolio</p>
    <div style="background-color: #222222; border: 1px solid #EAEAEA; border-radius: 50px;
    width: 200px; height: 25px; margin: auto; display: flex; align-items: center; padding: 20px;">
        <p style="margin: auto;">
            <a href="http://www.newantlers.com/" style="height: 100%; font-size: 20px; color: #ffffff; text-decoration: none;">Aaron Powers</a>
        </p>
    </div>
</div>
```

Figure 7 - HTML and CSS code for item elements on a tour

A rendering of what this code produces can be seen in Figure 9.

Figure 2 - Map of tour

On a larger scale, I created the tour using the Omeka content management system. Their user interface allowed me to create “Items” as stops on a tour with metadata such as location, preview image, and title, that I could then organize in my own way in a “Tour” as it is classified with Omeka. I then had Omeka organize these items sequentially as I had planned them. The sequence of stops on the tour was determined by myself plotting out a map of the 2019 murals and tracing the shortest route between them to see them all without backtracking. The ending route looked like what is shown in Figure 2.

Results

1.0 Survey Data

The data from my survey showed some correlation between which music people connected with certain murals. For example, of the 14 responses for the mural by Aaron Powers as seen in Figure 3, the majority of the responses were directed towards calmer, slower paced music and sound such as ambience, Jazz and Folk. This helps to prove the connection between color, music and mind as the colors of the mural are mostly deep blues and greens. Both of these colors also were shown to invoke a calmer and slow paced way of thinking in my research.

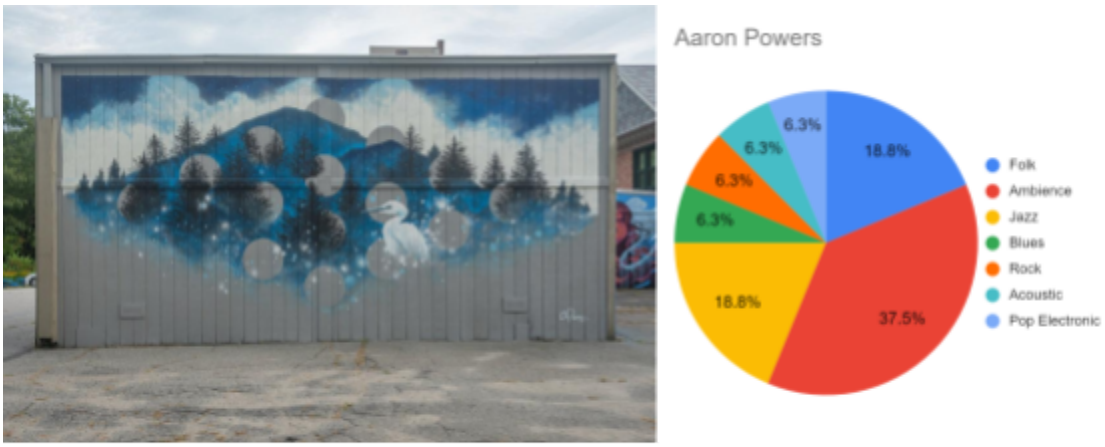

Figure 3 - Pow! Wow! Worcester 2019 mural by Aaron Powers and survey results for "What music does this mural make you think of?"

On the other hand, data regarding the mural done by Matt Gondek, as seen in Figure 4, shows how a mixture of different tones, shades and themes in color in a mural, can lead to drastically different responses in terms of musical pairings. As you can see the genres suggested include but are not limited to: hip hop, parody, horror, metal and punk rock. All of these genres are different in nature, with the exception that they mostly represent faster paced, more aggressive sounding music. This is interesting to note as the mural shown in Figure 4 has an underlying tone of dark red, a color previously explained to inspire action and intensity.

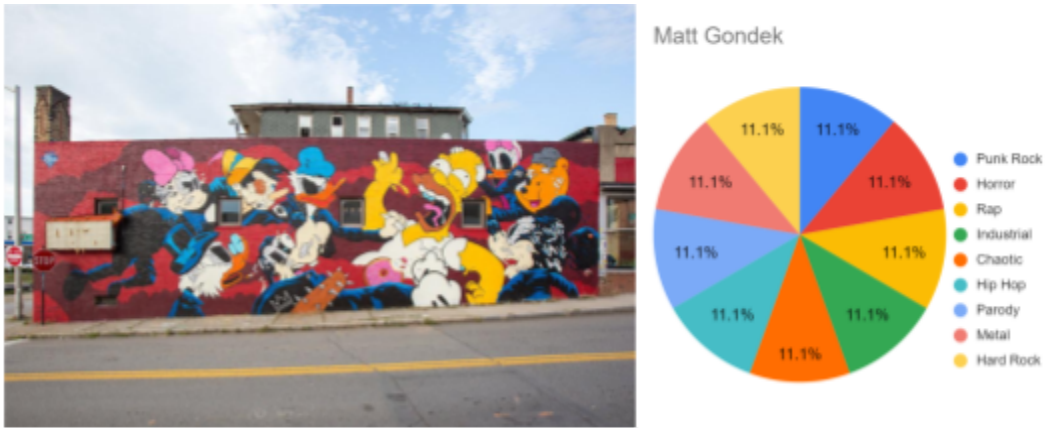

Figure 4 - Pow! Wow! Worcester 2019 mural created by Matt Gondek and the survey responses to the question "What music does this mural make you think of?"

2.0 Pairings

To complete my first objective, I met with Professor Richard Falco of the WPI Humanities department. Professor Falco runs WPI's Jazz history database as well as is a professional at finding art and music pairings from his research. I spoke with Professor Falco about each mural of the 2019 Pow! Wow! Worcester festival and had a conversation about what he might pair with them. "A painting is never static", said Falco when I asked him why he believes art can always speak to a viewer (Falco, 2020). He said that visual art has layers that need to be examined and understood by someone who is observing it. These layers are something that can make us feel something we don't even realize. In turn, the feelings we get from these layers can correlate to music. For example, the mural by Lena McCarthy, as seen in Figure 5, he paired with music that was more of a solo piano; something with one calming instrument to complement the blue layers in the painting. He recommended artists such as Cecil Taylor, Rufus Reid and Muhal Richard Abrams.

Figure 5 - Lena McCarthy - Pow! Wow! Worcester 2019 mural

We discussed the pairings for each of the 2019 murals and how the instruments in the music might complement the mood the art represents. Falco also talked about how different instruments can portray diverse meanings in sound; such as a saxophone having a more aggressive, masculine tone, whereas a guitar would have a benign acoustic sound.

One of the artists, Czr-Prz, or Caesar, created the mural as seen in Figure 6. Caesar has been an artist since his teenage years and got involved in Pow! Wow! through personal connections. This mural of a bird and a fish morphing into one confluent animal was inspired by Caesar trying to show how two vastly different things can still be similar and work together to create something beautiful. Something important to notice in his work is that the colors of red and blue are both shown in great quantity, but are working together. Caesar's goal for this

Figure 6 - Pow! Wow! Worcester 2019 mural created by Czr-Prz

mural to inspire in his viewers was “for people to become creative and feel free”. This perfectly embodies the emotions that the colors red and blue were shown to represent.

3.0 Website

To complete my second objective, Professor Cullon cloned worcestermuraltour.com and assigned it to the domain http://bosikiqp.com. This domain is where my current prototype for the tour resides. I was able to use the curatescape framework of Omeka to design each stop on the tour as an “Item”. These items each contain different fields such as: map location, site description, artist media url, image, and of course music file. The items could then be loaded into a tour and organized in any way I saw fit as seen in Figure 2. I created a tour that involved 13 of the 18 murals that were within 3.3 miles of each other. The tour sequence can be seen in Figure 8.

Figure 8 - Omeka styled, sequence of stops on the tour

The other 5 murals, while still wonderful to see, were too far to be walking distance on a walking tour. A screenshot from one of the stops on the tour can be seen in Figure 9. The code for this example screenshot can be seen in Figure 7. As you can see, the audio embedded in the stop can be played through the users mobile device by pressing the “Play” triangle button. Volume can also be adjusted on playback. This playback can be transmitted through the Bose Frames if the listener has connected the Frames to their mobile device via Bluetooth.

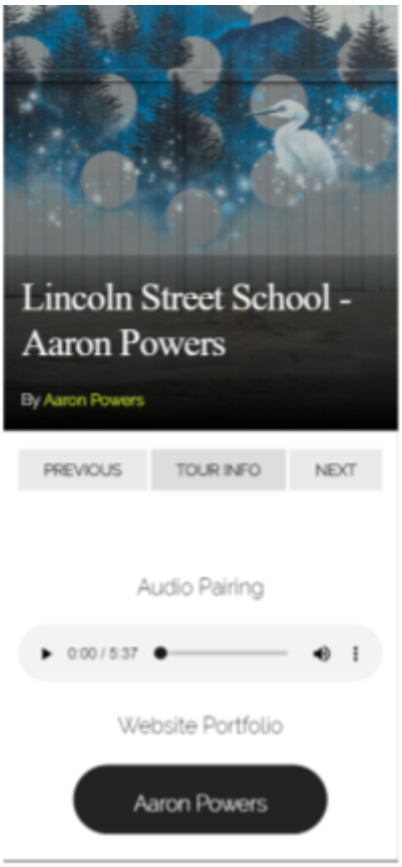

Figure 9 - Screenshot of stop on the tour including audio playback and artist portfolio elements

The playlist for each of the stops on the tour is as follows (Format: Mural Artist - Song - Song Artist):

- Croc Paints - Space Oddity - David Bowie

- Kaplan Bunce - Classical Drumming - Vadrum
- Lena McCarthy - All of Me - Rufus Reid, Benny Carter
- Mags Munroe - this girl - Elijah Who
- Aaron Powers - Blue in Green - Miles Davis
- Jason Naylor - Nangs - Tame Impala
- Isabelle Ewing - King and Lionheart - Of Monsters and Men
- Lillipore - Tired of This - Unknown
- Jeks - Let the Drummer Kick - Citizen Cope
- Angurria y M. Tony Peralta - Morning - Alfredo Valdes Jr
- Jason Naylor - Madam Fatima - Rowell and the Dickson Group
- Wooden Wave - Bounds - Limes
- Xylene - Levitating - IAVI

4.0 Challenges During this Project

One of the biggest challenges that I had encountered throughout this project was data collection. The data collection methods I used consisted of online surveys, in person interviews and phone call interviews. All of these methods had flaws in their execution, mostly relating to timing and poor communication. For instance, I had emailed close to 20 artists in this process for interviews about their work and gauging opinions on song pairings. Only 4 of the artists responded to me in time for me to accurately use their responses. This could be because the artists did not notice the communications I gave them or because they did not want to respond. Another example of timing was found while creating the survey that I posted online.

Another challenge I faced regarding the survey was collecting a proper amount of responses. I had posted surveys on the same sub-reddit forum r/SampleSize in the past and had gotten over 100 replies. For this survey, I had only received 14 responses. I believe this is because of the length of the survey. It contained 18 open ended required questions that totalled to around 30 minutes of time commitment. This most likely caused participants to not want to complete the survey. In the future, if I were to create a survey that long, I would plan to incorporate a reward for completion such as a raffle prize for all participants. Also, another way I could have gotten more responses would have been to release the survey on more than one platform. I had only gotten clearance from WPIs IRB to release the survey on this subreddit, but more input from other locations could have increased sample size.

Conclusions and Recommendations

The main conclusion from my IQP is that there is a connection between music, murals and mind. Through research and practice, I was able to determine that certain types of music are more fitting to certain types of art. My research has shown me, for example, that the color red invokes

a more intense, angry emotion, while the color blue brings out the calm in an individual. This relates to my survey data in the sense that there is a correlation between the color red and intense, angry music, while blue correlates to a slow, relaxed genre.

To continue this IQP in the future, I would recommend that a researcher look into more augmented reality implementation of these findings such as working with the Bose Frames. Although my IQP will work with a Bluetooth paired set of the Frames, the hardware in the device is not used to its full extent. There are code libraries that could be further developed to create compatibility with the Bose SDK and WebGL, allowing for the use of the Frames on an online web application.

Another recommendation I have would be to utilize either WICN's or WPI's Jazz History Database to get a more solid selection of songs to be paired with the 2019 murals and future murals to come.

Appendix 1

Survey Questions

A copy of the survey used in this project can be found here:
https://forms.gle/epj6idkhmxRUs5qT6

The questions were as follows:

Checkbox - I am over the age of 18. (Required)
Short Answer - What is your age?

(For each mural - 18)
Paragraph - What music does this mural make you think of? Why?

Code

The following HTML code was used on each item of the tour to show a link to the artists portfolio as well as an element to play audio.

Note: FILENAME is a variable to be replaced by the audio file for the item. URL is a variable to be replaced by the url to the artists portfolio for the item.

```
<div style="margin: auto; text-align: center;">
     <p style="font-size: 20px; margin: auto; padding:
20px;">Audio Pairing</p>
     <audio controls="controls">
          <source src="FILENAME" type="audio/mpeg" />Your
     browser does not support the audio tag.
     </audio>
     <p style="font-size: 20px; margin: auto; padding:
20px;">Website Portfolio</p>
```

```
     <div style="background-color: #222222; border: 1px solid
#EAEAEA; border-radius: 50px; width: 200px; height: 25px;
margin: auto; display: flex; align-items: center; padding:
20px;">
          <p style="margin: auto;">
               <a href="URL" style="height: 100%; font-size:
          20px; color: #ffffff; text-decoration: none;">Aaron
          Powers</a>
          </p>
     </div>
</div>
```

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