BA (Hons) Creative Music Production Professional Project

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Using music, colour, and technology to improve emotional recognition for individuals with Autism Spectrum Disorder

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Abstract

Often referred to simply as ASD, autism spectrum disorder is a neurological condition. Typically, the developmental disorder is diagnosed during the first two years of life. The characteristics of autism include challenges with social interaction and repetitive behaviours. A combination of behavioural therapy and educational support is typically used as a treatment method. Although some individuals with autism have excellent interpersonal skills and communication abilities, other individuals with this disorder may have difficulty recognizing and expressing emotions.

The aim of this study was to investigate whether or not musical engagement could improve the emotional awareness of autistic people. The objective of this endeavour was to develop an application (app)[1] with the goal of improving emotional recognition. In order to establish whether there exists any potential for improvement in the chosen field, the study examined the correlation between music, technology, and colour, as well as how these factors relate to emotions. A social worker was interviewed to determine whether music can be effective in enhancing emotional awareness, and the results indicated that it certainly can.

This investigation has provided insight into a number of key factors which have been discussed and how these factors may contribute to the advancement of individuals with autism spectrum disorders (ASD). In light of these findings, it is pertinent that future research pays particular attention to the aforementioned aspects. This study is primarily aimed at demonstrating the effectiveness of music as a tool for enhancing communication skills. As a result, users are able to practice recognizing and expressing their feelings in a safe and enjoyable setting.

[1] App is an abbreviation of application.

Contents

Introduction

The question to be answered in this research paper is can music, colour and technology assist people with disabilities to communicate their feelings more effectively?
A Unity[2] app will be created, and the user will select a colour based on their emotion. Sound effects accompany the emotion, so the user can express their feelings through sound. Following the sound effect, a composition based on the colour selected will be played. Users will be able to trigger sound effects in the app by interacting with the touch buttonpad or sensor. By triggering the elements when desired, the user is able to express themselves through music as well as create their own musical narrative.

The research project explores the use of music as a tool for individuals with disabilities and how developing an assistive technology app can make music more accessible. Creating a new form of communication through music and improving emotional recognition for individuals who struggle to communicate their emotions are the potential outcomes of the research.

The literature review discusses and analyses the chosen resources while also highlighting how they will contribute to this project. It is pertinent to note that although the project is inspired by these resources, the study consists of original work and merely uses the resources as a starting point.

The methodology is used to distinguish how the study will be approached over the course of the project. The methodology chapter will outline the proposed techniques for gathering data. The procedure for developing the app will be covered in full along with plans to provide proof of the claim made through thorough ongoing interviews with an employee of *Sunbeam House Services*. The methodology chapter provides a framework for creating an app that evokes emotion through colour association and music.

The overall aim of the project is to creatively express colour and emotion through the medium of music. This project is invaluable as a concept and has the ability to develop into a resource that can be used as an aid to people with disabilities and allows for further research.

[2] 'Unity' is a multi-platform game engine which is used to create video games.

Literature Review

The project in question involves creating an app intended to be used by people with different disabilities and sensory issues. The app will require sound design and composition in order to create an immersive experience. The research question at hand is: Can music, colour, and technology be combined to assist people with disabilities to communicate their feelings more effectively? This project aims to develop an innovative method for positive emotional communication.

A Unity app will be developed, and users will select a colour based on their emotions. Sound effects help users express their emotions by allowing them to associate sounds with certain feelings. An audio composition based on the selected colour follows the sound effect. The application triggers sound effects with a touchpad or sensor. By triggering the elements, users can fully express themselves while also creating their own musical narrative. Feedback will be sought after the application is developed. The application will be evaluated for its potential to be utilized in real-world scenarios and for its potential to advance the field.

In this research project, it is crucial to display knowledge of music therapy, musical composition, and emotions in music. A substantial amount of literature and previous studies in the field are discussed in this chapter to assist in understanding how music colour can enhance emotional recognition.

Carrie Lennard is a special needs music teacher who has years of experience in this area. The resource chosen[3] gives an insight into how improvisation can aid people with disabilities and allow them to be involved in creating music. This is relevant to the project in question as it delves into the relative topics such as assistive interactive performance and the composition of sounds.

In her work, Carrie's goal is to create opportunities for students with special needs to explore their own playing abilities through music. She wants to provide students with a musical structure that instils confidence in them. She also wrote the book to help those who work with disabled people to enable them to use the tools at their disposal to the best of their ability to help others. Her goal is to make music accessible to everyone and also to make it an enjoyable experience that encourages people to get in touch with their creative side.

Due to the sounds being triggered through software, this piece is relevant to the current project. She shows examples of clean-cut sounds that can be looped and one-shot sounds that are easy to trigger. Lennard claims that by using the key of C and the scale of C major pentatonic, the clashing notes are eliminated, allowing for a more harmonious sound to sync up with the backing track. To make tuned percussion sound more intact, she suggests removing the B and F notes (IV and vii).

Working with many people with disabilities, she has contributed significantly to the development of accessible assistive technology. In dealing with this topic, she says informed choices are vital. The goal of Lennard's work was to empower people of all abilities to play. No wrong notes create a positive musical experience for students, according to Lennard.

Making informed decisions and creating sounds that are harmonious with any background music was advised. For the project in question, this is essential. Based on Carrie Lennard's suggestion, the project will experiment with writing in the major pentatonic scale. Having no tension or clash of notes makes music more enjoyable and encourages users to keep playing. As a result, players can boost their self-confidence and enjoy playing, which is the ultimate goal of this project. Using this resource has been extremely beneficial to the planning of this

[3] Lennard, Carrie. *The Improvise Approach*, 5 August 2016, Accessed 12/10/22

https://www.improviseapproach.com

project and will be used to help with composition, to trigger events in the proposed app, and to understand what users will find interesting.

This journal[4] aims to understand the cross-modal association between music and music and determine if it is a rare neurological phenomenon experienced by only a select few or whether it occurs in a more widespread population. Among the main aims of this resource was to explore cross-modal associations between music, colour, and emotion. This project aims to take advantage of this cross-modal association[5] and determine if it is possible to create a new form of communication using colour, emotion and music.

Authors convey information in a clear and concise manner. This study is participant-focused, making the results more relevant to reality. In addition to the case study, they provide relevant hypotheses that have previously been proposed that link music and colours. One that was particularly striking was a proposal made by Jose Caviano in 1994[6].
Jose Caivano suggested that the octave-based musical scale maps to hue, luminance to loudness, saturation to timbre, and size to duration. This perfectly summarizes the relationship between music and colour. Using Caviano as a reference further validated the authors' point by using previous research.

The research resource will be valuable when deciphering the cross-modal association between music colour and emotion. When composing a musical piece for a colour, the information collected during the participant survey will aid the composition process. It is pertinent to the project in question that this resource explores colour sound and emotion. This resource explores music-colour synaesthesia, which is a main element of the research. Emotional mediation also occurred in the music-to-colour association study. This research project focuses on these three main elements, and this resource will prove extremely useful for further investigation.

[4] Whiteford, K. L., Schloss, K. B., Helwig, N. E., & Palmer, S. E. (2018). *Color, Music, and Emotion: Bach to the Blues. I-Perception,* 9(6). Accessed 12/10/22

[5] Cross-modal association occurs when the different regions of the brain co-ordinariate certain sensory inputs such as matching audio with visuals

[6] Caivano José Luis. *Color and Sound: Physical and Psychophysical Relations*. Vol. 1, J. Wiley, 1994.

The research resource[7] relates to the subject under investigation as it contains information regarding sensory issues and how music is used to address these issues. It shows how music is an effective tool and coping mechanism for children with disabilities. The investigation into how the mind works and responds to music in this book is a topic that needs to be looked into in the current project as it is important to understand the audience that the project is aimed towards.

Through this book, the author examines how children with disabilities react to music. The foregoing discussion implies that music therapy is beneficial to people with disabilities. The author asserts that focusing on sensory integration and functional adaptation will result in positive outcomes. Sensory integration involves organizing, processing, and responding to information our brain receives. The treatment can benefit people with sensory issues.

According to the author, using the six main elements of music correctly (rhythm, melody, harmony, dynamics, timbre, and form) will lead to successful sensory integration. Using these elements and paying attention to the details can ensure that a strong collection of sounds can be created for the current project. These elements will help shape and create sounds that users will find comfortable and manageable.

As well as emphasizing their own theories and methods, the author suggests further reading by other authors concerning the topic. They provide clear, concise and to the point information to engage their readership. In Appendix B, she shares actual treatment reviews and progress briefs for three children who received music therapy. This shows the effectiveness of music as a treatment tool for people with disabilities.

This resource will be used in this research project to understand how individuals with autism perceive sound and cope with sound differently. Additionally, the clear referencing system and detailed and descriptive writing style will assist with thesis writing. The resource is aimed at making music accessible to all, which is the objective of this project, and therefore, will be a major benefit to it.

[7] Berger, Dorita S. *Music Therapy, Sensory Integration, and the Autistic Child*. Vol. 1, Jessica Kingsley, 2008.

The chosen resource[8] explores how music therapy can be used to enhance self-expression and communication skills for people with autism. This is heavily related to the project in question as the end goal is to create a new method of communication and self-expression through music. The object of Geretsegger's work was to assess the positive impact music therapy has on individuals with ASD. The author questions whether music can improve a human's capacity for social interaction. Due to the lack of recent information surrounding the issue at hand, the author set out to conduct an up-to-date evaluation of new studies related to music therapy for ASD.

Geretsegger's work reveals the life-altering benefits music can have for someone with ASD. The author states that music therapy can also improve social relationships with family members. The recorded facts and figures are clearly stated in this resource which creates an informative piece of writing which contributes to and expands the field. Geretsegger draws on an extensive range of sources to assess critical information needed to create a useful and insightful evaluation. The research project will draw on this resource for information regarding the relationship between individuals with ASD and music.

The resource relates[9] to the subject in question as it contains information regarding music colour association. This article shows a strong correlation between music and colour. An important part of the current project is determining how musical scales correlate with colour hues. According to Wells, musical harmony and visual colour were evidently related to the spacing between hues on a colour A parallel is drawn between the division of the musical circle into twelve half-steps or six full steps, and the division of the colour circle into three primary colours and three secondary colours, as the author argues in his paper. As can be seen from the article presented thus far, music and colour have a close relationship.

[8] Geretsegger, Monika et al. "*Music therapy for people with autism spectrum disorder*" The Cochrane database of systematic reviews vol.6 2014 CD004381. 17 Jun. 2014, Accessed 26/10/22

[9] Wells, Alan '*Music and Visual Color: A Proposed Correlation*.' The MIT Press, 1980, Accessed 29/10/22 musejhu-edu.ezproxy.iadt.ie/article/599336/pdf.

In the author's table, there is a correlation between colour and chromatic music scales. Each colour corresponds to a note and frequency. In the project at hand, this can serve as a prompt for composing music to accompany the colours displayed on the app. The author reflects on their own experience and states 'One day I decided to apply complementary colours in sequence as the tritone harmonics occurred in sequence in the music. This linking of complementary colours to complementary tritone harmonies in sequence seemed to enrich my aesthetic appreciation and enjoyment of both the audio and the visual media enormously by combining them in this way.'[10]

This shows the detailed and insightful approach in which the author researched the question at hand. Wells credits other resources and authors in his work to add credibility to the claim he is making. He highlights where previous studies have failed and the reasons behind the failure. The valuable insight into the correlation between harmony and colour in this resource will be a crucial part of completing the project in question. This article[11] will potentially help with the composition of music and thesis writing. The author uses a descriptive and analytical style of writing. Although the whole article is not solely music related, the research that has been conducted is crucial in understanding the relationship between music and colour. For that reason, it will be a beneficial resource to draw on.

The author of this journal[12] investigates the longevity of certain types of assistive music technology. The resource is relevant to the project as it contains vital information which could help to decipher what methods of assistive technology do work and what methods do not work. The author is trying to make assistive music technology more accessible by assessing what is already currently in use and how it can be elevated to benefit a wider range of people. The importance of the HAAT model is stressed in this piece of writing. The HAAT model consists of four questions that need to be answered in order to create an effective piece of assistive technology.

[10] Wells, Alan '*Music and Visual Color: A Proposed Correlation*.' The MIT Press, 1980, Accessed 29/10/22

[12] Lucas, Alex, et al. "*Enabling Communities of Practice Surrounding the Design and Use of Custom Accessible Music Technology*." *Computer Music Journal*, vol. 44 no. 2, 2020, p. 9-23. *Project MUSE* muse.jhu.edu/article/801768. Accessed 29/10/22

The proposed questions are as follows:

1. Human: What are the goals, skills, and abilities of the artist?
2. Activity: What is the nature of the planned activity?
3. Technology: What features does it have, and how does one interact with it?
4. Context: What are the physical, social, and cultural attributes of the environment in which the three elements above exist?

This list of questions will be invaluable when designing an app for a specific audience. According to the author, music technology access is determined by cost and availability of resources, skill level, and time. This is an important aspect to keep in mind when attempting to create the current project.

The author's writing is clear, concise and has an effective and straightforward structure. References are made to previous works and other resources. A critique that expresses admiration while critiquing the resource is tasteful. The author's critical and analytical methods for planning the interactive user experience can be adapted and used in the present project. Adapting Lucas' approach to assessing previous assistive technology projects will be part of this project. Any issues that may arise will be addressed with a clear plan and solution

In the doctoral thesis “The Interaction between Music and Language in Learning and Recall in Children with Autism Spectrum Condition.”[1], Adam Reece reviews the benefits of learning through music for children with Autism Spectrum Disorder. Reece obtained his PhD in 2015. As a special education teacher and a private consultant, he continues to conduct research in the field. The resource in question focuses on the ways in which music can enhance learning and communication skills for individuals with special needs.

This study sought to prove that music therapy is therapeutically effective for people with autism. The claim of Reece is that singing could enhance verbal learning. In order to prove his theory, Dr. Reece uses a variety of research methods. Twelve parents, teachers, carers, and music therapists were interviewed as part of his preliminary study. A questionnaire was also conducted, in which three hundred twenty people participated. Following the questionnaire, he conducted a comparative intervention with twenty four ASD participants and thirty two neurotypical primary school children. Reece received two contrasting responses to his work. The methodology section of this project would benefit from this model.

Throughout this thesis, the author uses crisp, persuasive language. By recommending further research into other authors' work, the author frequently cites other resources found relevant to the topic. There are a number of sections in this thesis, each focusing on a different topic. He references previous studies such as Bowler's (1997) task support hypothesis[1]. Using the style of writing in this thesis will be helpful for writing the thesis for the research project. This thesis presents helpful, insightful and knowledgeable information and guidance.

Dr. Adam Reece's comparative intervention showed that children with ASD remembered rhythm better than melody. The melodic condition was also found to be more appealing to children with ASD.[13]. This proves the theory that music is a therapeutic medium and can be used as a communication tool. In this research project, this information will aid composition and production. By utilizing the resources presented in this thesis, the finished artefact will act as a musical communication aid and improve emotional recognition.

The authors of this research paper[14] are NRSA postdoctoral researchers at Yale University. In this specific resource, a quantitative method is used to conduct a survey. The following experiment investigated how music–colour associations are mediated by emotional connotations. This research resource will be beneficial to the project in question as it discovers the relationship between music, colour and emotions and gives more realistic real world evidence of the relationship between the three elements. The participants included 128 participants who were both non-musicians and musicians.

Three experiments were carried out to prove the theory that music–colour associations are mediated by emotional connotations. The first experiment asked the participants to choose 1 of 8 colours to match certain excerpts of 24 Preludes from Bach's Well-tempered Clavier. The second asked the participants to rate the colours on a number of emotion scales. Experiment 3 asked them to rate the excerpts from the Preludes on the same emotion scales, and found that the emotion ratings grouped together The results of the survey support the claim that there is a clear link and correlation between music and emotion, and colour and emotion.

[13] Reece, Adam. "The Interaction between Music and Language in Learning and Recall in Children with Autism Spectrum Condition."*Thesis (PhD) (School of Education) - University of Roehampton*, University of Roehampton, 2015, pp. 155–157 See Table 6.23. Accessed 24/11/22

[14] Isbilen, Erin S., and Carol Lynne Krumhansl. "The Color of Music: Emotion-Mediated Associations to Bach's Well-Tempered Clavier." *Psychomusicology: Music, Mind, and Brain*, vol. 26, no. 2, 7 Apr. 2016, pp. 149–161

This resource paper uses short, succinct wording to express their findings clearly. The authors are transparent and honest about the results obtained from the experiment. Their style of writing is fluent and formal. This stylistic approach to writing will influence the research project in question when attempting to write the methodology section.

Erin Isbilen and Carol Lynne Krumhansl chose the preludes according to tempo, mode, pitch height, and attack rate. This would indicate that these are vital elements which link music, colour and emotion. The resource in question has provided an insight into a connection can be made between music colour and emotion while also investigating what musical elements best aid this theory. This study will act as an aid to the project in understanding what will resonate with the users.

Methodology

The methodology is used to distinguish how the study will be approached over the course of the project. The methodology chapter will outline the proposed techniques for gathering data. This section looks at the previous use of methodology by other successful projects, thus indicating where to begin.

This study aims to learn more about the benefits of music therapy and develop an app that makes music more accessible to people with autism. From the information reviewed in the previous chapter, it is apparent that music, colour and technology can be used to assist people with disabilities. Music therapy recognizes the ability to express emotion through music. An understanding of the field chosen and attention to detail are critical for effective results.

To date, various methods have been developed and introduced to create interactive assistive technology. The research project at hand will draw on previous methods used while using new and innovative methods. A proposed method of composition for colour is that the octave-based musical scale maps to the hue circle[15]. Jose Luis Cavino[16] identified several advantages of this method in his case study. Whilst the main focus will be linking colour to musical notation, Cavino suggests linking luminosity to loudness, saturation to timbre, and size to duration will add an extra dimension to the chromesthesia[17] experienced during the composition.

One of the first people to explore the colour and music association and pave the way for future case studies was Sir Isaac Newton[18]. Newton came to the conclusion that because red is the lowest visible colour of light, it is therefore linked with the tonic of a scale starting on D in a Dorian scale. Yellow and blue are equated with F and A which forms a minor triad. Newton's methodology will be of great use in this research project.

The primary tasks to be carried out are as follows. Coding the app in Unity and carrying out the necessary testing methods to ensure the app is running correctly. Deciding which sounds

[15] A hue circle may also be referred to as a colour wheel or a colour circle. It is an arrangement of colour hues around a circle that depict the connections between colours.
[16] Caivano José Luis. *Color and Sound: Physical and Psychophysical Relations*. Vol. 1, J. Wiley, 1994
[17] Chromesthesia is a sort of synaesthesia in which a sound may induce a colour perception.
[18] Newton, Isaac. *Opticks: or, A treatise of the reflections, refractions, inflexions and colours of light.* , London: Printed for Sam. Smith, and Benj. Walford, https://doi.org/10.5479/sil.302475.39088000644674

will be suitable to use when expressing the selected emotion, creating the sound effect while discovering how it can be replicated in a 'DAW'[19].

One spot sound will be recorded and or composed for the initial emotion selection. There will be eight further spot sounds chosen from Splice[20] for each emotion to allow users to interact with the composition. This task follows a method of planning, listening, testing, adding audio effects and refining the chosen sounds. The sounds will then be mixed and mastered in a DAW before being added to FMOD[21].

The next step will be to compose four musical loops which can be synchronized with the spot sounds or played separately. A generative music system will be used to limit repetition. Composing the pieces will involve developing a melody, rhythm, and adding dynamics and timbral elements to convey the emotion that is being triggered. Listening critically to the piece will ensure the work is of higher quality.

This methodology emphasizes time management and maximizing previous skills. This project has a strict timeline for the following core elements: composing, researching, producing, building apps in unity, conducting interviews, and user testing. Each element has been assigned a specific number of weeks in which it should be completed. The project will be enhanced through self-motivated and self-disciplined learning and research. This project will incorporate quantitative and qualitative methods. Quantitative methods use more experimental methods with sounds, instruments, and audio effects. Qualitative looks into human behaviour and will involve conducting a survey and user testing with care assistants who will provide important feedback on the app and suggest improvements.

A survey will be conducted to examine the correlation between music, emotion and colour. The survey will be created on Microsoft forums and suitable participants will be found. The first section of the survey will test the relationship between colour and emotion while the second section will test the relationship between music colour and emotion.
In order to gain feedback and criticism on the application, several informal interviews were conducted with social care workers throughout the academic year. The responses from social care workers were analysed to identify areas for improvement and inform future decisions.

[19] DAW is an abbreviation for Digital Audio Workstation
[20] Splice is a cloud based royalty free sample library.
[21]FMOD is a sound effects engine used alongside Unity to create sounds in video games.

When the app is fully developed, it will be reviewed by one social worker and a formal recorded interview will follow.

The overall methodology chosen will be used to improve project management and organization skills as they are key components in this research project. The main technique which will be used is based on planning before carrying out a task and when the task is completed, it should be analysed and improved where necessary. This allows for a more structured workflow and eventually will generate a better end product.

The methodology for this project will be heavily influenced by the Leeds University paper "Methodology for reviewing processes : A Practical Guide To Delivering Results." *A Practical Guide To Delivering Results*[22]. The resource suggests a more practical based approach to methodology. The steps to be taken were to create a plan, understand the purpose, understand the context, identify the process, 'map' then 'model', document findings, ask for feedback and store and update content. These assets contribute to a more polished and finished piece of work.

In conclusion, the chosen methodology will be used to achieve the best possible outcome for this research project.

Analysis

[22] Leeds University. "Methodology for reviewing processes : A Practical Guide To Delivering Results." *A Practical Guide To Delivering Results*, Leeds University, 2021, https://deliveringresults.leeds.ac.uk/a-practical-guide-to-documenting-and-designing-processes/process-documentation/process-information/methodology-for-reviewing-processes/. Accessed 21 November 2022.

The analysis chapter of this thesis examines the design and coding of the developed application in conjunction with the results of the survey. Additionally, an analysis of the steps taken in the methodology in terms of the project's objectives will be conducted, as will an assessment of the effectiveness of the app, as determined through the interview with a social care worker.

Implementing a framework for creating an effective and comprehensible user experience has proven valuable as part of the project's timeline. Appendix A details the framework. Using this framework, it is clear what needs to be considered when developing an app. To ensure a successful outcome, the framework for creating an easy-to-understand and suitable user experience has proven to be one of the most valuable exercises performed during the course of the project.

In the framework, an outline of key components is provided in order to create a successful design. A user-friendly and enticing application was created by ensuring that all questions in the framework had valid answers. A significant improvement has been made in the interface and design of the app as a result. Furthermore, it has been learned that it is essential to plan what objectives are to be achieved.

Upon launching the application, the user sees four emoticons. It is up to the user to decide which emoticon best describes their current mood. On a second screen, the user can confirm that they are experiencing the emotion or return to the primary menu. SceneManager.LoadScene(sceneID) was used to switch between displays. transition between scenes was created by a public void[23] The most successful operating method to enable screen switching in the application was found after experimentation.

A complex code was required for the play and pause buttons. A sprite[24] was used to create a 2D graphic object to enhance gameplay. Boolean[25] variables were used to create objects with true/false arguments. Upon pressing the button, "if (MusicIsPlaying == false)" sends a

[23] In programming, a public void means nothing has been created, and it has no return value, but it is visible and can be called on by other objects.
[24] A sprite is an interactive and moveable computer graphic.
[25] Boolean variables are binary computing variables, meaning their outcomes can only be true or false, named after George Boole.

message to Unity, and "Music.start" and "MusicIsPlaying = true;" tell Unity to start the music from FMOD. The equal-to operator returns to false if the track is muted.

"Music.stop(FMOD.Studio.STOP_MODE.ALLOWFADEOUT);" stops the music immediately, returning "music is playing" to false. Despite the complexity, the Boolean logic provided only one possible answer. The most significant learning occurred from researching the Boolean logic and implementing trials and errors. Perhaps in the future, it would be more beneficial to thoroughly examine the problem before indulging in multiple hours of trial and error.

Survey

A survey was conducted to examine the correlation between music, emotion and colour. The first section of the survey tested the relationship between colour and emotion. Colour was linked to emotions in this section of the survey. The results of this section would be used as input for future development of the app to determine the most common colours associated with emotions. Colours chosen when creating the application would be clarified in this section.

The second section of the survey investigated the validity of the theory of tonal-spectral associations developed by Russian composer Alexander Scriabin, whose notebooks[26]were later translated by *The Oxford University Press*. Many synesthesia specialists have disputed whether Scriabin was a synesthete, which poses certain disadvantages. In spite of this, Scriabin's theory remained the only viable source for colour directly relating to keys.

A total of 46 suitable participants took part in the survey. Three minutes and twenty-four seconds was the average time to complete the survey. The age range of participants was considered because Marilyn Schneck[27] proved that older people perceive colour differently from younger people. This would allow the study to obtain a variety of opinions. Participants ranged in age from 18 to 65. The results obtained are shown in fig.1 below:

[26] Skrjabin, Aleksandr N., et al. *The Notebooks of Alexander Skryabin*. Vol. 1, Oxford University Press, 2018.

[27] Schneck, Marilyn E., et al. "Comparison of Panel D-15 Tests in a Large Older Population." *Optometry and Vision Science*, vol. 91, no. 3, 2014, pp. 284–290., doi:10.1097/opx.0000000000000152.

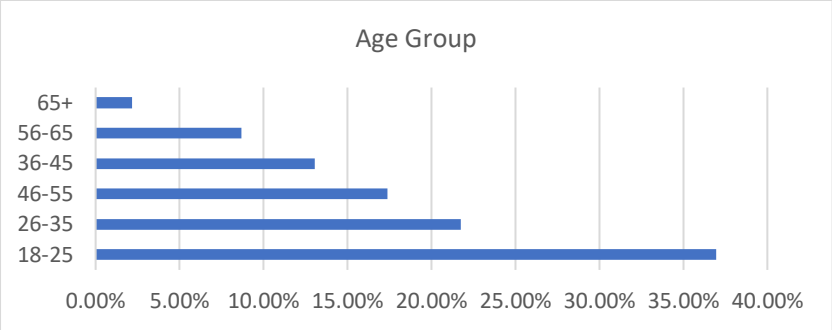

Fig.1 - Age Group distribution

Level of education was also examined. The reasoning behind this was to ensure that there was a broad range of responses from participants who come from various different backgrounds.

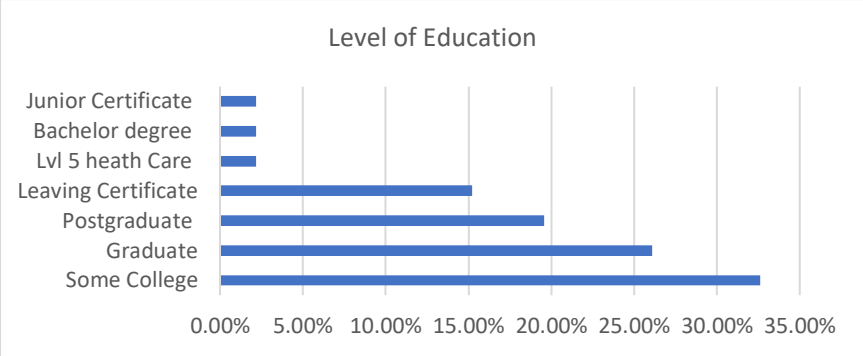

Fig.2 – Level of education distribution

<u>Section One</u>

In response to Question Three, seen below in figure 3, 93% of those surveyed indicated that Red is the colour they associate with feeling angry. This coincides with the selection of red for the app.

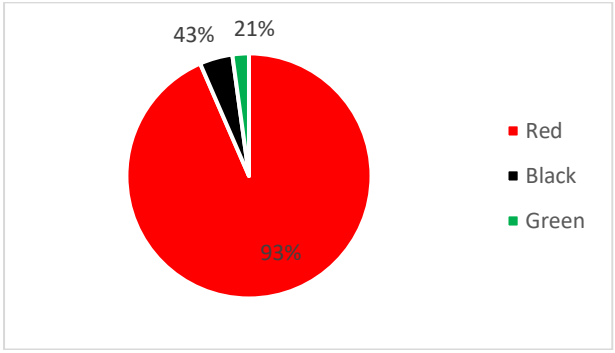

Fig.3- Question Three.

Unsurprisingly, 80.43% of those who were interviewed indicated in question four that blue best represented feeling sad.

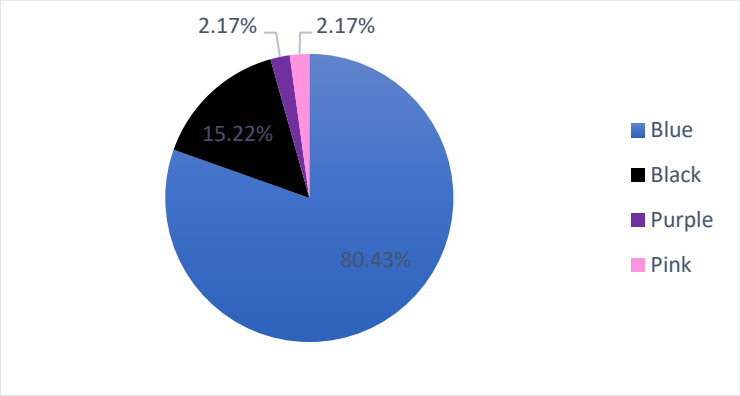

Fig.4- Question Four

In question five, respondents were asked to indicate which colour they felt best represented feeling happy. Although a wide range of responses were recorded, yellow was ultimately identified as the most common colour associated with happiness.

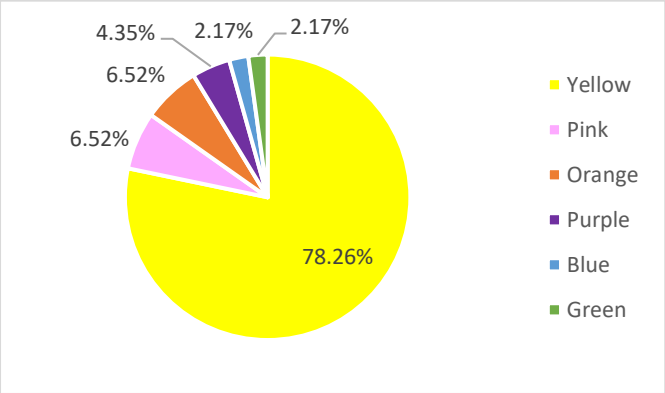

Fig. 5 – Question Five

The most striking result to emerge from the data, shown below in figure six, is that the majority of people associated feeling tired with the colour purple. This created a stark contrast between the colour green which was chosen for the app. This decision was made following the advice given during meetings which were held with care workers. It may be reviewed in the future due to the results of this survey.

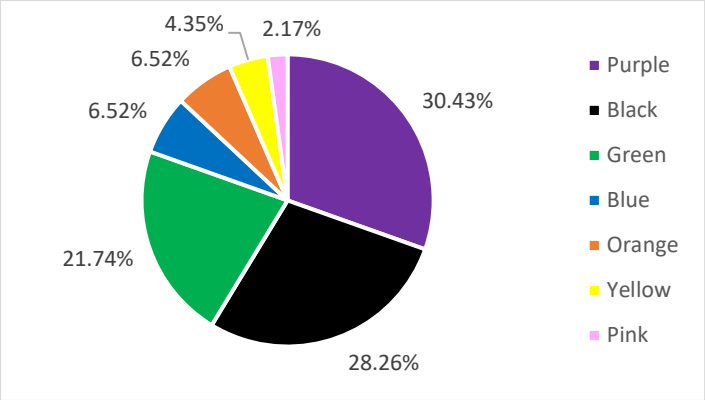

Fig 6 – Question Six

Section Two

The first question in section two, as seen below in fig. 7, asked participants to listen to a musical scale. They were then asked to identify what emotions came to mind when listening to this scale and how they would describe the musical scale a using colour.
When the participants were asked to select the emotions that the musical scale brought to mind, the majority selected happy, calm and cheerful.

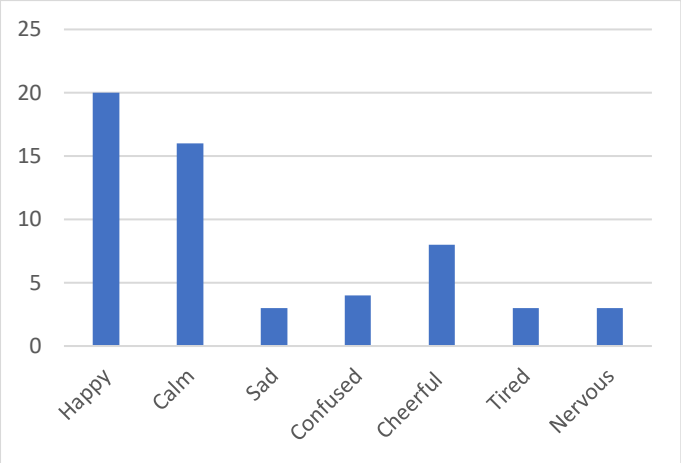

Fig. 7 – Question Seven

D major was used to compose the happy piece prior to following Scriabin's theory. Strong evidence of Scriabin's key and colour theory was found in the survey when the majority of participants used the colour yellow to describe the scale.

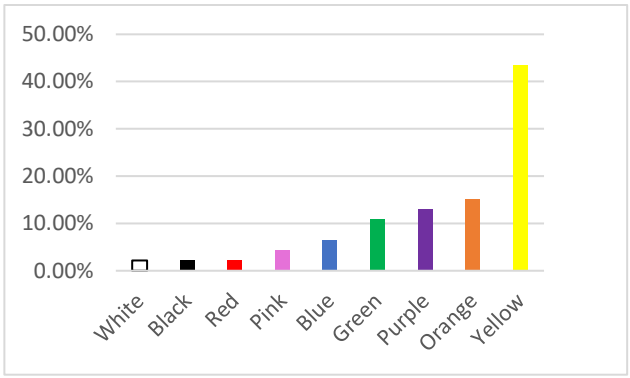

Fig. 8 – Question 8

Question Nine, as seen below in fig. 9, asked participants to listen to the scale of F sharp minor. They were then asked to identify which emotions came to mind when listening to this scale. The vast majority of participants described the scale of F sharp minor as sad. Confused and calm were the second most popular answers.

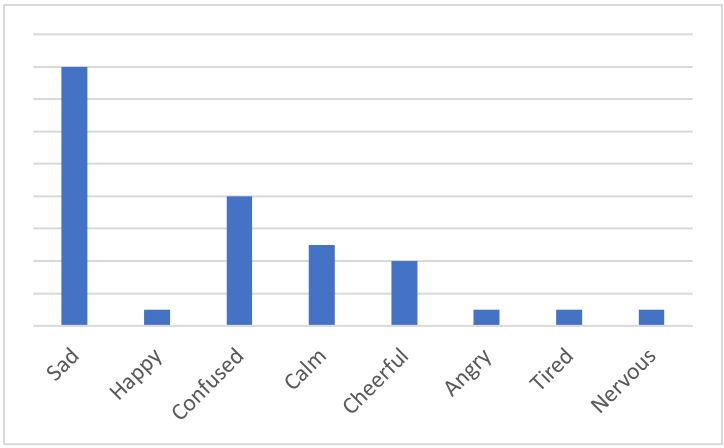

Fig 9 – Question 9

The research which was carried out prior to this survey shows that the most evident key that corresponds with the colour blue appeared to be F sharp. Blue held a staggering 45% of the overall vote despite numerous colours being chosen. The survey results add validity and support the findings of previous research.

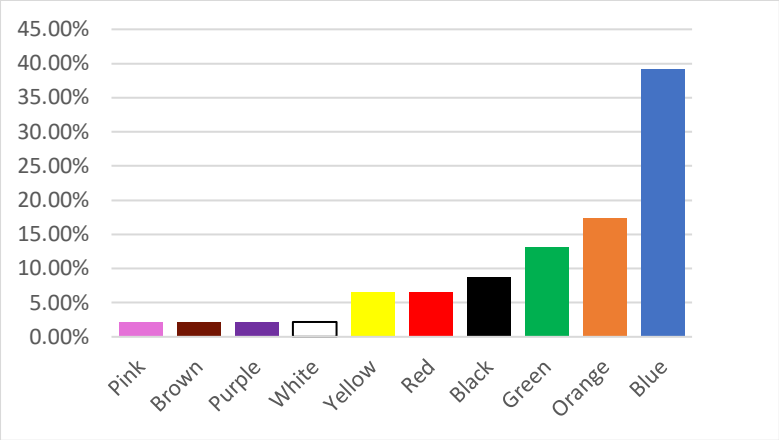

Fig. 10 – Question 10

Question Eleven, as seen below in fig. 11, asked participants to listen to a musical scale. They were then asked to identify what emotions came to mind when listening to this scale and how they would describe the musical scale a using colour.

When the participants were asked to select the emotions that the musical scale brought to mind, the majority selected calm and tired.

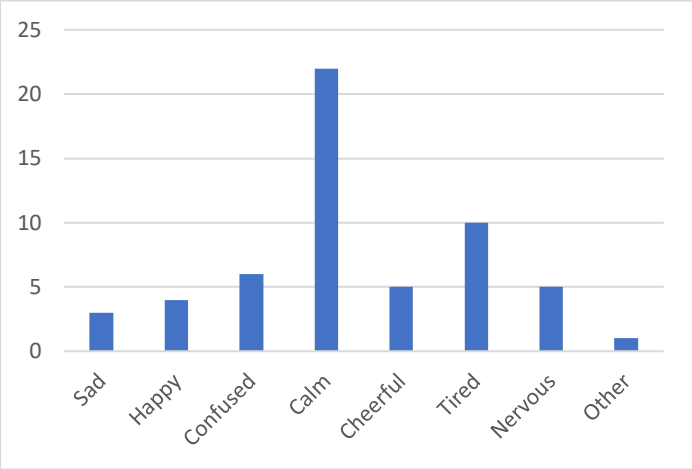

Fig. 11 – Question 11

D major was used to compose the happy piece prior to following Scriabin's theory. Strong evidence of Scriabin's key and colour theory was found in the survey when the majority of participants used the colour yellow to describe the scale. This has shown a clear link between music, colour and emotion.

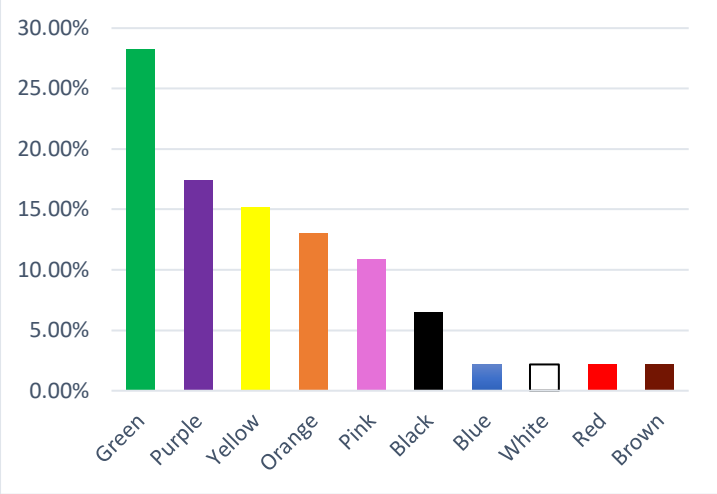

Fig. 12 – Question 12

Question Seven, as seen below in fig. 7, asked participants to listen to a musical scale. They were then asked to identify what emotions came to mind when listening to this scale and how they would describe the musical scale a using colour.

When the participants were asked to select the emotions that the musical scale brought to mind, the majority selected happy, calm and cheerful.

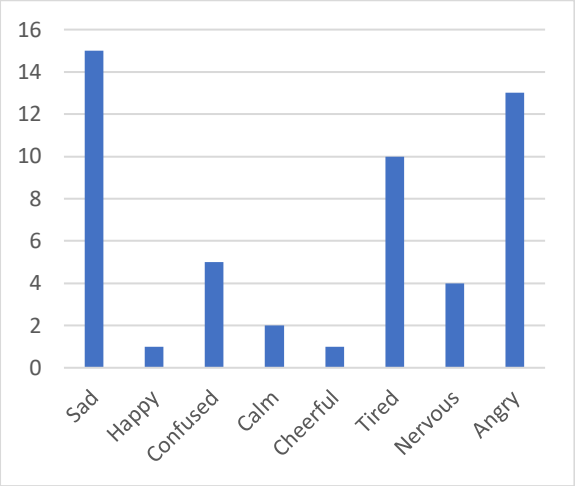

Fig. 13 – Question 13

The question regarding the C minor scale created the biggest divide in the results as there was not a single answer but rather two. was used to compose the happy piece prior to following Scriabin's theory. Strong evidence of Scriabin's key and colour theory was found in the survey when the majority of participants used the colour yellow to describe the scale. This has shown a clear link between music, colour and emotion.

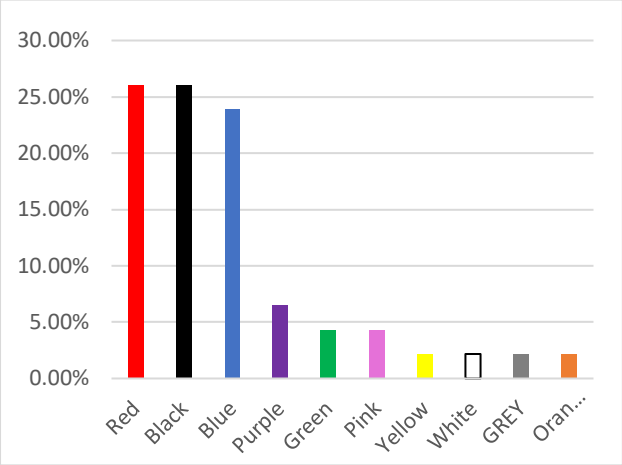

Fig 14 – Question 14

The first question in section two, as seen below in fig. 7, asked participants to listen to a musical scale. They were then asked to identify what emotions came to mind when listening to this scale and how they would describe the musical scale a using colour.

When the participants were asked to select the emotions that the musical scale brought to mind, the majority selected happy, calm and cheerful.

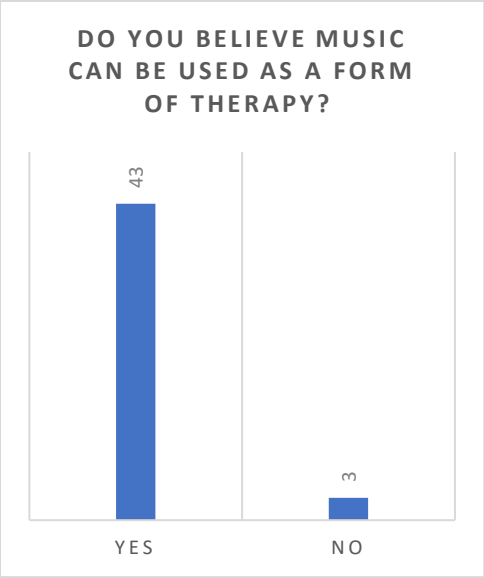

Fig. 15 – Question 15

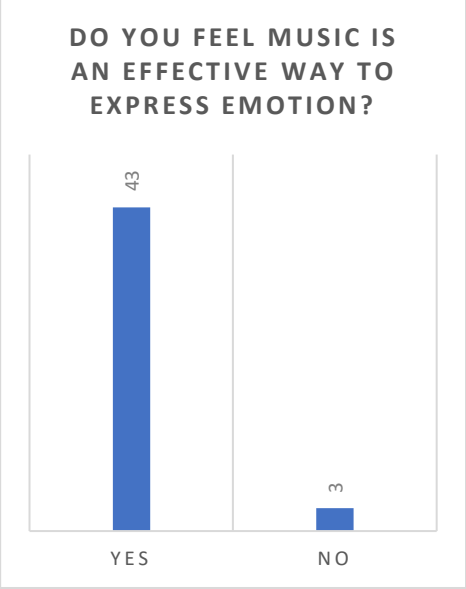

Fig. 16 – Question 16

Interview

An interview was conducted on the 16th of April with Myrtle McElwee[28] who is a social care worker with *Sunbeam House Services.* Myrtle was an essential part of answering the research question and the feedback given during the interview was crucial to the current project.
The interviewee spent a portion of the interview testing the application. A series of questions were then posed to Myrtle in order to gain an insight into how effective she felt the finished application was. An brief introduction stage was carried out in the interview where the interviewee stated what her profession was and what it consisted of.

When asked what she thought about the final app, Myrtle responded with:

> "I loved the colour element of it and that reflected emotions very well in the way that we would normally see it within our field. I liked the use of the facial expressions. I thought that was really good, and the link of the facial expression to the particular colour, I thought that was really good."

The next question asked was "What did you like or not like about the app?"
According to the interviewee, there should be musical notes around the screen to emphasize the musical element of the app. In addition, the 'x' symbol on the mute button should be removed so that it does not appear as a negative sign.
The interviewee stated:

> "There's different needs and different abilities. So they need to be able to use a variety of communications to support them to express their feelings. And quite often, they will have used certain things all along from when they were younger, so they recognise symbols, and imagery"

When asked what specific individuals would find the application most useful, Myrtle said that it could benefit multiple individuals with a broad range of disabilities. One of the most striking aspects of the interview was the suggestion made by Myrtle that the app could be used not only by individuals with autism, but could also be used to assist children who suffer from behavioural issues.

[28] McElwee, Myrtle. *Social Worker Interview User Testing* Becky Corrigan. 16 April 2023.

The interviewee went on to state that she would use the application in her place of work. She elaborated on this point by saying:

> "Most people love music, people with additional needs are no different. Most people will relate to music, most people. I think that it's very useful. It's a good tool to be able to use because most people can identify with it."

According to Mrs. McElwee, the sounds which were used in the app were appropriate for individuals with autism. She expressed that no sounds appeared to be too sharp or shrill Elaborating further on the matter , she stated:

> "No, I thought they (the sounds used) were all they're all well allocated to each group. I thought they worked well, I particularly liked the happy that actually made me smile. I thought that was pretty good."

The thesis question was then presented to the interviewee and in response, she agreed with the claim which has been made throughout this research project.

Her further remarks to the question "Can colour music and emotion be used to improve emotional recognition" were as follows:

> "Yeah, absolutely. I do. You have something that I think can be developed further. […] It gives people with additional needs a chance to be able to apply it across the board. If they're feeling sad, they might try to put on a blue t shirt, or they might even try maybe linking into the music and the colour, they can maybe then punch to a colour and somebody might be able to identify "oh, you're feeling blue today, do you want to play some music?" So it has lots of possibilities."

The final question posed to Myrtle was "What would you recommend if the app was to be developed further"

Myrtle suggested that a physical trial of the app with groups of individuals in “different brackets” would be beneficial to explore the effectiveness of the application. She recommended breaking down the app into different segments to target different audiences

Speaking on her years of experience, Myrtle stated:

> “Most certainly on a severe to profound, you would probably even only be going with a two (emotions) at first and then expanding it to a three to a four, and you'd be doing really well to get those basic emotions in”

She suggested adding in emotions such as pain, hurt and bored for children with higher levels of functioning. She believes the app could benefit a wide range of people and target various sectors of the social care industry.

> “You might have children who have no intellectual disability but they're maybe coming from dysfunctional backgrounds, they don't know how to interact or socialise or so they don't have the luxury of roleplay and good positive roleplay. […] There's lots of different areas that you could fit it into but you would probably have to streamline it for different target groups.”

A link to the full transcription and recording of the interview can be found in Appendix B.

The interview which was conducted, was an insightful and positive experience. It played an essential role in answering the question posed at the beginning of this research paper. Speaking with real world professionals broadened the projects horizons and perspective on the matter at hand.

The transcript for this interview and the survey results can be found in Appendix B.

Discussion

The discussion chapter of this thesis will exhibit the knowledge gained from the completion of this investigation. The aim of this chapter is to highlight the research projects most intriguing aspects in an effort to elucidate its significance. The research project has provided a solid foundation of knowledge in the fields of music therapy and assistive technology.

The question which has been answered in this research paper is can music, colour and technology assist people with disabilities to communicate their feelings more effectively? The tasks which have been carried out during the course of this project have been fundamentally cructial in terms of solving the research question. Complex coding, app design and development, music composition, editing, and mixing have been completed successfully. These activities have been conducted with exemplary precision and efficiency, which has fostered more productive workflows and improved results. This has allowed us to create high-quality products quickly and efficiently. Consequently, remarkable work has been produced, pushing the boundaries of creativity and productivity. This study has provided unequivocal confirmation that music has a significant correlation to colour and emotion.

The results of the survey are mostly in agreement with the findings of Russian composer Alexander Scriabin which are detailed in the journal titled "Synesthetic Perception: Alexander Scriabin's Color Hearing." by Kenneth Peacock[29]. The relevant key and colour combinations founded by Scriabin coincided with the survey results in section two. By combining the information in section one and section two there are evident cross-overs that occur, therefore, proving that the is in fact a distinct link between music colour and emotion.

The results of the present study also correlate with the Alan Wells theory which was investigated in the literature review. By dividing the musical circle into 12 half-steps or 6 whole steps to work in conjunction with the division of the colour circle, a profound cross-modal colour and sound association can be achieved. The findings of the survey clearly show that chromesthesia occurs more frequently than expected among the general public.

[29] Peacock, Kenneth. "Synesthetic Perception: Alexander Scriabin's Color Hearing." *Music Perception*, vol. 2, no. 4, 1985, pp. 483–505., https://doi.org/10.2307/40285315.

By combining previous studies about the relationship between colour and music and studies about colour and emotion, new information has been uncovered by carrying out this survey which highlights the relationship between music colour and emotion. These findings have helped to fill the gap of knowledge in this field.

The interview with social care worker Myrtle McElwee provided clear evidence that music can indeed be used as a form of communication and as a way to express emotions for people with additional needs. The feedback which was given by Mrs. McElwee was insightful and will help to progress this study further in the future. Obtaining constructive criticism throughout this research project has helped to further adapt and evolve the application into something that could potentially be used to improve the lives and communication skills of individuals with disabilities.

One of the more meaningful findings to emerge from this study came from the interview. When asked would she use the app with a client Myrtle stated the following:

“I think that it's very useful. It's a good tool to be able to use because most people can identify with it.”

“I loved the colour element of it (the application) and that reflected emotions very well in the way that we would normally see it within our field.”

The significance of this statement lies in the fact that, as a creator, knowing that something one has created will be utilized by others in order to improve the quality of their lives is both humbling and inspiring. It is a reminder that what one creates can have a powerful and lasting impact on people's lives. It also serves as a motivation to keep striving, so that the boundaries within the field can be pushed further.

The main weakness of this study is the failure to carry out user testing with people who may use the app. Perhaps this would have provided insight into how well the application worked or did not work. A number of ethical considerations prevented this from being possible. There will be consideration given to future testing. While this project has some shortcomings that will need to be addressed in the future, its most notable feature is that it pushes the boundaries of creativity and productivity. Overall, it sets the stage for further development and progress.

Conclusion

It can be concluded that the project was a fruitful endeavour that provided valuable knowledge and experiences. As a result, numerous skills were honed across a wide range of fields, and a large amount of work was accomplished with only a limited amount of potential remaining. Through this project, resources were efficiently managed and intended objectives were achieved. By demonstrating the interconnection between music, colour, and emotion, the project in question has created a remarkable and valuable resource.

The application that has been developed may be revised and submitted to the application store for publication. It is feasible to further expand the application. A social care professional's recommendations will assist in the development of a resource that will, in the future, provide support to those with autism spectrum disorder.

This project integrated several course modules, including music theory, music and audio for games, psychoacoustics, audio programming, critical listening, and sound design. In terms of effectiveness, the application achieved all the objectives outlined at its inception.

Based on previous research and the interview and survey carried out in this paper, it is evident that colour, music and emotion are closely related. The findings of this study suggest that these three factors can have a powerful impact on an individual's developmental growth. Furthermore, the study indicates that a combination of sound and colour can be used to improve emotional recognition.

As a creator, it is both rewarding and awe-inspiring to be able to influence the lifestyle and development of another individual through the implementation of what one has produced. Music is anticipated to become increasingly prevalent in the near future as a form of therapy due to its demonstrated effectiveness.

It is intended for this project to contribute to the aforementioned area. This project will provide a new perspective to the area of research, enabling new discoveries and opportunities. The aim of this research project was to make a significant impact in this field and provide a framework for future research.

In conclusion, this research paper has shown that music, colour, and technology can indeed be used to assist people with disabilities in communicating their feelings more effectively.

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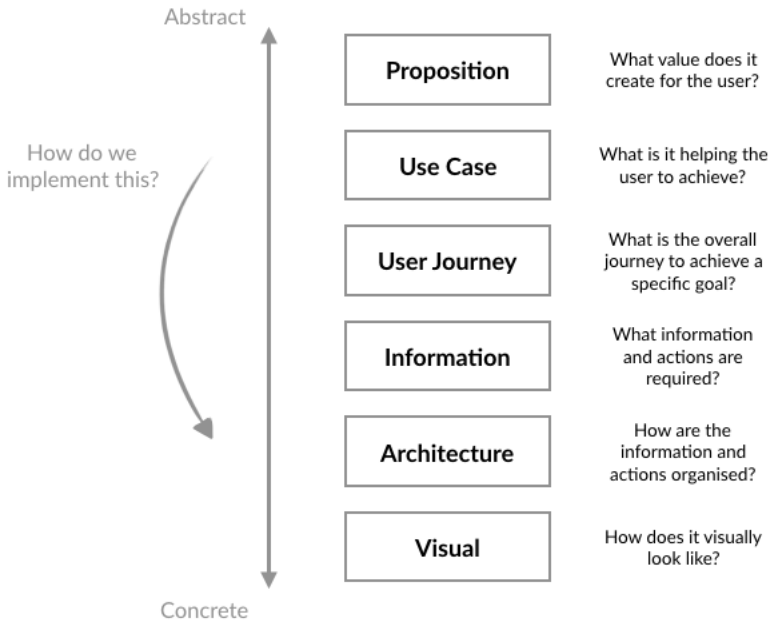
Appendix

Appendix A



Appendix B

Submission Folder