FRAMEWORK FOR VISUALISING MUSIC MOOD USING VISUAL TEXTURE

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DECLARATION

I declare that this thesis is my own account of my research and contains as its main content work, which has not previously been submitted for a degree at any tertiary education institution.

ABSTRACT

Modernised online music libraries and services provide effortless access to unlimited music collections. When contending with other competitors, online music developers have to devise interesting, fun, and easy-to-use interaction methods for their users to browse for music.

The conventional way of browsing a music collection is by going through a text list of songs by song title or artist name. This method may not be sufficient to maintain an overview of the music collection. Users will end up searching for the same artist that they are familiar with, and will not be able to discover other new and interesting songs that are available in the music collection.

There are many ways of browsing songs in an online music library. In the field of Music Information Retrieval (MIR), various types of visual variables such as colour, position, size, and shape have been investigated when representing music data. ***Texture*** is also one of the visual variables. However, to the best of our knowledge, there is no research focusing explicitly on texture.

Mood of music is one of the essential cues used for music exploration. It is also commonly used in music recommendation research as tags to describe music. A listener would select a song depending on his/her feeling or mood at a particular moment, regardless of the song's genre or other preferences.

In this thesis, we are interested in creating a new method of browsing music in the mood category. We developed a framework for visualising ***music mood*** using ***visual texture***. This framework is specifically designed to choose the best design elements in designing ***visual texture***, which can represent a specific ***music mood*** that can be understood by the user.

In order to determine how well people can interact with ***visual texture*** to browse through songs in the music library, usability testing was conducted. In usability testing, the ISO 9241-11 standard that consists of three elements – ***effectiveness***, ***efficiency***, and ***satisfaction*** was employed.

Two outcomes were gathered from this usability testing. First, the feedback on the suitability of ***visual texture*** that represented each of the ***music moods*** was

gathered. Secondly, by measuring the ***effectiveness***, ***efficiency***, ***ease of use,*** and ***satisfaction***, the usability of the music collection from the sample website was tested. Besides, the scores for ***ease of use*** and ***satisfaction*** for the first time were also compared to long time use.

From the usability testing, it was found that the design elements that were chosen for the ***visual texture*** to represent the moods - ***angry***, ***sad***, ***happy***, and ***calm*** were suitable. The average task times for all moods were acceptable, and these results indicate that browsing music using a ***visual texture*** is efficient. The completion and success rates for all moods were acceptable, and these findings point out that browsing music using the ***visual texture*** is effective.

This research revealed that ***visual texture*** is an associative visual variable and can be used to represent ***music mood*** in a music collection application or website. By using this method of browsing music, users can explore songs by the mood in the online music library, rather than search for songs by song title or artist name.

Overall, the main outcome of this research is the development of the Framework for Visualising ***Music Mood*** Using ***Visual Texture***. Positively, the framework will help online music developers invent a new and interesting method to browse for music.

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LIST OF DEFINITION

Design element: A design element is the visual component of colour, line, shape, texture, and value.

Visual variable: A visual variable is the characteristic of a visual symbol that consists of seven main categories, which are position, size, shape, value, colour, orientation, and texture (Bertin, 1981).

Visual texture: A visual texture is a texture designed using the drawing application.

Visual grammar: A language that implies meanings in the form of visual design.

Objects: Basic design elements that consist of two types, namely concrete and abstract.

Structures: Formal and informal arrangements of objects in the design space to depict certain meanings towards the whole design.

Activities: Processes that take place in compositing the design elements.

Relation: The type of relationship between objects, patterns, and processes.

Music mood: The type of music metadata that a person would select at a particular moment to listen to so as to suit his/her feeling or mood.

LIST OF PUBLICATIONS RELATED TO THIS THESIS

Conference Papers

C1. Husain, A., Shiratuddin, M. F., & Wong, K. W. (2019). Evaluating the Usability of Browsing Songs by Mood using Visual Texture. In *6th Research and Innovation in Information Systems (ICRIIS)*, Johor

C2. Husain, A., Shiratuddin, M. F., & Wong, K. W. (2015). Establishing a framework for visualising music mood using visual texture. In *5th International Conference on Computing and Informatics (ICOCI)*, Istanbul

C3. Husain, A., Shiratuddin, M. F., & Wong, K. W. (2014). Combining visual elements as a new method to browse and discover music mood. The *2nd - International Virtual Conference on Advanced Scientific Results* (Vol. 2, pp. 489-492). Slovakia: EDIS - Publishing Institution of the University of Zilina

C4. Husain, A., Shiratuddin, M. F., & Wong, K. W. (2013, November). A proposed framework for visualising music mood using texture image. In *2013 International Conference on Research and Innovation in Information Systems (ICRIIS)* (pp. 263-268). IEEE.

SUMMARY OF CONTRIBUTIONS TO THE THESIS

Chapter	Contribution	Paper Number
Chapter 1 – Research Background Chapter 2 – Literature Review	A review of previous studies that introduce various methods to retrieve music by mood. The process of identifying the specific type of design element that is related to a particular mood.	C4
Chapter 3 – Research Methodology Chapter 4 – Phase 3: The Development Phase	A discussion on the research methodology involved in achieving all the research objectives, from designing the visual texture to the development of an online music collection website for testing.	C2 & C3
Chapter 5 – Phase 4: The Evaluation Phase	An exploration into the process of validating the proposed framework by conducting usability testing and discussing its results.	C1
Chapter 6 – Discussion of results	An analysis of the main outcome of this research, which is the development of the Framework for Visualising ***Music Mood*** Using ***Visual Texture***.	C1

1 RESEARCH BACKGROUND

1.1 Overview

As an introduction to an in-depth discussion on the research topic, Chapter 1 provides deliberations on issues that underlie the foundation of the research, research problem, research objectives, research questions, research scope, research contribution, and the definition of the terms that are used in this research.

1.2 Introduction to research

In the area of Music Information Retrieval (MIR), there has been research that introduces various techniques of browsing and discovering songs in digital music libraries using visual forms (Allik, Fazekas, Barthet, & Swire, 2016; Andjelkovic, Parra, & O'Donovan, 2016; Hamasaki, Goto, & Nakano, 2014; Lehtiniemi & Holm, 2012; Pesek, Strle, Kavčič, & Marolt, 2017). Visual forms that include an album cover, avatar, colour, emoticon, and mood picture are used to represent music in a way that can be easily understood by listeners.

In general, music listeners search for a song either by the artist's name or song title. Instead of generating artists and songs by artist name or title, music listeners are also able to search for songs by the category of mood.

The mood has become a popular segment and has been explored in different contexts for various purposes. For example, research by Krishnan et al. (2015) makes use of the mood-mapping process to identify a suitable song to play according to the current context of a car driver to help reduce road accidents due to tiredness. Hides et al. (2015) developed and tested the effectiveness of a new mobile app using music to aid young people with emotion regulation. This research was done to help reduce mental health problems amongst young people by using something that they use daily - their smartphones.

For some listeners, the mood has become a way of selecting a song. The ***mood of music*** is one of the essential cues used for music exploration and is commonly used in recommendation research as tags to describe music (Andjelkovic et al., 2016; Plewa & Kostek, 2015).

Recently, researchers have developed several methods to retrieve music by mood. The emotional component of music has captured the interest of the MIR community, and experiments have been conducted to classify music by mood.

For example, there is a music recommendation player called Moodplay (Andjelkovic et al., 2016). Moodplay is a hybrid recommender music system that integrates content and mood-based filtering in an interactive interface (Figure 1.1).

Figure 1.1: MoodPlay interface (Andjelkovic et al., 2016)

Based on the MoodPlay system, Allik et al. (2016) developed a web app called myMoodplay. It is a collaborative jukebox that enables users to collectively select music based on their moods. It allows users to interactively discover music by selecting desired emotions through a natural touch interface (Figure 1.2).

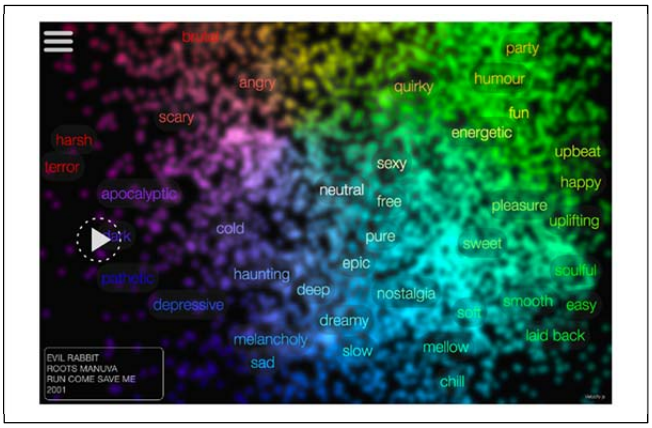


Figure 1.2: The myMoodplay app user interface (Allik et al., 2016)

Other than MoodPlay and myMoodplay, there is another study in the MIR field carried out by Plewa and Kostek (2015) that used a graphical representation for visualising a map of songs by mood based on the Self-Organizing Maps method. A map is created in which music excerpts with similar moods are organised next to each other on the two-dimensional display.

There is also another music browsing service developed by (Hamasaki et al., 2014) called Songrium (Figure 1.3). It is a collection of web applications designed to enrich the music listening experience. Songrium offers various ways to browse music, such as a graph-based visualisation of songs using audio similarity for placement and covers song exploration in a solar system-like structure.

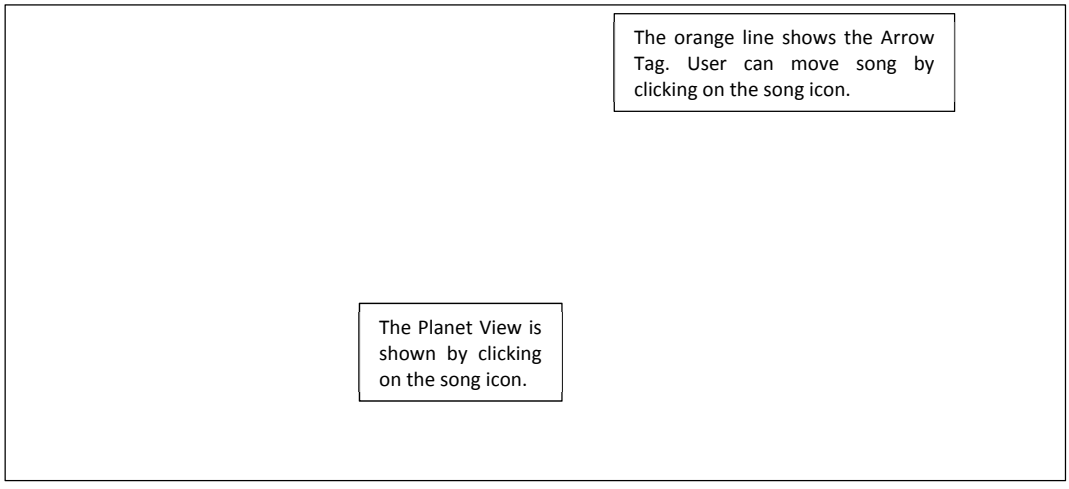


Figure 1.3: (A) "Music Star Map" and (B) "Planet View" interface in Songrium

There is also another software prototype developed by Lehtiniemi and Holm (2012) that lets users interact with a collection of pictures showing different moods to receive new music recommendations from the associated genres. The prototype features seven other built-in mood pictures with the related music (Figure 1.4). The images were designed to match up with potential daily activities and situations of the targeted user group.

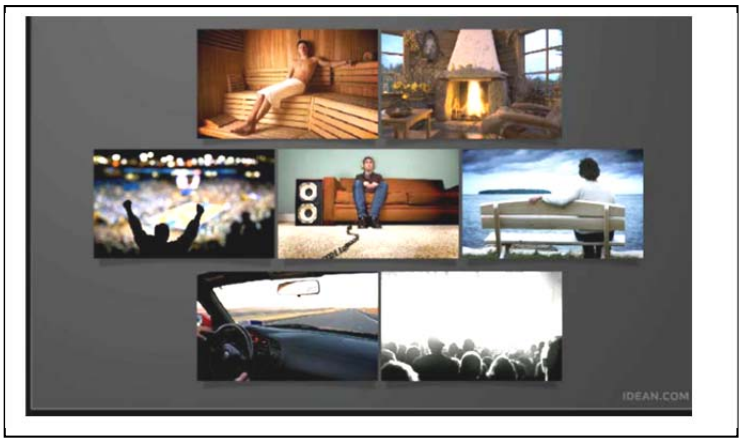


Figure 1.4: A sample of different mood pictures

1.3 Problem statement

There are a few approaches to browsing and discovering new music. In the field of Music Information Retrieval (MIR), various types of visual forms such as colour, avatar, mood pictures, and album cover have been introduced.

Table 1.1: Related works and type of the visual variable used

Related works	Visual variable
Moodo dataset (Pesek et al., 2017)	Colour
Moodplay (Andjelkovic et al., 2016)	Colour, position, orientation
myMoodplay (Allik et al., 2016)	Colour, value, shape, orientation
Songrium (Hamasaki et al., 2014)	Shape, size, position
Mood Pictures (Lehtiniemi & Holm, 2012)	Pictures

In Table 1.1, examples of related works that have investigated visual variables such as colour, orientation, position, size, shape, and value in representing ***music mood*** are

given. As mentioned in the list of definitions, there are seven main categories of visual variables introduced by Bertin (1981), which are position, size, shape, value, colour, orientation, and texture. However, to our knowledge, there is no research focused explicitly on textures (Holm & Siirtola, 2012a; Adzira Husain, Mohd Fairuz Shiratuddin, & Kok Wai Wong, 2013).

Mackinlay (1986) ranks texture as the third-best variable to convey nominal data and the fifth-best to represent ordinal data. Holm (2012) suggests that different textures could be used in various User Interface (UI) elements, such as buttons, icons, skins, and potentiometers. Potentially, smooth textures could be mapped to ***happy*** genres such as pop and rough texture to an aggressive genre such as heavy metal or rock (Zuo, Hope, Jones & Castle, 2004).

Research in consumer studies, psychology, material design, and user interface also suggests that ***texture*** has some kind of emotional connection with human moods (Sedgwick, Henson, & Barnes, 2003; Wang, 2009b).

Inspired by these findings, this thesis will explore the feasibility of visualising music mood by using visual texture.

1.3.1 Conventional versus visual variable

Fairly recently, the extensive use of digital music has led to an increase in the capacity of online music applications and personal music libraries. Music listeners are looking for new ways to search for songs in their music libraries or online music collections, not only by title, artist, or other keywords, but also by similarity, genre, and mood (Cheng & Hsu, 2016; Plewa & Kostek, 2015). In large libraries, the songs which are not listened to will regularly go unnoticed. A study by Celma (2010) on 5000 iPod users found that only 23% of the songs were played 80% of the time. 64% of the songs were never played at all. Sometimes, users become lost and confused as to which song to listen to at a particular moment. It is because there are too many songs in their library, and this can lead to information anxiety. Information anxiety is a level of inaccessibility that results

from not knowing exactly where or what to look for from a vast amount of information or data.

The conventional way of browsing a music collection is by going through a text list of songs. This method may not be sufficient to maintain an overview of the music collection (Watanabe & Goto, 2019). Allik et al. (2016) considered that the traditional browse method is ineffective in response to the escalating growth of music collections.

Music listeners will end up searching for the same artist that they are familiar with, and will not be able to discover other new and interesting songs that are available in the music collection. This view is supported by Ji, Sun, Shu, and Li (2015), who points out that a user usually listens to songs of the same album, artist, or genre in a listening session. A promising alternative for representing musical metadata is through Information Visualisation (InfoVis). InfoVis is a multidisciplinary research field that bridges many areas, including Human-Computer Interaction (HCI), computer graphics, and cognitive psychology. In this field, images and structures of data are generated to support the exploration, analysis, and decision making (Forsell, 2012). Besides that, InfoVis is often evaluated as a tool that can support the performance of a specific task (Baumer, Snyder, & Gay, 2018).

There is quite a several research on music visualisation using visual variables such as colour, position, size, shape, and value. However, there is no research focusing explicitly on ***visual textures*** (Holm, 2012; A. Husain, M. F. Shiratuddin, & K. W. Wong, 2013).

Many researchers have visualised music collection in various ways to make music browsing more exciting and efficient; this includes treemaps (Torrens, Hertzog, & Arcos, 2004), geographical maps (Kornhauser, Wilensky, & Rand, 2009; S. Leitich & M. Topf, 2007), rainbows (Pampalk & Goto, 2006), 3D spiral (Lamere & Eck, 2007), and many more.

In the next section, the researcher will explain the research gap questions that lead to the idea of proposing a framework for visualising ***music mood*** using ***visual texture***.

1.4 The research gap and questions

In general, music listeners search for songs either by artist name or song title. Nevertheless, mood has become a popular segment and has been recognised as an essential criterion when listeners organise and access music in digital music libraries. For some listeners, mood has become a way of selecting a song. A listener would choose a song depending on his/her feeling or mood at a particular moment regardless of the song's genre or other preferences (Krishnan et al., 2015; Plewa & Kostek, 2015).

A new and exciting way to represent musical metadata like mood and genre is via visual forms (Holm, 2012). For example, the most common way to represent songs and albums in digital music collection applications is to use the album covers (Holm & Siirtola, 2012b). In conveying the ***music mood***, the album covers may utilise design elements such as colours, fonts, and symbols. In 2014, it was proven that ***visual texture*** could represent ***angry***, ***calm***, ***happy***, and ***sad*** moods (Husain, Shiratuddin, & Wong, 2014).

However, to date, ***visual texture*** has not been used as a visual form to represent ***music mood***. Due to this fact, the researcher would like to propose a framework for visualising ***music mood*** using ***visual texture***.

Many of the existing MIR datasets contain a reasonable amount of demographic information. However, there is no research focusing on the interactions between visual and auditory modalities like connecting emotional and colour perceptions of music (Strle, Pesek, & Marolt, 2016). It is also relevant to find out about the relationship between emotions and music for a more innovative approach to music visualisation (Strle et al., 2016).

This leads to the following research questions:

RQ1: Which of the ***visual texture*** characteristics are suitable to be associated with a specific ***music mood***?

RQ2: How can we incorporate suitable ***visual texture*** characteristics and other components into the construction of the proposed framework?

RQ3: How well does the ***visual texture*** match the ***music mood***?

RQ4: How can we evaluate the usability of browsing music according to mood using ***visual texture***?

1.5 Research objective

In regards to the problems mentioned above, this research aims to develop a framework for visualising ***music mood*** using ***texture***. The following specific aims are outlined by means to support the general aim:

RO1: **Identify suitable texture characteristics in associating with a particular *music mood*.**

To find suitable design elements such as line, shape, colour, and colour value that can represent mood. These design elements will be verified by conducting an online survey.

RO2: **Incorporate the identified *visual texture* characteristics and other components in the construction of the proposed framework.**

a. To construct a proposed framework.

b. To design a ***visual texture*** for each mood and apply it in a music application sample website to represent the ***music mood*** category.

RO3: **Validate the framework by conducting usability testing on a music collection sample.**

a. Using the music application sample website, participants will select a ***visual texture*** to browse for songs in the mood category. After browsing for 5 to 15 minutes, the participants will give their opinion and feedback on how well the image matches the ***music mood*** by answering a questionnaire.

b. The participants are then observed via Camtasia Studio while they are completing the task. Camtasia Studio is a digital recording software of the

computer screen's output, also known as a video screen capture, that will record the participants' movements in video log. From the video recording, the researcher will be able to gather data on the ***effectiveness*** and ***efficiency*** of browsing ***music mood*** using **visual textures**. The participant will then give feedback on the ***ease of use*** and ***satisfaction*** of using the application for the first time and after two weeks.

1.6 Research scope

The visualisation of ***music mood*** in music collections is an essential topic in this research. It involves many related fields, such as Human-Computer Interaction (HCI), Music Information Retrieval (MIR), and Information Visualisation (InfoVis). Hence, to avoid misguided perception, it is essential to specifically cover the scope range of this research to focus on the target. The following outlines the scope of the research:

1.6.1 Music mood

In general, music listeners search for songs either by artist name or song title. Nevertheless, the mood has become a popular segment and has been recognised as an essential criterion when listeners organise and access music in digital music libraries (Van Selm & Jankowski, 2006; Wright, 2006). For some listeners, the mood has become a way of selecting a song. A listener would choose a song depending on his/her feeling or mood at a particular moment regardless of the song's genre or other preferences (Shanks, Arnott, & Rouse, 1993). Hence, in this research, the researcher is focusing only on one type of music metadata - ***music mood***.

1.6.2 Visual variable

In the field of Music Information Retrieval (MIR), there are many methods of browsing music libraries using visual variables such as colour, position, size, shape, and value. However, this research focuses only on ***visual texture*** as the visual variable to represent ***music mood***.

1.6.3 Proposed framework

The proposed framework is specifically designed to help choose the best design elements in designing ***visual texture*** to represent a specific ***music mood*** that can be understood by the user. There will be neither programming language nor algorithm involved in this research.

1.7 Research contribution

This thesis provides contributions to both academic researchers and developers of digital music services. The first contribution comprises a suggested visual variable, which is ***visual texture*** and structures for visualising mood metadata. Design elements such as line, shape, colour, and colour value that portray certain moods were studied in an online survey, and ***visual texture*** designs were further user-tested with an online music collection sample. To the best of our knowledge, studies on visualising mood musical metadata using ***visual texture*** have not yet been conducted elsewhere.

The anticipated research contributions can be summarised as follows:

1) Certain texture characteristics can be associated with particular ***music moods***.

This research will determine whether certain texture characteristics can represent particular ***music moods***. The texture characteristics represent the possible variables that can be incorporated into the framework for visualising ***music mood*** using texture.

2) The establishment of a framework for visualising ***music mood*** using ***visual texture***.

Previous research has made use of other visual variables to associate music metadata but has not focused explicitly on textures. Hence, this research will contribute a framework that can be used by music player software developers or online music service providers to visualise ***music mood*** using texture.

3) Confirming that ***visual texture*** can be used as a method to browse music via the mood category.

Research shows that texture is an associative visual variable. However, there is still no proof that ***visual texture*** can enhance the use of images for visualising music collections, particularly ***music mood***. By going through a few processes, this research will prove that ***visual texture*** can be used in visualising ***music mood***.

1.8 Definition of terminologies

This section describes the terminologies related to this research, which are commonly used throughout this thesis.

Design element: A design element is the visual component of colour, line, shape, texture, and value.

Visual variable: A visual variable is the characteristic of a visual symbol that consists of seven main categories, which are position, size, shape, value, colour, orientation, and texture (Bertin, 1981).

Visual texture: A visual texture is a texture designed using the drawing application.

Music mood: The type of music metadata that a person would select at a particular moment to listen to so as to suits his/her feeling or mood.

Relation: The type of relationship between objects, patterns, and processes.

1.9 Outline of the thesis

This thesis is presented in six chapters. An overview of the content of each chapter is as follows:

Chapter 1: Research background - This chapter provides deliberations of issues that underlie the foundation of the research, the research problem, objective, scope, and limitations.

Chapter 2: Literature review - This chapter discusses the processes in Phase 1: The Awareness of Problem Phase. It includes the reviews on concepts and theories

underlying this research, as well as the comparative analysis from the previous study to obtain the components involved in proposing the design framework.

Chapter 3: **Research methodology** - This chapter is about Phase 2: The Suggestion Phase. It discusses the processes involved in developing the proposed framework. All methods are based on the triangulation methodological approach, which is widely adopted in the research design of the information system. Each phase of the methodology is detailed. The relationship between the outcomes of each phase and the research objective is also discussed in this chapter.

Chapter 4: **The development phase** - This chapter discusses the processes in Phase 3: The Development Phase. It contains the descriptions of the activities involved in designing the four ***visual textures.*** Each of the ***visual texture*** represents four respective types of ***music moods*** which are; ***angry, calm, happy,*** and ***sad***. Besides, the development of an online music application sample website is also explained.

Chapter 5: **The evaluation phase** - This chapter discusses the processes in Phase 4: The Evaluation Phase. In order to achieve Research Objective 3 of this research, the online music collection website sample is set up and evaluated by conducting usability testing. Two outcomes were gathered from the test, namely the feedback on the suitability of ***visual texture*** and the usability of browsing ***music mood*** using ***visual texture***.

Chapter 6: **Discussions of results** - This chapter deliberates on the insights of the findings concerning the Research Questions and Research Objectives. The outcome of this research, which is the finalised framework, is presented in this chapter.

2 LITERATURE REVIEW

2.1 Introduction

Prior to embarking on constructing a framework for visualising ***music mood*** using ***visual texture***, working knowledge of the visual representation theory is needed. It is crucial to ensure that the framework is set with all visual design needs and comply with all the objectives outlined in this research. This chapter includes reviews of Music Information Retrieval (MIR), Information Visualisation (InfoVis), underlying theories, and previous studies of users' perceived usability of browsing and discovering songs in digital music libraries.

MIR focuses on the different strategies for helping users seek music or music-related information, and information visualisation studies the use of visual representations of abstract data to amplify cognition.

2.2 Music Information Retrieval

Music information retrieval (MIR) is an interdisciplinary research field that studies different methods and approaches to access music collections (Casey et al., 2008; Schedl, Gómez, & Urbano, 2014). Its objective is to undertake the three primary aspects: music information, the user, and the interactions between the two (Herrera-Boyer & Gouyon, 2013; Schedl et al., 2014; Strle et al., 2016).

Research efforts in MIR have involved experts from music perception, cognition, musicology, engineering, and computer science engaged in a genuinely interdisciplinary activity. MIR covers a wide range of topics such as the computational method for music analysis, musicology and music theory, software development, Human-computer Interaction (HCI), and User Interaction (UI) development (Pesek et al., 2017).

Music information contains inherent musical properties and contextual information about music. User information consists of general information about the user, such as

personality traits and music preferences. Besides that, it also consists of context-related details about the user's use and perception of music, such as current mood and emotions.

Music information retrieval requires user interfaces that facilitate the retrieval, classification, browsing, and management of extensive collections of music. The most popular and basic interface for browsing a music collection is based on lists of bibliographic information such as titles, artist names, and genres on display. Research on music visualisation and browsing for a music collection or a musical piece are, therefore, necessary to provide end-users with comprehensive and functional interaction (Schedl et al., 2014).

Three primary audiences benefit from MIR: industry bodies, music professionals, and end-users who want to find and use music. Among the topics that have been studied in the MIR field, recommending new songs and finding music from specific genres is an important topic to be explored (Casey et al., 2008; O'Bryant, 2017; Ren, Kauffman, & King, 2019). From their observation, Caset et al. (2008) found out that most of the activity in the field has been engineering-led. There have been very few user studies that attempt to understand and evaluate the way that MIR tools get to be used by non-research communities. They suggested that new research is required better to understand the requirements of user control of search.

Hence, to improve the field of music recommendation systems, O'Bryant (2017) carried out a literature review on the strengths and weaknesses of collaborative and content-based filtering. From the study, O'Bryant proposed a new next-track recommendation system that relies on user skipping behaviour. He believed that this system has the potential to provide users with a music experience for practical recommendations.

Ren et al. (2019) also proposed a new method for recommending streaming music that aims to improve consumer utility related to the recommendations they receive. After an investigation of this newly proposed method, the results show some improvement in recommendation performance in conjunction with other factors, including time, location, and external information and listening behaviour.

2.2.1 Interaction design in MIR

A successful product is a product that is useful, usable, and provides an enlightening overall user experience (Jones & Marsden, 2006b). Users should be able to obtain three different levels of functionality, usability, and pleasure by a progressive relationship from low to high (Liu & Idris, 2018).

User experience (UX) refers to “a person's perceptions and responses that result from the use and/or anticipated use of a product, system, or service” (ISO 2009). UX involves both pragmatic and hedonic quality aspects of the product, and it is highly personal. UX also changes over time (Kim, 2015); the longer-term user experience is especially crucial for business success (Kujala, Roto, Väänänen-Vainio-Mattila, Karapanos, & Sinnelä, 2011). According to Kujala, Miron-Shatz, and Jokinen (2019), the positive and negative changes in user enjoyment over time are essential as they were reflected in users’ loyalty to the service. Thus, in this research, ***satisfaction,*** and ***ease of use*** of browsing ***music mood*** using ***visual textures*** will be evaluated twice, once during the first-time use and the next, after two weeks.

The usefulness, usability, and UX of products can be improved by utilising proper interaction design methods. Interaction design refers to “designing interactive products to support people in their every day and working lives” (Rogers, Sharp, & Preece, 2011).

A study by Strle et al. (2016) has shown that interaction with the proposed interfaces improves usability. Besides that, Andjelkovic, Parra, and O’Donovan (2019) also proved that the interactive features in their application improved user satisfaction.

Interaction design involves three main types of activity: 1) understanding users, 2) developing prototype designs, and 3) evaluation (Jones & Marsden, 2006b). In the following sections, the different phases of interaction design in the context of MIR will be discussed.

2.2.2 Understanding users

According to (Jones & Marsden, 2006b), to understand users means "having a sense of people's capabilities and limitations; gaining a rich picture of what makes up the detail of their lives, the things they do and use." Methods such as observation, interviews, and focus groups, surveys, contextual inquiry, probing, and diary studies can be used to get a better knowledge of the target (Jones & Marsden, 2006a; Kim, Chae, & Lee, 2018).

Krause and North (2016) studied how music users organised and accessed their digital music collections. Cunningham, Bainbridge, and Bainbridge (2017) conducted an ethnographic study on music media and formats, collection organisation schemes, and approaches to music acquisition and use. Recently, a study by (Kim et al., 2018) has incorporated user musical preferences and cultural background in their model to improve recommendation performance.

A few large-scale user studies focused on investigating particular user groups such as university music library users (Lai & Chan, 2010) or visitors to a music museum (Maguire, Motson, Wilson, & Wolfe, 2005). Lai and Chan (2010) learned about participants' preference for certain materials such as scores and multimedia over other types of library materials.

2.2.3 Developing prototype design

After enough knowledge of the users has been gathered, the next step in interaction design is to design and implement a prototype. A prototype is a mock-up or simplified representation of an object. For example, a prototype of an aeroplane design is often used to test its aerodynamics before building the real plane. It is very unlikely that the first version is perfect in every way, but re-designing is much cheaper in the early phase of the work rather than after the product has already been launched. Prototypes may vary from simple paper prototypes to complex beta releases. Prototypes differ from the final product in two ways: their fidelity and scope. Fidelity has to do with how

closely the prototype looks like the final product. It is convenient to think about prototype fidelity as having two levels: low and high-fidelity prototypes. They can be categorised according to their resemblance to the final product or the functionality that they provide. Horizontal prototypes show a lot of functionality with little details, while vertical prototypes offer a lot of functionality for only a few functions (Rogers et al., 2011).

A critical part of designing the prototype application is the User Interface (UI) design. Most current interfaces belong to the category of graphical user interfaces (GUIs), which is sometimes referred to as WIMP (windows, icons, menus, and a pointing device) systems.

There are a variety of guidelines and standards for designing prototypes and User Interface (UI). Jones and Marsden (2006a) provide examples of design starting pointers as follows:

1) Design for straightforward manipulation.

2) Design for ecological use.

3) Design for maximum impact through minimum user effort.

4) Design for personalisation.

5) Design for play and fun.

6) Design for one-handed use.

Nielsen (1994) and Shneiderman (2010) imparted some well-known basic rule of thumb for usable interfaces, which included natural and straightforward dialogue, “less is more,” minimising user’s memory load, “recognition over recall,” consistency, and shortcuts. Also, many developers have published more detailed UI guidelines for their platforms.

2.2.4 Evaluation

Once the prototype has been designed, the final step is to evaluate the prototype with end-users, experts, or without users (automated testing). Expert and automated testings are usually referred to as usability inspections (Lazar, Feng, & Hochheiser, 2010). For testings with end-users, the term 'usability testing' is used. Usability testing refers to "a group of representative users attempting a set of representative tasks," which include activities such as observation, interviews, and surveys/questionnaires.

While the ultimate goal of MIR systems is to help users seek music or music-related information, however, the evaluation of MIR algorithms and prototypes has been primarily dominated by automated system-centred approaches (D. Weigl & C. Guastavino, 2011). This type of assessment typically measures how well systems classify music and how relevant their retrieved music is. There are only a few studies in the MIR domain that investigate users' music needs, use patterns, preferences, and behaviours (Lee, Cho, & Kim, 2016).

Thus, in this fast-changing field, the understanding of users' current music information needs and behaviours is vital for developing successful music information retrieval (MIR) systems (Lee et al., 2016). The focus on users has also been identified as one of the five most important MIR challenges for the next ten years (Downie, Byrd, & Crowford, 2011), and the number of user-based tests is increasing steadily. The beginning of the substantial growth of MIR user studies can be traced back to the early 2000s (Lee & Cunningham, 2015).

User studies in MIR focused on investigating specific issues that emerge from users' music information-seeking, use, storage, and sharing activities. These studies investigated various aspects that are related to users' experience and interaction with music such as users' information needs, music use, and organisation, search and browse behaviours, and music perceptions, preferences, and opinions (Lee & Cunningham, 2015; M. D. Weigl & C. Guastavino, 2011)

Table 2.1: User-testing music discovery applications

No.	Evaluation	Literature
1.	Semi-structured interview	(Laplante & Downie, 2006); (Inskip, Butterworth, & MacFarlane, 2008)
2.	Questionnaire & semi-structured interview	Leitich & Topf (2007); (Li, Ng, & Hu, 2018); (Kassim et al., 2018)
3.	Survey	Chen & Kluber (2010);(Strle et al., 2016)
4.	5-week user trial	Lehtiniemi (2008)
5.	Experiment task	Hoashi et al. (2009); Li et al. (2018)
6.	Crowdsourcing	Lee (2010b); Mandel, Eck & Bengio (2010); Urbano, Morato, Marrero & Martin (2010); Lee, Hill, & Work (2012); (Andjelkovic et al., 2019)

Table 2.1 illustrates a few examples of evaluating MIR applications with end-users.

Questionnaires and the semi-structured interview method were applied by Leitich and Topf (2007) to conduct initial user experiments for their Globe of Music application (Figure 2.1). The investigation received promising results in terms of high user acceptance. Outcomes from the experiment show that the visualisations provide the user with an intuitive interface that is easy to handle and fun to explore.

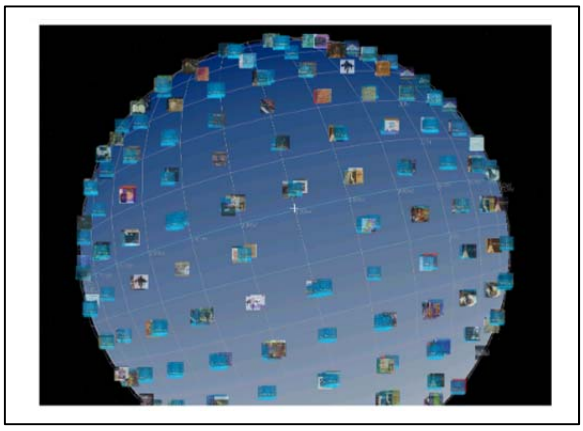


Figure 2.1 Globe of Music interface (Stefan Leitich & Martin Topf, 2007)

Li et al. (2018) also applied pre and post-experiment questionnaires in their user experiment to evaluate an application called Moody_v3. In the user experiment, participants were asked to search and listen to music for 40 minutes. Kassim et al. (2018) also used questionnaires in their investigation to investigate the type of music information that is important for music students in their studies.

The survey method was applied by Strle et al. (2016) in their experiment. An online evaluation survey was conducted to evaluate MoodStripe interfaces. The results from the evaluation validated the usefulness of the proposed interfaces. A study by Chen and Kluber (2010) also used the survey method to evaluate four concepts of visual thumbnails to visualise music content (Figure 2.2). This application is called ThumbnailDJ. Figure 2.2 shows four selected concepts in ThumbnailDJ, namely a) Beat Histogram, b) ArchDiagram, c) TimbreGrams, and d) simplified ring icon with petals. The number and shape of the petals represent tempo and aggressiveness. From the survey, it was found that the participant did not like the concept. They commented that these visualisations were too complicated for them. However, they conducted a discussion session with seven selected DJs, and the visual thumbnail concept was appreciated.

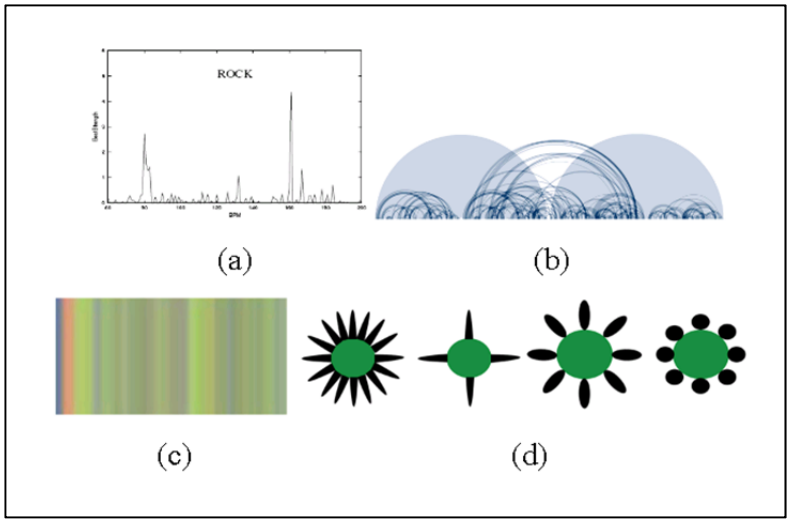


Figure 2.2: Four concepts of visual thumbnail to visualise music content (Chen & Klüber, 2010)

Another evaluation method that has been used by a researcher in their evaluation process is the user trial method. For example, Lehtiniemi (2008) conducted a five-week user trial of the SuperMusic system with 42 participants. Based on the results, the author concluded that 97% of the users were satisfied with the concept, and it was seen as a potential "killer" application in the music domain with some modifications.

Another popular evaluation method that has been applied by various researchers is the experiment task. Hoashi, Hamawaki, Ishizaki, Takishima, and Katto (2009) conducted a comparative evaluation of a traditional list-based and a 2D visualisation for a content-based MIR system. Participants were given the task to search for a song by a specific artist. Based on the results, the authors concluded that visualisations could improve the usability and efficiency of the system and give a better impression of the accuracy of the MIR results.

A few studies employed crowdsourcing and collected around 50 to 2,500 user responses on ***music mood*** and similarity (Lee, Hill, & Work, 2012; Mandel, Eck, & Bengio, 2010; Urbano, Morato, Marrero, & Martín, 2010). Lee et al. (2012) employed crowdsourcing by creating an online survey that requested participants to listen to several short music clips. The participants were then asked to provide five tags describing the mood of each song. Mandel et al. (2010) also explored crowdsourcing alternatives to gather semantic tags. Besides that, Urbano et al. (2010) proposed crowdsourcing as a practical and inexpensive alternative method to evaluate music systems. From the studies, they managed to disclose the issues in collecting users' judgments, as well as demonstrating the use of the crowdsourcing method in getting the ground truth for multiple evaluation tasks.

Recently, Andjelkovic et al. (2019) conducted a user study involving 279 crowd-sourced participants. In the research, four versions of the interface with various visualisations and interactions were evaluated (Figure 2.3). The interface was divided into three sections. The left panel is for generating a user profile by entering the artist's name. The centre panel is the snapshot of the mood space visualisation, and the right panel is the recommendation list, along with a slider for adjusting the mood influence. The

results show that the interface design with a specific combination of interactive features improved objective and perceived recommendation accuracy and user satisfaction.

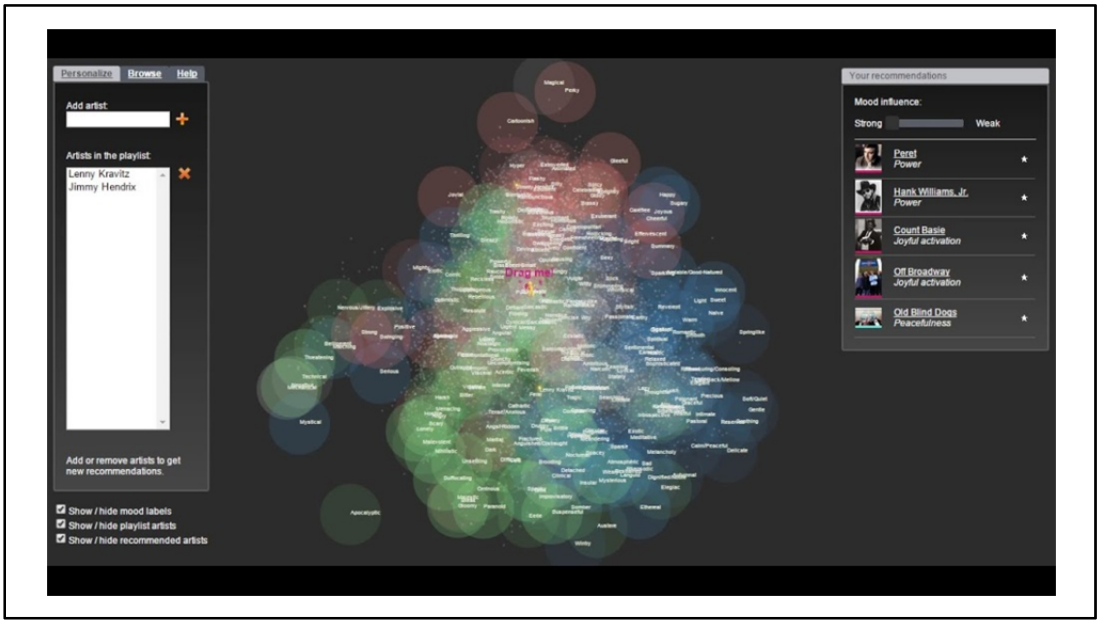


Figure 2.3 Screenshot of the MoodPlay interface (Andjelkovic et al., 2019)

On the whole, these MIR user studies have helped to improve the general understanding of various aspects of people's use of music information systems, including the different types of metadata that are most significant and potentially useful, users' music search behaviour, problems in how users manage their collections, and the value of user data such as ratings and judgments for the purposes of system development and evaluation.

2.3 Mood model in MIR

The mood has become a popular segment and has been recognised as an essential criterion when listeners organise and access music in digital music libraries (Andjelkovic et al., 2016; Garrido & Schubert, 2015; Van Selm & Jankowski, 2006; Wright, 2006). For some listeners, the mood has become a way of selecting a song. Experimental evidence shows a strong relationship between emotion and music (Koelsch, 2009).

A listener would select a song depending on his/her feeling or mood at a particular moment regardless of the song's genre or other preferences (Garrido & Schubert, 2015; Shanks et al., 1993). In music retrieval by mood, the listener selects music to enjoy. For example, when someone is sad for some reason, she or he wants to listen to a piece of music that can cheer them up. At this moment, they will search the music segment by mood no matter what the melody sounds and which the piece of music is similar to (Feng, Zhuang, & Pan, 2003).

Two music dimensions could explain the transfer of emotional content from performer to audience: tempo and articulation (Juslin, 2000). Tempos were either fast or slow, while articulations were either staccato or legato. Tempo provides essential factors to determine whether the music sounds ***sad*** or ***happy***. A slow tempo is associated with ***sad*** and ***calm,*** whereas music played with fast tempo is commonly associated with positive emotions such as happiness, liveliness, and excitement (Feng et al., 2003).

Holm, Holm, and Seppänen (2010) conducted a high-level mapping between music genre and emoticon as a description of emotions and mood. Their findings show that in a ***sad*** mood, participants liked to listen to blues, alternative indie, and classical music. When feeling ***happy***, participants listened to a few types of music such as pop, electronic dance, world, soul, RnB, and funk music. When feeling ***angry***, participants listened to metal and rock music.

Moods are the states of human feelings that are felt at a lower intensity but for more extended periods, and are less focused on specific objects or reasons that are emotions (Juslin & Västfjäll, 2008). Typically, a mood can most commonly be described as being either good or bad. Therefore, the term 'mood' refers to a more general concept of emotions.

Most existing MIR studies on emotions in music, use some variation of the dimensional emotion modeling approach for gathering user input. One commonly used method to categorising moods in the mood-based music player is Russel's circumplex model of emotions (Lehtiniemi & Holm, 2012). Russell proposes a two-dimensional model, and the most widely used dimensional emotional scale (Figure 2.4).

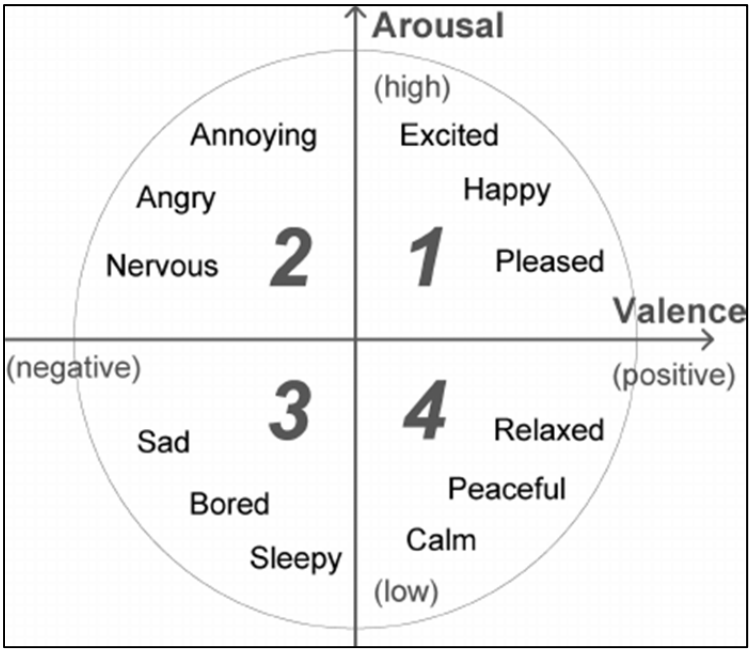


Figure 2.4: Russel's circumplex model of emotion (Russel, 1980)

This model suggests that emotions are distributed in a two-dimensional circular space containing arousal and valence dimension. The emotional states can be represented at any level of valence and arousal, or at a neutral level of one or both of these factors. The adaptation of this model is essential for a mood-based music recommendation as it allows for the categorisation of mood (Russell, 1980).

Variations of Russell's dimensional model have been used in several music-related studies (Barthet, Marston, Baume, Fazekas, & Sandler, 2013; Baume, Fazekas, Barthet, Marston, & Sandler, 2014; Godec et al.; Saari et al., 2016), alongside suggestions by other researchers to improve the structure of musical emotions.

In the area of Human Emotion Recognition studies, a simplified version of Russel's model (Figure 2.5) were used to measure the degree of discrete emotional state such as '**happy,**' '**sad,**' '**angry,**' and 'relaxed' (Candra et al., 2015; Valenza, Citi, Lanatá, Scilingo, & Barbieri, 2014). In another study by Kolivand, Abuhashish, Zraqou, Alkhodour, and Sunar (2015), it is found that **happy** and **sad** emotions are clearly determined during audio-video stimuli.

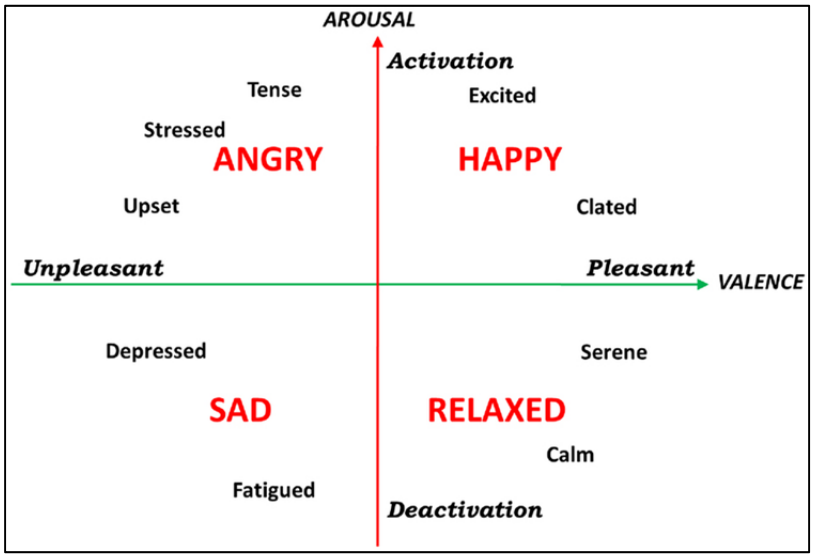


Figure 2.5: Russel's circumplex model (Valenza et al., 2014)

Based on the review of the mood model, one mood from every quarter of Russell's model, the ***angry***, ***sad***, ***happy,*** and ***calm*** moods were selected to be represented by ***visual textures***. ***Happy*** (high valence) and ***angry*** (low valence) will represent moods from the high arousal dimension, whereas ***calm*** (high valence) and ***sad*** (low valence) will represent the moods from the low arousal dimension. Songs for each mood will be taken from the first 20 out of 50 songs provided for each mood from the AMG website, allmusic.com.

2.4 MIR Datasets

It is challenging to distribute music data due to very restrictive copyright laws freely. However, different groups try to overcome this problem by using music with a free license. The MIR dataset is a freely-available collection of audio features and metadata for a million contemporary and popular songs. The availability of standard datasets is essential in the progress of the music information retrieval (MIR) community. One of the potential music databases is last.fm. It is a popular internet radio-based and music community website from the UK.

However, as seen from a few related research, music datasets that focus on modeling emotions in music are taken from widely used websites such as allmusic.com (AMG) (Bogdanov, Porter, Urbano, & Schreiber, 2018; Çano & Morisio, 2017; Yang, Huang, Yang, & Lin, 2017) and last.fm (Andjelkovic et al., 2019; Bogdanov et al., 2018; Lee & Downie, 2004).

Thus, in this research, songs based on mood will be taken from AMG because this website is a popular music database. AMG is a large and influential online repository for Western popular music that provides professional reviews and metadata for albums, songs, and artists. It also consists of 182 mood labels that are applied to songs and albums by professional music editors.

2.5 Information Visualisation

Apart from applying textual lists, information visualisation is an alternative approach to representing musical metadata. Information visualisation (InfoVis) is a multidisciplinary research field that bridges several research areas, including HCI, computer graphics, and cognitive psychology. InfoVis tools and applications can help us transform data into useful information, form mental models, and gain insight, perform tasks more effectively and accurately, and thus subsequently saving time and money (Spence 2007).

Information visualisation is the study of visual representations of abstract data to reinforce human cognition. It is an art of representing data in a way that is easy to understand and helps users make sense of the information. Yi, Kang, Stasko, and Jacko (2008) described information visualisation as one way to decrease the gap between data and the user's mental model. Gershon and Eick (1995) describe information visualisation as a process of transforming data and information that are not inherently spatial, into a visual form, to let the user observe and understand the information. Though the definitions mentioned above were formulated before the time of computers, currently, the InfoVis tools are becoming increasingly computer-based.

Thus, some authors limit information visualisation to computer-related activities. For instance, Card, Mackinlay, and Shneiderman (1999) describe information visualisation as the use of a computer-supported visual representation of abstract data to increase human cognition. There are various ways to improve human cognition, such as shifting part of the workload from a human's cognitive system to the perceptual system, reducing searching, and enhancing the recognition of patterns (Ware 2004).

2.5.1 General visualisation reference model

Most of the existing information visualisation toolkits follow the General Visualisation Reference Model (GVRM), initially specified by Ed Chi and refined by Card, Mackinlay, and Shneiderman (Card et al., 1999; Chi & Riedl, 1998). One of the well-known frameworks for creating dynamic visualisations of structured and unstructured data is also based on the GVRM. (Heer, Card, & Landay, 2005). This framework is called Prefuse. Similarly, research by Upton and Doherty (2007) integrates GVRM in their Ecological Interface Design (EID) framework that use to generate visual components in ecological interface design.

The model defines three stages: Data Table, Visual Structure, and View. One of its main benefits is that it explicitly represents an interaction. The General Visualisation Reference Model (Figure 2.6) traces the path of transforming raw data into a visual form that can be viewed by the user. Through the Visual Mapping stage, data will be transformed into a visual form that can be understood by the users. To convert data from one stage to another, it requires one of the three types of operators, namely Data Transformation, Visual Mapping, and View Transformation. View Transformation takes information that is in a visualisable format and presents it in a graphical view.

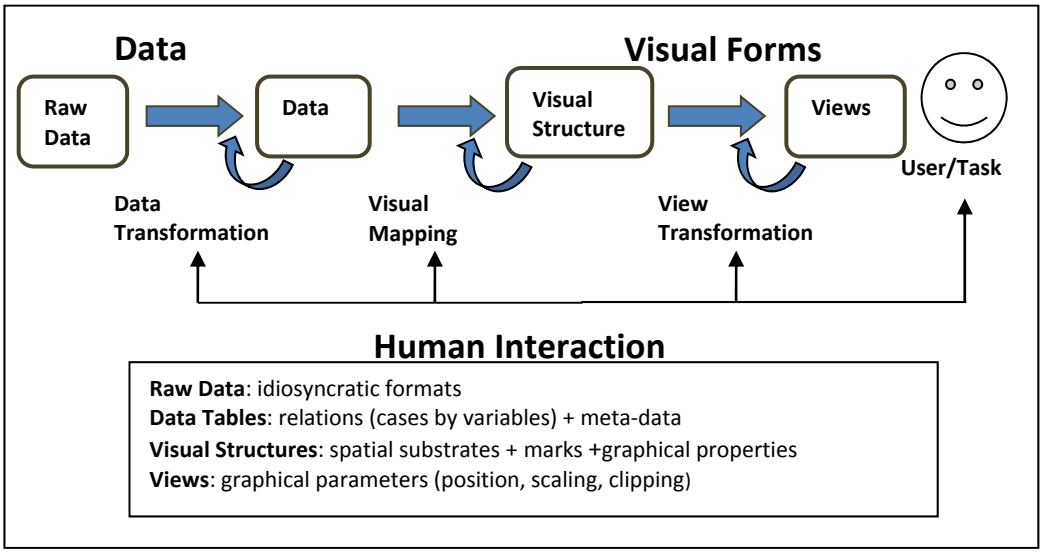


Figure 2.6: General visualisation reference model (Card et al., 1999)

2.5.1.1 Visual Mapping

According to (Card et al., 1999), three elements in the visual mapping process provide a strong structure for overall information visualisation. It consists of a spatial substrate, graphical elements, and graphical properties. These elements will help information visualisation designers gain a better understanding of the data that they are going to portray and also give an idea of how it can be used to deliver value to users.

2.5.1.2 The Spatial Substrate

The spatial substrate is the space available to create our visualisation. The majority of information visualisation takes place in a 2-dimension space. However, visualisation can also be made in 3 dimensional, as well as hyper-dimensional spaces. In designing information visualisation, the first thing to do is to choose the type of space to be used and the type of data available. Data can be in the form of quantitative, ordinal, or nominal data. Quantitative data has a numerical measurement of some quality of the data set, for example, height or shoe size. Ordinal data is not associated with a number, but still offers some form of order like months in a calendar year. Nominal data is a collection of non-numerical and non-ordered data, such as occupation or gender.

2.5.1.3 Graphical Elements

Graphical elements are design elements that appear in the spatial substrate. Humans see images as a whole rather than in parts. However, images can be broken down into design elements that have particular meanings and the ability to express emotion. There are four types of graphical elements (Figure 2.7), which are points, lines, surfaces, and volumes (Card et al., 1999).

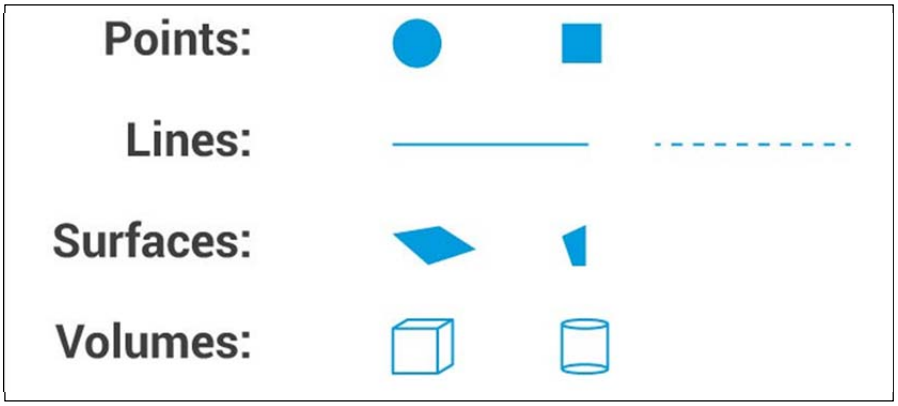


Figure 2.7: Type of graphical elements

A point is a precise position or location on a surface. It is the basic building block of every variation of line, texture, and plane. Points can be used to direct attention, be the focus of attention, and create emphasis.

A line is the second most essential element of design. Lines are useful for dividing space and drawing the eye to a specific location. A line can be actual or implied. Actual lines are real marks made in a composition. Implied lines are lines that are suggested by changes in colour, tone, and texture, or by the edges of shapes.

A surface is a flat section that has defined borders. It is a compositional tool for clustering design elements into visual fields.

A volume is a two-dimensional form that appears as a three-dimensional form. It comprises of length, width, and depth.

2.5.1.4 Graphical Properties

Graphical properties (Figure 2.8) are properties that can be applied to the graphic elements, which make them more or less noticeable and valuable to the representation viewer. They are colour, orientation, size, shape, and texture (Card et al., 1999).

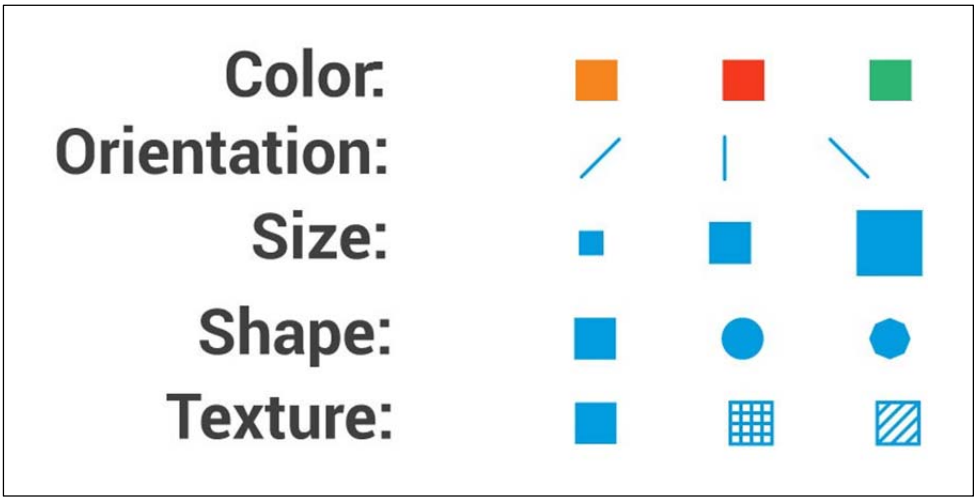


Figure 2.8: Type of graphical properties

Definitions of each graphical properties are as follows:

1) Colour: colour coding can be used to provide a visual key to data or to provide a "call to attention" to the eye.
2) Orientation: the orientation of a line or volume in space can help clarify the purpose of the line or volume.
3) Size: the size of a point, surface, or volume can convey information about significance or weight.
4) Shape: hexagons, circles, triangles, etc. can be used to provide a visual key to the data.
5) Textures: textures can be used to provide visual keys to the data.

2.6 Theories of Visual Representation

Designing computer displays that are as meaningful as possible to human viewers requires an understanding of visual representation. It is the principles by which

markings on a surface are made and interpreted. A visual presentation is also another approach for viewers to understand the message of a particular visual.

2.6.1 Gestalt theory

The Gestalt theory of visual perception is derived from a simple observation. This theory appeared when Max Wertheimer (German psychologist) received his inspiration during a train trip in the summer of 1910. "Gestalt" – comes from the German noun 'carried,' meaning 'form' or 'shape.'

Table 2.2: Fundamental principles of grouping

No.	Category	Explanation
1.	Proximity	Proximity occurs when elements are placed close together. They tend to be perceived as a group.
2.	Similarity	Similarity occurs when objects look similar to one another. People often perceive them as a group or pattern.
3.	Continuation	Continuation occurs when the eye is compelled to move through one object and continue to another.
4.	Closure	Closure occurs when an object is incomplete or when space is not entirely enclosed. People perceive the whole by filling in the missing information.

Table 2.2 shows the explanation of the four fundamental principles of grouping. According to Lester (2003), gestalt psychologists further refined the initial work from Wertheimer to conclude visual perception as a result of organising sensual elements or forms into various groups. The separated elements within a scene are combined and will be interpreted by the brain through four series of fundamental principles of grouping. These four fundamental principles are laws of similarity, proximity, continuation, and common fate.

In conclusion, the gestalt approach clearly shows that the brain is powerful in clarifying a visual material in the discrete group. According to Lester (2003), what we see when we are looking at a picture is modified by what we have seen in the past and also what we want to see.

2.6.2 Semiotic

The word 'semiotic' is derived from the Greek word 'semeion,' meaning "sign." Augustine, a Roman philosopher, emphasizes that semiotics is a study of signs and the link between nature and culture. 'Sign' is anything that stands for something else. Almost any action, object, or image will mean something to someone at someplace. Lester (2013) emphasizes that any representation of something physical is a sign that the subject has a meaning beyond itself. Therefore, the meaning behind any sign must be learned.

In Europe, semiotics is called semiology, and it is a study or science of signs. In his book, Lester (2013) mentioned that actually, it is the culmination of Aldous Huxley's anthem: the more you know, the more you see. He also stresses that images will be more interesting and memorable to the viewer if the signs that are understood by many are used in a picture. Semiotics study is vital because signs permeate every message. It also attempts to identify and explain the signs that are used by societies around the world.

2.6.3 Types of signs

Charles Sanders Peirce (1839 – 1914) contributed three different types of formulation to semiotics study (signs). He formulated the innovative triadic model of the sign, emphasizing in his theory that the way we interpret a 'sign' is what allows it to be signified – what gives it its meaning. The three different formulations are: iconic, indexical, and symbolic. The researcher found that, when we think about iconic, indexical, and symbolic signs, we are looking and studying visual messages in a much more thorough and critical manner. If this process is done, we will realise that even the most straightforward image has a complex cultural meaning. However, we need to realise that these three categories (iconic, indexical, and symbolic) are not mutually exclusive.

2.7 Summary

Based on the literature review, understandings about Music Information Retrieval (MIR), Information Visualisation (InfoVis), perceptual theories of visual communication,

and cognitive fit theory are gained. Accordingly, the topics provide a general understanding of MIR and gradually immerse into the detailed aspects of graphical elements and properties in visual mapping. Discussions on design elements such as colour, line, and shape and how they can portray ***music mood*** were also taken into consideration, pertinent to proposing a framework for visualising ***music mood*** using ***visual texture***. As mentioned in Section 1.4, ***visual texture*** has not been used as a visual form to represent ***music mood.*** Hence, from the literature review, visual representation through ***visual texture*** is found to be one of the relevant strategies for helping users discover songs in digital music libraries. Also, related theories were also interpreted to provide a foundation for the propositions made in this research. Figure 2.9 shows the overview of the literature that is reviewed. Overall, the topics covered in the literature reviews facilitate the process of achieving the objectives of the research.

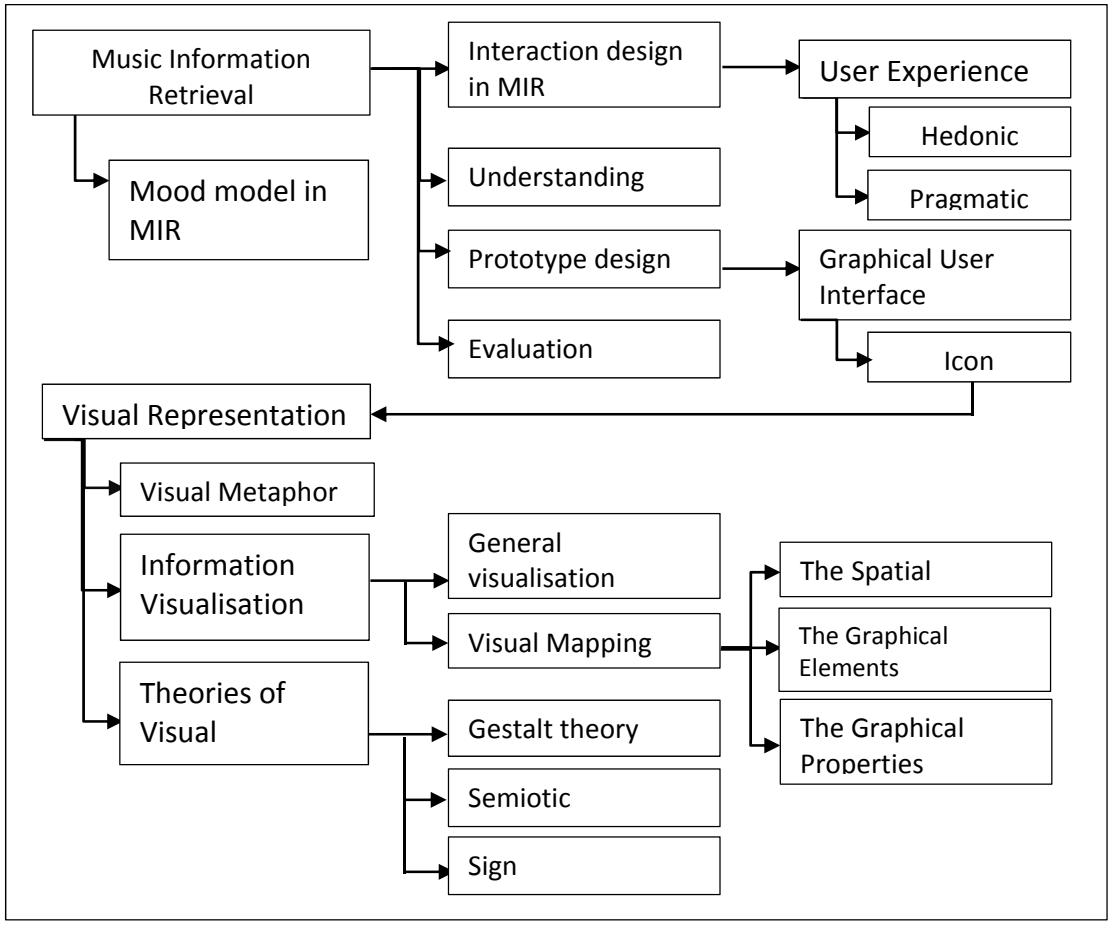


Figure 2.9: Overview of Literature

3 RESEARCH METHODOLOGY

3.1 Overview

This chapter discusses the research methodology involved in achieving all research objectives, as outlined in Chapter 1. The processes are based on a methodological approach that is widely adapted in Human-Computer Interaction (HCI). Each phase in the methodology is detailed, and the relationships between the outcomes of each phase and research objectives are also discussed in this chapter.

3.2 Research design & justifications

As part of the HCI approach, this research employed a user-centred design science research method. The user-centred design (UCD) has been specified as a multidisciplinary design approach based on the active involvement of users to improve the understanding of user and task requirements and the iteration of design and evaluation (Mao, Vredenburg, Smith, & Carey, 2005). Design science research has become popular as the methodology in multiple fields such as information system (Vaishnavi & Kuechler, 2007; March & Smith, 1995; Purao, 2002), Human-Computer Interaction (HCI) (Druin, 2002; Carroll, 2000;), instructional design and technology (Reigeluth, 2008;), and educational research (Barab & Squire, 2004).

In design science research, the knowledge and understanding of a problem domain and its solutions are achieved through building and evaluating innovative and purposeful artefacts (Hevner & Chatterjee, 2010). The artefacts can be constructs, such as vocabulary and symbols. They can also be in the form of models such as abstractions and representations, methods such as algorithms and practices, or instantiations such as implemented and prototype systems (Hevner & Chatterjee, 2010). However, outcomes such as working prototypes, algorithms, user interfaces, processes, techniques, methodologies, and frameworks can also be considered as valid artefacts under the design science research method (Norshuhada & Shahizan, 2010).

In music recommendation research, several innovative and purposeful artefacts such as graphical representations and prototypes for music retrieval and visualisation have been developed and evaluated (Allik et al., 2016; Andjelkovic et al., 2019; Lehtiniemi & Holm, 2012; Plewa & Kostek, 2015). The outcomes of this research overlap with the list of artefacts mentioned. Therefore, the design science research method applies to this research.

3.3 Phases in Research Methodology

To ensure that the research objective is achieved, systematic tasks need to be planned (Dwolatzky, Kennedy, & Owens, 2002). Thus, in this research, five sub-phases were adapted from the design science research method, such as (i) awareness of problem, (ii) suggestion, (iii) development, (iv) evaluation, and (v) conclusion. These were further associated with the activities in achieving the main objective of this research (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2008).

An overview of the sub-objectives, methods, and outcomes that were used to achieve the main aim of this research is shown in Figure 3.1. Five boxes represent the five phases in this research. Below each phase box shows a sub-objective, methods, and outcomes boxes. Once the outcomes of the particular phase were obtained, the next step will be carried out until all phases are completed. All of the processes in each stage contribute to the achievement of the main aim of this research, which is the development of the framework for visualising ***music mood*** using ***visual texture***.

In Phase 1, an extensive literature review in multiple domains related to music such as Music Info Retrieval (MIR), Library and Information Science (LIS), Human-Computer Interaction (HCI), Graphic Design, Visual Communication, Psychology, and Musicology were conducted to establish these studies. Different combinations of search terms were used, such as music, user, human, people, need, use, behaviour, testing, involvement, learning, interaction, design, graphic, accessibility, and usability.

By affirming the main issue from the literature study, it then leads to the formulation of the research gap, objectives, and scopes of the research, as discussed in Chapter 1.

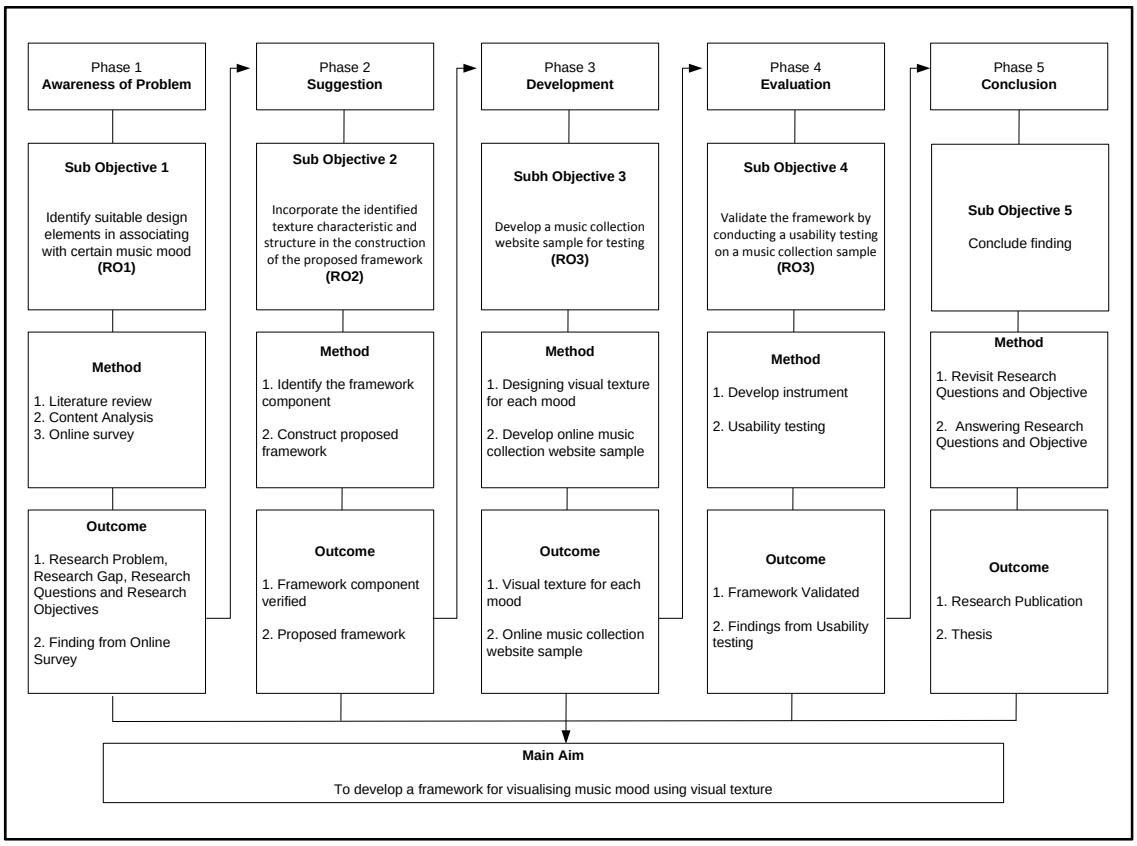


Figure 3.1: Research Phases

In Phase 2, the findings from the previous phase, such as design elements and ***music mood,*** were incorporated to construct the proposed framework. The critical challenge in this research is in Phase 2 because it leads to the main contribution of this research.

In Phase 3, ***visual textures*** for each ***music mood*** were designed by combining the specific type of design elements that have been chosen in the online survey. Then, the ***visual textures*** were applied in a music application sample website to represent the mood category.

Next, Phase 4 involved a framework validation where usability testing on the sample of music collection applications was conducted. Tasks and questionnaires for usability testing were constructed to validate the proposed framework. Using the sample

application, participants selected a ***visual texture*** that represented certain ***music moods*** and gave feedback on how well the ***visual texture*** can express certain ***music moods*** by answering a questionnaire. The outcomes of this phase were analysed, and the framework was validated.

Lastly, in the final phase, all findings gathered in each of the previous phases were concluded through revisiting and answering all the research questions and research objectives. Finally, a full thesis and several publications result in the contribution of this research. In the next subsection, the activities in each of the research phases are briefly explained.

3.4 Phase 1 – Awareness of the problem

Based on the literature review in Phase 1, a few types of research have proven that texture is an associative visual variable. However, there is still no proof that texture can be associated with the mood in selecting music. A thorough review and analysis were conducted to understand texture characteristics, theories, and concepts from the disciplines of Information Visualisation (Infovis) and Music Information Retrieval (MIR). The design elements identified from the literature review were verified by conducting an online survey.

An online survey was set up to identify which specific type of design element is mostly related to a particular mood. The survey was divided into four mood sections, which are ***angry***, ***sad***, ***happy,*** and ***calm***. In each section, there are four different subsections, namely colour, colour values, lines, and shapes (Figure 3.2). All possible types for the particular elements are listed in the answer options.

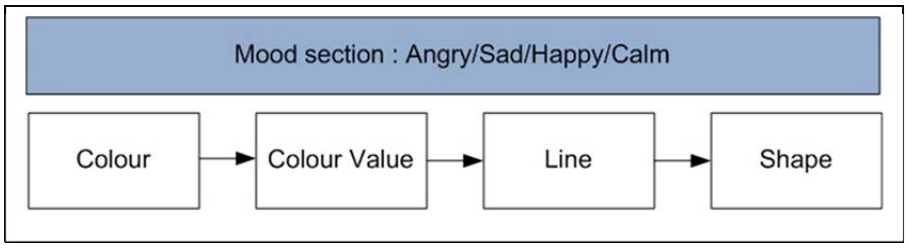


Figure 3.2: Online survey flowchart

The respondents will then select an option from the list, which they think best represents the particular mood, before moving on to the next subsection and submitting the survey as soon as they have finished. From the list of design elements, the respondents will select the type of element they think matches the particular mood. The results from the online survey are presented in Chapter 6.

Once the specific types of design elements for each mood have been confirmed, it will be incorporated in the construction of the proposed framework in Phase 2.

3.5 Phase 2 – Suggestion

After confirming the specific types of design elements for each mood in Phase 1, a framework for visualising ***music mood*** using ***visual texture*** was proposed. The proposed framework was developed based on the Visualisation Reference Model by Card (1999) (Figure 3.3). The model comprises of four main phases that are needed in mapping the raw data and transforming them into a visual form. In this model, visualisation was described as the mapping of data to a visual form that supports human interaction. It also can be thought of as adjustable mappings from data to visual form to the human perceiver (Card, 1999). Hence, this model is suitable for this research because it complies with the research objective, which is to visualise the ***music mood*** using ***visual texture***.

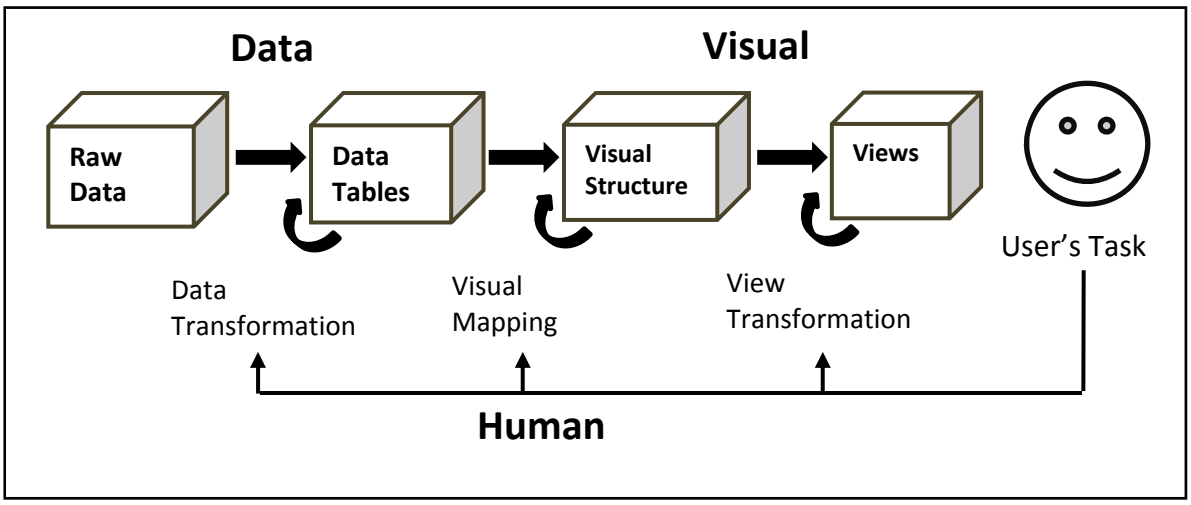


Figure 3.3 : General visualisation reference model (Card, 1999)

In the proposed framework (Figure 3.4), the main focus is on the visual mapping process. In this process, four types of ***music mood*** were mapped to a particular ***visual texture***. In order to come out with the ***visual texture*** design, applicable design principles were chosen to compose the design elements.

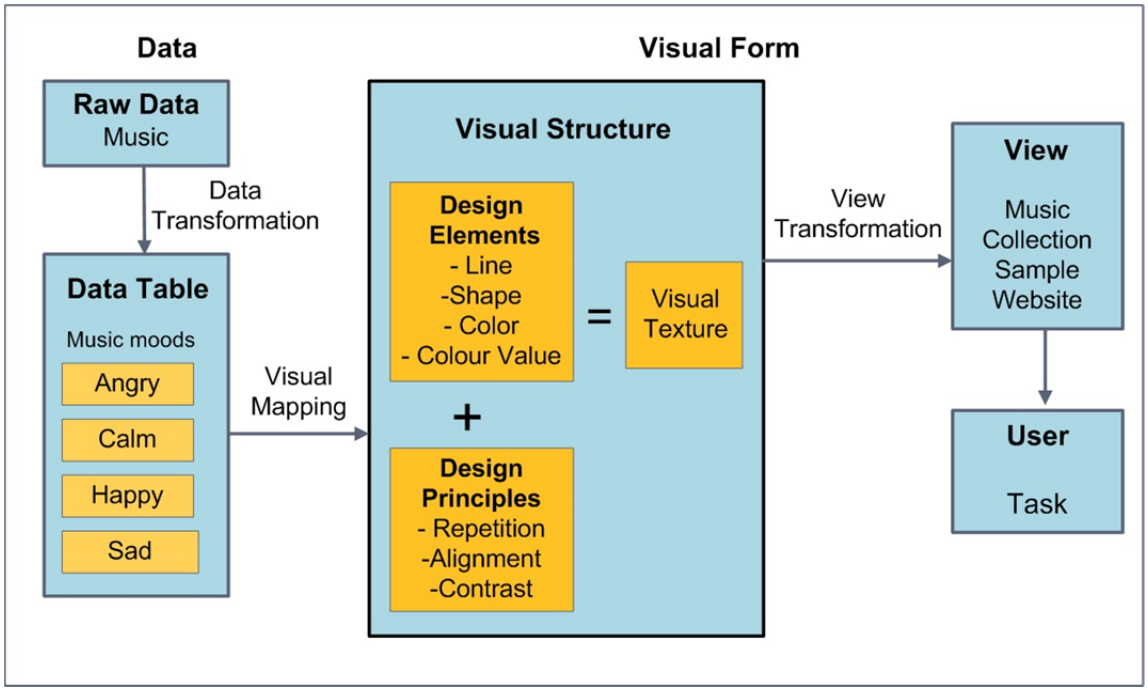


Figure 3.4: The components of the proposed framework

This framework is developed to help designers or software developers to select suitable design elements when designing respective **visual texture** to represent a specific ***music mood*** that can be understood by the end-user.

One of the components of the proposed framework is ***music moods*****,** which include ***angry***, ***calm***, ***happy***, and ***sad***. Research shows that 30% of music searching using search engines is based on a theme of an event like parties or weddings, while 15% is based on specific moods like happy or sad (Thompson & Russo, 2004). It has been found that music listeners are more interested in creating music libraries that allow them to access songs according to their moods rather than the song's title, artist's name, and genre (Patra, Das, & Bandyopadhyay, 2013). Mood label is also considered as emerging metadata in the field of digital music libraries (Patra, Das, & Bandyopadhyay, 2015).

Another essential component of the proposed framework is the design elements. Like any other image, ***visual textures*** also consist of a few design elements such as colour, colour value, line, and shape that can represent mood. Different types of design elements will convey different moods (Husain et al., 2014).

Long, short, thick, and thin lines express a wide range of feelings. A curved and smoothly rounded shape appears friendly and pleasant, whereas shapes with sharp angles represent a negative mood. Specific colours are undoubtedly able to portray certain moods. In this research, selected design elements such as line, shape, colour and colour value are combined using appropriate design principles to come out with a ***visual texture*** that is suitable to represent a particular ***music mood***.

3.6 Phase 3 – Development

In Phase 3, the ***visual texture*** for each mood was designed. The texture images were then applied in a music collection website sample as an alternative browsing method to discover new music in the mood category. The process of designing the ***visual texture*** is based on the Visual Mapping stage in the General Visualisation Reference Model (Card, 1999) (Figure 3.3). This model traces the path of transforming raw data into a visual form that can be viewed by the user. Through the visual mapping process, the data table will be mapped into visual structures. Details about these processes are explained in Chapter 4.

3.7 Phase 4 – Evaluation

This research presents a formal user evaluation of a typical visualisation method for content-based music information retrieval (MIR) and also proposes an interface to improve MIR usability. It is evident that, for any MIR system, the usability of its interface is essential for the user to search for songs that match their preferences efficiently. In this research, to determine how well people can interact with ***visual***

texture to browse for music, usability testing was conducted. Usability testing is the process of watching or tracking an actual user while they use a particular product or system to see if it is usable.

In this usability testing, the ISO 9241-11 standard was employed to operationalise the concepts of three usability elements. According to the ISO 9241-11 standard model, usability consists of three elements – ***effectiveness***, ***efficiency***, and ***satisfaction***.

Each element can be defined and measured according to the following:

- ***effectiveness***: level of completeness at which users achieve specified goals;
- ***efficiency***: resources used in completing a task; and
- ***satisfaction***: positive attitudes towards using the system (ISO, 1998)

Another element that was measured in this research is the ***ease of use***.

- ***ease of use***: a basic concept that describes how easily users can use a product

By adopting Jeng's (2006) usability assessment model, measurement scales were developed for each usability element:

- ***efficiency***: time spent to complete the tasks;
- ***effectiveness***: the proportion of successfully completed tasks; and
- ***ease of use***: seven-point Likert scale from "strongly agree" to "strongly disagree."
- ***satisfaction***: seven-point Likert scale from "strongly agree" to "strongly disagree."

The results from this usability testing were analysed, and the proposed framework was finalised accordingly. Before conducting the test, the number of participants that had to be recruited was identified. Details on the population and sample will be discussed in the next section.

3.7.1 Population and sample

In a Human-Computer Interaction (HCI) research, 30 or more participants are sufficient for the test method (using a questionnaire) to be valid (Lazar et al., 2010; MacKenzie & Castellucci, 2014). However, it is suggested that this research should have the same number of participants as other similar researches. Based on that justification, 40 participants were recruited, following the numbers of a few other similar types of research.

Participants of this usability testing were selected using purposive sampling. The main goal of purposive sampling is to focus on particular characteristics of a population that are of interest, which will answer the research questions. This type of sampling is usually used to seek one or more specific predefined groups (Trochim & Donnelly, 2007). Participants were recruited through an online advertisement distributed via email and social media, as well as an offline ad in the form of a posted notice on campus notice boards (Appendix B). In the advertisement, participants aged 18 years old and above who love to listen to music are invited to take part in this research. Once the participants read the ad, they can volunteer to take part in the usability testing. Should they meet all the criteria, they can contact the researcher using the contact number shown in the advertisement, and their decision to participate in the research is entirely voluntary. The usability testing consists of two separate sessions to evaluate participants' first impression and their longer-term use. In the next section, the researcher will explain briefly how the sessions were handled.

3.7.2 Data Collection Procedure

The data collection for this research was approved by the Murdoch University Human Research Ethics Committee (Project Number: 2013/186). Participants were recruited through an online advertisement that was distributed via social media and email, as well as an offline advertisement that was posted on the information boards around the university (Appendix B). Active music listeners, aged 18 years old and above, are

cordially invited to take part in the usability testing. If they meet all the criteria, they could take part in the usability testing by contacting the researcher using the contact number shown in the advertisement, and their decision to participate is entirely voluntary.

Before participating in the usability testing, the participant reads an information letter that gives a brief description of the nature and purpose of the test (Appendix C). Participants must understand all details of the testing, and they are welcome to ask any questions regarding the flow of the testing. Once they are satisfied with the answers, they can then sign the consent form (Appendix D). In the consent form, they will be informed that they must meet all the criteria. The participants are also made aware that they can withdraw anytime during the session if they feel uncomfortable, but they are unable to do so after the session is completed.

In the first session, the participants filled in a short background information questionnaire. Each participant was given a code number during Session 1. The participant needs to provide their email address to send them the reminder and identification for Session 2. There were two objectives for Session 1. The first objective was to evaluate the suitability of design elements in the ***visual texture*** used to recommend mood. The second was to assess the usability, ***ease of use,*** and ***user satisfaction*** towards browsing music according to mood using ***visual texture***. Session 1 was conducted according to the steps shown in Figure 3.5.

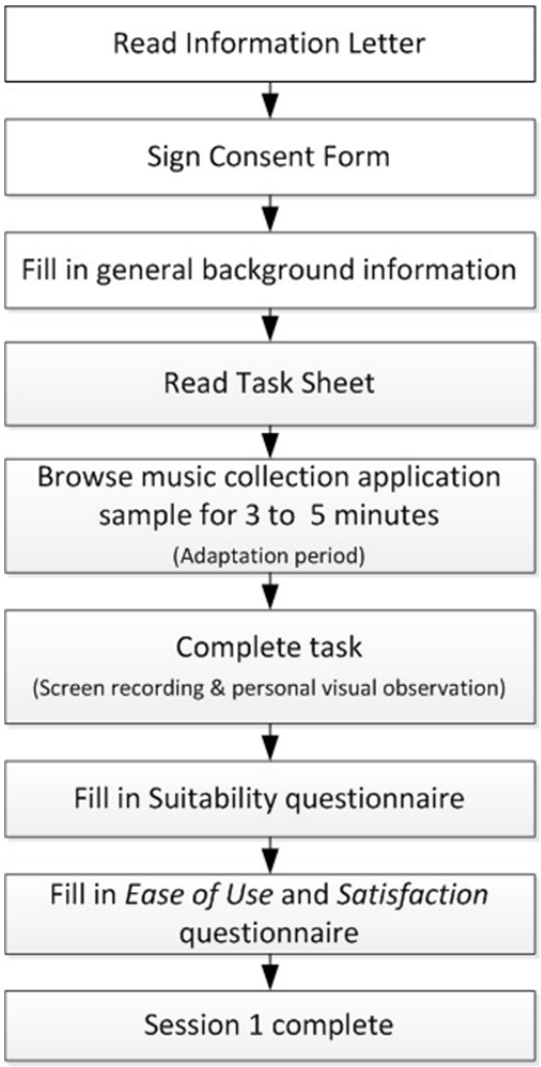


Figure 3.5: Flowchart for Session 1

Session 2 was conducted online. Two days after completing Session 1, participants received a reminder email that contained some simple tasks for them to complete. They then logged into the music application sample website using the given login name and password. Next, the participant would browse the website for 5 to 15 minutes and then log out. They repeated these steps four more sessions within the next two weeks. This experiment was carried out more than once because repetition can increase the amount of information stored in human memory (Raaijmakers, 2003). At the end of Session 2, participants filled in online, the same ***ease of use*** and ***satisfaction*** questionnaire as per the first session. These activities were conducted to understand if

there was any difference between the score of ***ease of use*** and ***satisfaction*** for the first time as compared to the long time use for browsing music using ***visual texture***. The collected data were entered into the statistical package for analysing. Session 2 was conducted according to the steps shown in Figure 3.6.

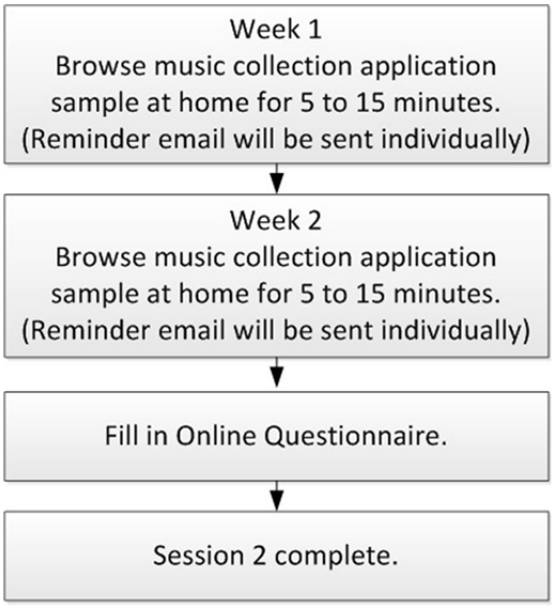


Figure 3.6: Flowchart for Session 2

3.7.3 Research Instrument: Task

One of the instruments that have been developed for the conducting of usability testing is the task. The task contains the list of steps that need to be completed by the participants during the procedure. The given task was used to ensure that participants were able to use and browse through the music collection website sample to look for songs in a particular mood category.

There will be no issues with the participants' level of mood during the experiment. In the first step for each task, participants were given a situation that related to the particular mood. Next, they were given one song title for the specific mood category. Participants need to look for the given song by clicking on the visual texture. If they choose the correct visual texture, they will find that specific song listed in the list of song suggestions. If they can't find it, they have to repeat the previous step.

Table 3.1: Task for Angry mood

No.	Task
1.	Read the scenario below: "You just had a heated argument with your friend and need to listen to an angry song."
2.	You want to look for a song with the title "Mandatory Suicide" from the Angry mood category.
3.	Click on any visual texture that you think represents an angry mood.
4.	Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on another visual texture.
5.	Once you have found the song, click on the Play button ( ) to listen to it.
6.	Listen to the song for at least 30 seconds. You may also listen to the whole song if you like.
7.	When you are ready, rate the suitability of the design elements in the visual texture in **Section B** of the questionnaire.
8.	Once you have completed the questionnaire, click on the Home button, and go to the main page.
9.	Continue with the next task.

Table 3.2: Task for Calm mood

No.	Task
1.	Read the scenario below: "You survived a dreadful traffic jam and would like now to listen to a calm song."
2.	You want to look for a song with the title "Kiss of Life" from the Calm mood category.
3.	Click on any visual texture that you think represents a calm mood.
4.	Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on another visual texture.
5.	Once you have found the song, click on the Play button ( ) to listen to it.
6.	Listen to the song for at least 30 seconds. You may also listen to the whole song if you like.
7.	When you are ready, rate the suitability of design elements in the visual texture in **Section C** of the questionnaire.
8.	Once you have completed the questionnaire, click on the Home button, and go to the main page.
9.	Continue with the next task.

Table 3.3: **Task for Sad mood**

No.	Task
1.	Read the scenario below: "You have lost someone close to your heart; naturally, you will reach for a sad song."
2.	You want to look for a song with the title "Ain't No Way" from the Sad mood category.
3.	Click on any visual texture that you think represents a sad mood.
4.	Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on another visual texture.
5.	Once you have found the song, click on the Play button ( ) to listen to it.
6.	Listen to the song for at least 30 seconds. You may also listen to the whole song if you like.
7.	When you are ready, rate the suitability of design elements in the visual texture in **Section C** in the questionnaire.
8.	Once you have completed the questionnaire, click on the Home button, and go to the main page.
9.	Continue with the next task.

Table 3.4: **Task for Happy mood**

No.	Task
1.	Read the scenario below: "You start the week feeling zesty, and you want to start it off with a happy song."
2.	You want to look for a song with the title "Two of us" from the Happy mood category.
3.	Click on any visual texture that you think represents a happy mood.
4.	Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on another visual texture.
5.	Once you have found the song, click on the Play button ( ) to listen to it.
6.	Listen to the song for at least 30 seconds. You may also listen to the whole song if you like.
7.	When you are ready, rate the suitability of design elements in the visual texture in **Section C** of the questionnaire.
8.	Once you have completed the questionnaire, click on the Home button, and go to the main page.
9.	Continue with the next task.

Table 3.1 – 3.4 shows the steps for each task that were given to the participants for ***angry*** (Table 3.1), ***calm*** (Table 3.2), ***sad*** (Table 3.3), and ***happy*** (Table 3.4) mood. These tasks were handed out randomly to each participant. The participants were given sets of questionnaires after each task to clarify further how much they agree with the suitability of the ***visual texture*** used to recommend the particular ***music mood***.

After the participants have completed Tasks 1 to 4, they were given the final task.

Table 3.5: **Final task in Session 1**

No.	Task
1.	Evaluate the ease of use of browsing music according to mood using visual texture in **Section F**.
2.	Evaluate the satisfaction of browsing music according to mood using visual texture in **Section G**.
3.	Session 1 completed.

Table 3.5 shows the final task where the participants need to evaluate the ***ease of use*** and ***satisfaction*** of browsing music according to mood using ***visual texture***.

In the next section, the development of the questionnaire is discussed. The questionnaire was used to measure the suitability of the ***visual texture*** along with the ***ease of use*** and ***user satisfaction*** of browsing music according to mood using ***visual texture***.

3.7.4 Research Instrument: Questionnaire

The usability testing measures the suitability of ***visual texture***, **ease of use,** and **user satisfaction** while interacting with the ***visual texture*** to browse for music in the mood category. Hence, a scale type measurement was used to quantify these values. Accordingly, each item in the instrument was measured on a 7-point Likert scale ranging from strongly disagree (denoted by 1) to strongly agree (denoted by 7). As

mentioned earlier, the instrument is partially used as a measure of outcome; hence, scale sensitivity becomes a critical concern (Cummins & Gullone, 2000).

Furthermore, the 7-point scale is more sensitive than a 5-point scale. With regards to concerns with scale reliability, Cicchetti et al. (1985) reported that using response options beyond 5 or 7-points does not significantly alter scale reliability. However, difficulties might arise in generating categorical names as the scales expand (Cummins & Gullone, 2000). Hence, based on the reasons discussed above, the 7-point scale was used in this usability testing (Figure 3.7).

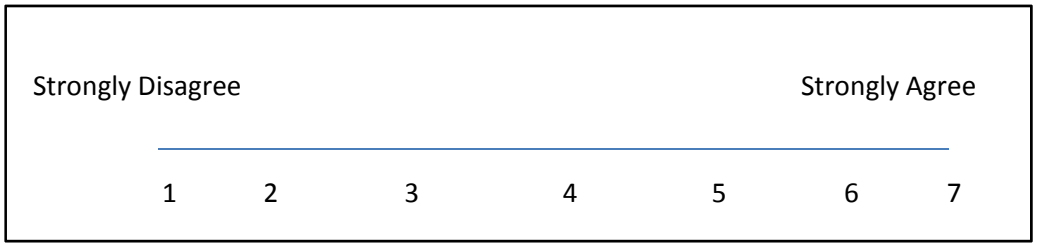


Figure 3.7: Sample of Evaluation

3.7.4.1 Measuring suitability of *visual texture* (RO 4a)

Once the participants have completed a task, they were asked to rate the suitability of the ***visual texture*** that they have chosen for the particular mood.

Table 3.6: **Questionnaire on how well the *visual texture* matched the *music mood***

No.	Question
Q1	It is easy to look for the song in Task X.
Q2	The visual texture matched the song that I found in Task X.
Q3	The type of line used in the visual texture matched the song that I found in Task X.
Q4	The type of shape used in the visual texture matched the song that I found in Task X.
Q5	The type of colour used in the visual texture matched the song that I found in Task X.
Q6	The colour value (tone) in the visual texture matched the song that I found in Task X.

Table 3.6 shows the questions that the participants were asked after each task. The objective of the questionnaire is to let the participants give feedback on the suitability of the ***visual texture*** to represent each ***music mood***. This is to achieve Research Objective 3a (RO 3a).

In the next segment, Research Objective 3b (RO 3b) about the usability of browsing songs in the ***music mood*** category using ***visual texture*** is discussed.

3.7.4.2 Measuring Usability (RO 3b)

Participants were observed while they were completing the tasks by using Camtasia Studio. Camtasia Studio is a digital recording software of a computer screen's output, also known as a video screen capture, that will record the participants' moves in a video log. From the video recording, the researcher will be able to gather data on the usability of browsing ***music mood*** using ***visual texture***. Usability is the intersection between ***effectiveness***, ***efficiency***, and ***satisfaction*** in a context of use. The official ISO 9241-11 definition of usability is: "the extent to which a product can be used by specified users to achieve specified goals with ***effectiveness***, ***efficiency***, and ***satisfaction*** in a specified context of use."

3.7.4.3 Effectiveness

Effectiveness is the accuracy and completeness with which users achieve specified goals. In this research, ***effectiveness*** is measured as the completion rate or percentage of participants who correctly found a song in a particular ***music mood***. Due to its simplicity, the completion rate is a metric that is very easy to understand. ***Effectiveness*** can be represented as a percentage by using the simple equation (1).

$$\text{Effectiveness} = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}} \times 100\% \quad \textbf{(1)}$$

3.7.4.4 Efficiency

Efficiency refers to the average time that each participant takes to complete each task. In this research, ***efficiency*** is measured in terms of task time; that is, the time (in seconds and/or minutes) the participant takes to complete a task successfully. It is essential to measure ***efficiency*** for this experiment. This is because, if the task time is short, it shows that the ***visual texture*** for the particular mood is easy to be understood. If the user takes a long time to complete the task, it shows that they are unable to interpret the message portrayed by the ***visual texture***.

The time taken to complete a task can then be calculated by only subtracting the start time from the end time, as shown in Equation (2).

$$\text{Task time} = \text{End time} - \text{Start time} \quad \textbf{(2)}$$

Efficiency can then be calculated in one of 2 ways, which are time-based ***efficiency*** and overall relative ***efficiency***. The overall relative ***efficiency*** uses the ratio of the time taken by the users who successfully completed the task with the total time taken by all users.

3.7.4.5 Ease of use

In measuring the ***ease of use***, a set of questions were given to the participants at the end of the session.

Table 3.7: **Ease of Use Questionnaire**

No.	Question
Q1	Browsing music according to mood by using visual texture is easy.
Q2	Browsing music according to mood by using visual texture is clear and understandable.
Q3	It is easy to become skilful at browsing music according to mood by using visual texture.
Q4	Overall, browsing music using visual texture is easy for me.

Table 3.7 shows the questions that the participants were asked to evaluate the ***ease of use*** of browsing music according to mood using ***visual texture***. The objective is to know if the participants quickly understood how to browse for songs according to mood using ***visual texture***. Next, the participants need to answer another questionnaire to rate their satisfaction level.

3.7.4.6 Satisfaction

In measuring ***satisfaction***, a set of questions was given to the participants at the end of the session.

Table 3.8: Satisfaction Questionnaire

No.	Question
Q1	I am satisfied using visual texture in browsing music according to mood.
Q2	I would recommend it to a friend.
Q3	Browsing music according to mood using visual texture is fun.
Q4	It works the way I want it to work.
Q5	Browsing music according to mood using visual texture is wonderful.
Q6	It is pleasant to use visual texture in browsing music according to mood.

Table 3.8 shows the questions that the participants were asked regarding user ***satisfaction*** of browsing music according to mood using ***visual texture***. The objective is to know if the participants were satisfied using this visual form to browse through music.

3.7.5 Pilot study

Before conducting the actual experiment, a pilot study of Session 1 and 2 was carried out face to face involving three respondents. The purpose of this pilot study is to test the research instruments and gather information prior to the actual experiment in order to improve the actual experiment's quality and efficiency. It was conducted for two weeks according to the steps that were planned.

From the respondent's feedback, a few steps, which are quite complicated, were revised. The task sheet was also modified, and rather than giving it out by task number; it was replanned to be handed out randomly to each participant.

3.8 Summary

This chapter discusses the research approaches that were adopted. It provides an elaboration of the methodology that was employed for evaluating the use of ***visual texture*** to browse through songs in the ***music mood*** category. Each of the phases is described in detail with the activities that were carried out throughout this research. In order to determine how well people can interact with the ***visual texture*** design to browse for music, usability testing was conducted. The results from RO 3a and RO 3b will be triangulated to prove whether using ***visual texture*** to represent ***music mood*** is usable as a method or technique for browsing songs in music collections. The results of the actual usability testing are reported in Chapter 6.

In the next chapter, the processes to develop an online music collection website sample for usability testing are discussed.

4 PHASE 3: THE DEVELOPMENT PHASE

4.1 Overview

This chapter discusses the processes in Phase 3: The Development Phase (Figure 4.1). The objective of this phase is to achieve Research Objective 2 (RO 2). RO 2 is to develop an online music collection website sample for testing. Two activities were completed in this phase. Firstly, the ***visual texture*** for each mood was designed. The selected design elements acquired from Phase 2 were combined using appropriate design principles. Then, the ***visual textures*** were applied in an online music collection website to represent the respective ***music mood*** category. The following sections discuss the process of designing the ***visual textures*** based on the Visual Mapping stage in the General Visualisation Reference Model (Card, 1999).

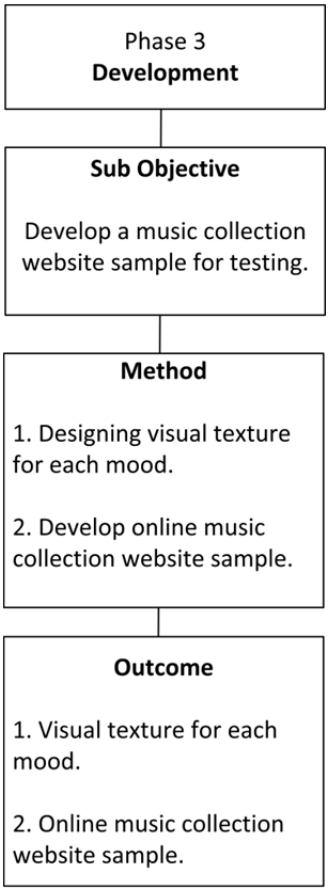


Figure 4.1: Phase 3 – Development

4.2 Visual mapping

The process of designing the ***visual texture*** is based on the Visual Mapping stage in the General Visualisation Reference Model (Card, 1999) (Figure 3.3). This model traces the path of transforming raw data into a visual form that can be viewed by the user. Through the visual mapping process, the data table will be mapped onto visual structures. Visual structures are made of visual variables, a specific set of symbols that can be applied to the data in order to translate information (Carpendale, 2003).

Table 4.1: Bertin's visual variable

Visual variable	Characteristics
Position	Quantitative, Order
Size	Selective, Order, Quantitative
Shapes	Associative
Value	Selective, Order
Colour	Associative, Selective
Orientation	Associative
Texture	Selective, Order

Table 4.1 presents the seven essential visual variables that can be used to create visual differences for a user to perceive and interpret the meaning of specific data. These visual variables can be used to create visuals that have meaning to the audience (Carpendale, 2003). The choice of a variable that would be the most appropriate to represent each aspect of information depends on its characteristics. The characteristics comprise of selective, associative, quantitative, and order. Selective refers to visual variables that can be perceived as different; associative is defined by visual variables that can be perceived as similar; quantitative is perceived as variables that can be interpreted numerically, and order is identified as variables that support ordered reading. For example, colour is considered an associative and selective visual variable because it can be useful when selecting specific items from a group. However, colour should not be used to visualise quantity.

In the field of music visualisation, visual variables such as colour, orientation, position, size, and shape have been investigated when representing music data (Lehtiniemi & Holm, 2012; Pesek et al., 2017; Plewa & Kostek, 2015). Texture is one of the visual variables, and it has been proven that ***visual texture*** can represent certain moods (Husain et al., 2014).

Texture is the look and feel of any surface. It can be divided into two categories that are ***tactile*** and ***visual textures***. A ***tactile texture***, also known as an actual texture, is the feature of a surface that can be touched and felt. V***isual texture*** is the texture designed using a drawing application, scanned from actual textures, or photographed. Research in consumer studies, psychology, material design, and user interface suggests that texture has some kind of emotional connection to human moods (Sedgwick et al., 2003; Wang, 2009a).

In the next subsection, the visual grammar that was used as the underlying guideline in designing the ***visual texture*** is explained.

4.3 Visual Grammar

In designing ***visual texture***, understanding, and using visual grammar is essential. Visual grammar is a language that implies meanings in the form of visual designs. Similar to the language that we are used to, visual grammar is made up of design elements and principles (Leborg, 2006). Visual grammar can be categorised into four major parts, namely ***Objects***, ***Structures***, ***Activities,*** and ***Relations,*** as shown in (Leborg, 2006). These four parts are used to define the basic elements, patterns, and processes of designing ***visual texture***.

4.3.1 Object

Objects are basic design elements. ***Objects*** consist of two types, namely concrete and abstract. In this research, the basic design elements used to design ***visual textures*** are

colours, lines, and shape. Each of these basic design elements has its own value to which it reproduces individual meaning to a design.

4.3.1.1 Colour

Colour is an inseparable part of our everyday life. It is widely recognised that colours have a substantial impact on our emotions and feeling (Hemphill, 1996). Several kinds of research have been conducted in various fields about the link between colours and human emotions. They have found that certain colours are undoubtedly able to portray certain moods.

In interior design research about colour, red has been associated with excitement, orange with distressing and upsetting. Purple has been perceived as dignified, yellow as cheerful, and blue associated with comfort and security (Ballast, 2002).

Genetic psychology research conducted on the subject of children's emotional association with colour found that light colours such as yellow and blue are generally associated with positive emotions like happiness and cheerfulness. Dark colour such as black is typically associated with a negative emotion such as sadness and anger (Boyatzis & Varghese, 1994). Similar results were obtained when the same investigation was done among college students (Hemphill, 1996).

Colour conventions differ from one society to another (Kaya & Epps, 2004). A well-known example is with the two achromatic colours, i.e., black and white. Death and mourning are associated with the colour black in Western traditions, whereas in China, the colour of death is white. Ancient Egyptians were known to mourn in yellow, while it is greyish brown in Ethiopia as that is the colour of the earth, to which they believe the dead will return. In Syria and Armenia, it is sky blue, which indicates that the deceased has gone to heaven. Hence, some colours may be associated with several different emotions, and some emotions are associated with more than one colour (Saito, 1996). We can conclude that mourning, which is linked to sadness, can be associated with more than one colour, namely black, blue, white, and yellow.

Table 4.2: Colour and mood

Colour and mood		
Mood	***Colour***	***Meaning***
Happy	Yellow	Cheerful (Ballast, 2002)
	Blue	Happy (Boyatzis & Varghese, 1994)
Calm	Green, Blue	Relaxation, calmness and happiness, comfort, peace and hope (Kaya & Epps, 2004) (Nijdam, 2009)
	White	Peace(Kaya & Epps, 2004)
Sad	Blue	Sadness depression (Kaya & Epps, 2004)
	Black	Funeral (Kaya & Epps, 2004) (Boyatzis & Varghese, 1994)
	White	Image of death (Saito, 1996)
	Yellow	Death (Boyatzis & Varghese, 1994)
Angry	Orange	Depressing and upsetting (Ballast, 2002)
	Red	Aggressive, bloody and raging (Ballast, 2002)
	Blue	Depression (Kaya & Epps, 2004)

In Table 4.2, a list of colours that represent the moods happy, calm, sad and angry was summarised. Still, it must be kept in mind that colour related emotion is highly dependent on personal preference and one's experience with that particular colour (Kaya & Epps, 2004).

4.3.1.2 Line

Lines are divided into several values. A line can be thin or thick. In general, a thin line represents weakness, lightness, and relaxation, while thick lines display power, rigidity, and heaviness. A line can express emotion and character based on how heavy or light, scratchy or smooth, angular, or curvy the line is. Different types of lines (Figure 4.2) express different emotive qualities.

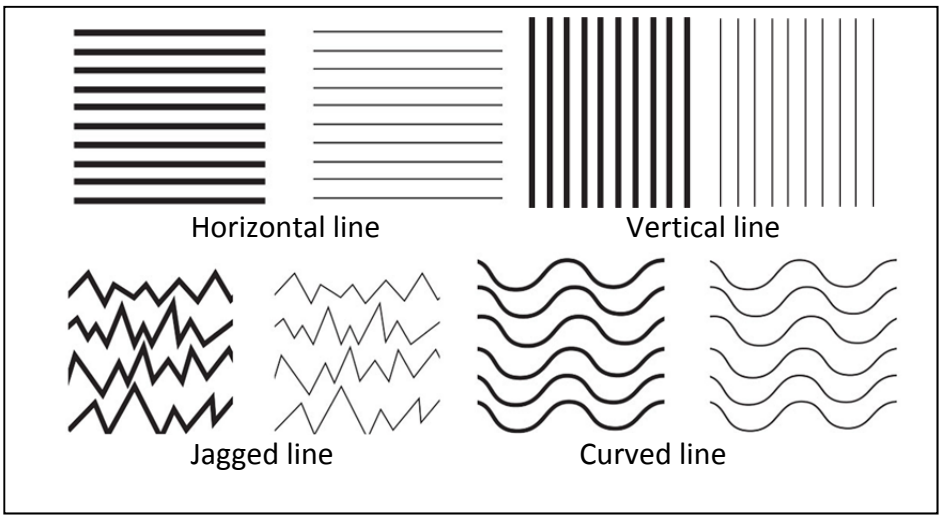


Figure 4.2: Types of lines

Some can experience thin lines as unstable and vulnerable. It is also fragile and seems easy to be broken or knocked over. Thick lines alternatively appear as difficult to break. It suggests strength and emphasizes nearby elements. Thick lines are bold and able to make a statement.

Besides the width of the line, the orientation of a line can further influence a visual message. Horizontal lines are parallel to the horizon like lying down, at rest, supine position, or asleep. Horizontal lines suggest calm and quiet, and serene. Vertical lines are perpendicular to the horizon. It communicates strength, height, and aspiration. It appears more active and expresses a more powerful and immediate message (Poulin, 2011). Vertical lines stretch from the earth to the heavens and often connect with religious feelings. Their tallness and formality may give the impression of dignity. Curved lines are softer than straight lines. It sweeps and turns gracefully between endpoints. Curved lines are less definite and predictable than straight lines. It bends, changes direction, and expresses fluid movement. Curved lines can also be calm or dynamic, depending on how much they curve. The less active the curve, the more peaceful it shows. Thin and curved lines are assumed to have the ability to represent sadness, whereas thick, jagged lines are more likely to be linked to anger. Besides that, horizontal, curved lines are assumed to have the ability to gravitate towards happiness and calmness.

4.3.1.3 Shape

Shapes are another way to emphasize the mood. Examples of basic shapes are circles, squares, and triangles (Figure 4.3). There are two types of shapes; organic and geometric. Geometric shapes have angles and straight lines and have an industrialised feel. Organic shapes are curvy, free-form, and have a more natural feel to them.

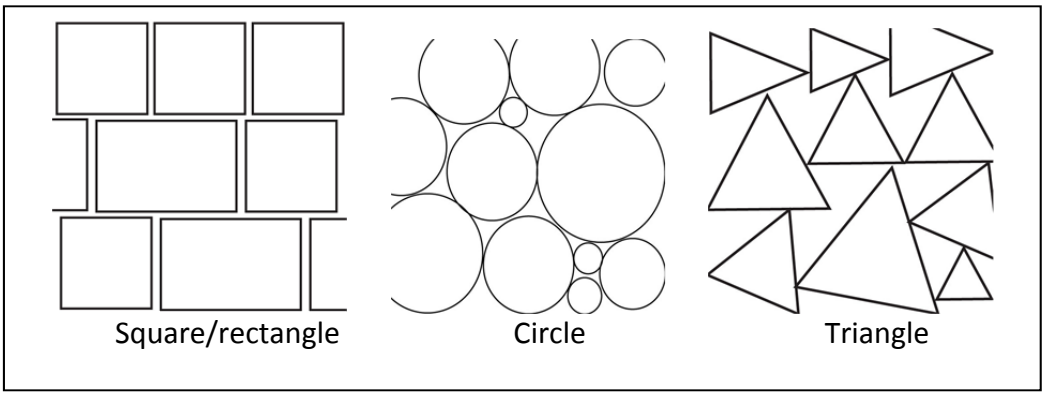


Figure 4.3: Types of shapes

The overall configuration of the type of shape can determine their inherent message and meaning. The soft, curvilinear shape may appear warm and welcoming, whereas a sharp, angular shape may appear cold and threatening (Poulin, 2011).

Among all the known shapes, the square is a unique and special one. Most of the human artefacts are made up of squares or its variations. For instance, houses are composed of windows, floors, tables, televisions, and doors that are square or square-like shapes (Pinna, 2011). Square and rectangle appear to be familiar and trusted shapes and suggest honesty, conformity, peacefulness, solidity, security, and equality.

The next basic shape is a circle. The circle also shows unique properties, but unlike the square, it appears mostly in nature. In every culture in the world, circles represent the sun, the earth, the moon, the universe, and other celestial objects in between. However, besides natural shapes, circles are used to suggest familiar human-made objects such as wheels and balls. The invention of the wheel is likely one of the most important inventions of all time. It was at the root of the Industrial Revolution (Pinna, 2011). Circle suggests well-roundedness and completeness. It is graceful, warm,

comforting, and gives a sense of sensuality and love. Circles protect, endure, and restrict. It confines what's within and keeps things out, hence offering safety and connection. Circles suggest community, integrity, and perfection.

Triangles suggest action. They are dynamic. The corners of a triangle tend to feel sharp and dangerous, but when used properly, they can convey a great sense of movement and progression. Triangles can direct movement based on which way they point. Upward pointed triangles represent progress or a better future. Downward facing triangles typically convey a message of danger, and they can feel off-balance and awkward (Bradley, 2010).

In summary, we assume that the rectangle, square, and circle have the ability to represent calmness and happiness. Circles can also represent sadness due to the human tendency to look for a warm and comforting shape when we are sad. Due to the dynamic property of its shape, triangles are assumed to have the ability to represent anger.

4.3.2 Structure

A ***structure*** is formed when we arrange ***objects*** in the design space to depict certain values towards the whole design. ***Structures*** can be categorised as formal and informal. For formal structures, the ***objects*** are evenly distributed, whereas, for informal structures, the ***objects*** are not arranged in a straight structural line. A structure is similar to one of the design principles, balance.

Balance is the concept of visual equilibrium and relates to our physical sense of steadiness. It is an understanding of opposing forces in a composition that results in visual stability. Most successful compositions achieve balance in one of two ways that are symmetrical or asymmetrical.

Symmetrical balance can be described as having equal weights on equal sides. It occurs when there are two identical sides of a design with a central point of axis. This axis may be horizontal or vertical. If the design was cut in half, the left and right are mirror images of each other. Since this form of design is usually very structured and rigid, it is

referred to as formal balance. It is also possible to build proper balance by arranging elements equally around a central point**,** resulting in radial symmetry.

Asymmetrical balance, also called informal balance, is more complex and challenging to visualise. It involves the placement of objects in a way that will allow objects of varying visual weight to balance one another. Asymmetrical designs can evoke feelings of movement and seem more modern than symmetrical designs. Still, it can be more difficult and less straightforward to create relationships between the design's elements.

4.3.3 Activities

Activities are the processes that take place in compositing the design elements. It is akin to applying a design principle to the design elements. There are a few ***activities*** that can be used to help a designer convey meaning through their design. Some examples of design principles are contrast, balance, emphasis, repetition, movement, direction, rhythm, and unity. However, in the process of designing ***visual texture***, we used repetition, movement, and direction activities in order to create some illusions of movement. The function of movement in visual communication is to guide the viewer's eye through and around any visual message (Poulin, 2011). It also shows action and creates a feeling of motion within a composition.

The principle of repetition simply means the reusing of the same or similar elements throughout your design. The repetition of certain design elements in a design will bring a clear sense of unity, consistency, and cohesiveness. The use of repetition is to create movement. It happens when elements, which have something in common, are repeated regularly or irregularly, creating a visual rhythm.

Movement is controlling the design elements in a composition. It led the eye to move from one element to the next. By using movement, the information will adequately be communicated to the audience.

Visual direction is about leading the eye to the next location. Every composition will have a dominant direction, whether horizontal, vertical, or diagonal. A horizontal

direction makes the composition appear calm and stable. A vertical direction adds a sense of formality, alertness, and balance. A diagonal direction suggests movement and action (Bradley, 2010).

4.3.4 Relation

Relation is the way ***objects***, patterns, and processes relate to each other. ***Relation*** is the most important part of visual design because, through the ***relation*** in the whole composition, elements convey a concept, and users will receive the message that the designer intends to communicate.

4.4 Related theories in the design process

In designing a meaningful ***visual texture*** to represent the ***music mood***, the design elements were mapped with a particular type of mood. In this process, suitable design elements were picked and combined. The knowledge and understanding of the theories of visual communication helped this step to proceed proficiently and artistically.

In this research, the two theories of visual communication, namely sensual and perceptual theories (Nolan, 2013; Yong-feng, 2008), were employed. These theories have been widely used in explaining visual communication images and messages.

Sensual theories are mainly Gestalt and Constructivism. They are concerned mostly with what the eyes see and not so much of what the mind makes of it. Perceptual theories are mainly Semiotics and Cognitive. They are concerned mainly with the meaning that humans associate with the images they see (Lester, 2006).

Sensual theories involve raw data that comes from the nerves and after that transmitted to the brain, whereas perceptual theories are meanings concluded after the stimuli are received. Thus, in this research, the Gestalt theory (Sensual) was applied in the visual mapping stage, while the Cognitive theory (Perceptual) was applied in the evaluation stage.

4.4.1 Sensual: Gestalt theory

Gestalt theorists follow the basic principle that the whole is greater than the sum of its parts. In other words, the whole, for example, a picture or a car, carries a different meaning than its components. The Gestalt principle is a set of laws that describe how humans typically see objects by similar grouping elements, recognising patterns, and simplifying complex images (Lester, 2006).

Gestalt also teaches a visual communicator or designer to combine the basic design elements into a meaningful whole. The approach they use in teaching the graphic artist is to get them to focus their attention on certain elements by playing against the gestalt principles.

4.4.2 Perceptual: Cognitive Theory

Visual perception is another approach for a viewer to understand the message carried by a design element. In visual perception, semiotic and cognitive approaches may be considered content-driven. The cognitive approach function concludes the perception through mental operations. According to this approach, a viewer does not merely witness a light-structured object as in the gestalt theory.

4.5 *Visual texture* design for each mood

In designing a purposeful ***visual texture***, the design elements were disbanded in order to study their individual connotations towards depicting the associative mood. To confirm this, an online survey was set up to identify which type of design element is related to a particular mood (Husain, Shiratuddin, & Wong, 2015). From the results shown in Chapter 6 (Table 6.2), the specific type of design element for each mood was confirmed. Then, the selected design elements were combined, and the ***visual texture*** for each mood was designed.

In conveying anger, the thick, jagged lines were arranged in a haphazard pattern. In visual grammar, this structure is informal and lacking the regularity in the

arrangements of objects. Though there is a pivotal point, this structure is merely spiraling out of proportion. Just like when a person is ***angry***, nothing seems to be in place. In this ***angry*** mood design, the patterns denote the activity of shapes moving or about to break into movement heading outwards. In essence, the designed ***visual texture*** is imbalanced, asymmetrical, diffused, and dominantly conveys the ***angry*** mood.

On the opposite end of the mood scale, calmness is conveyed using a structured pattern and basic fixed objects such as thin horizontal lines and four-sided closed shapes. Visually, this communicates a static pattern and is easily understood as a smooth texture. Just as in smooth textures, it is easy on the eyes and evokes a sense of calmness in the viewer. The desired ***visual texture*** is designed to suit the ***calm*** mood of a viewer where everything is in order and symmetrical. This design is also neutral in design elements, principles, and colour.

Happiness is naturally represented in bright and cheery depictions. The texture image design uses thick, curved lines and round, hollow shapes. In the design, the lines are repeated with a close gap. The round shapes of variant sizes and displaced positions convey upbeat energy. Movement of the round shapes along the path of the curved lines also displays the connotation of delight and joy. Adding to the lines, shapes, and various displacement, the colour yellow expressively conveys a ***happy*** mood.

For a ***sad*** and gloomy mood, of utmost significance will be the colour. In particular, white is naturally a neutral yet dull and sorrowful colour. As for the lines, the designs are arranged using thin, curved lines with a large gap. The repeating lines signify consistency and frequency. As the round shapes are grouped towards the bottom of the design, it creates a sense of heaviness, and a sober mood is related to the viewer. The final results of the ***visual texture*** design for each mood are shown in Figure 4.4.

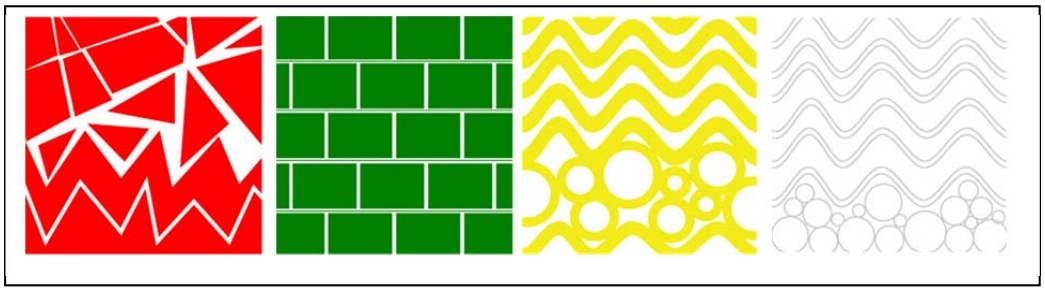


Figure 4.4: *Visual texture* for *angry*, *calm*, *happy* and *sad* mood

4.6 View transformation

Once the ***visual texture*** for each mood was designed, it was applied in a music application sample website to represent the relevant mood category. This process is based on the Visual Transformation stage in the General Visualisation Reference Model (Card, 1999) (Figure 4.2). The music sample application website is designed using WordPress, which is an open-source Content Management System (CMS). A web hosting service is used to get this website up and running on the internet.

On the main page, there are four visual images representing four types of mood - ***angry***, ***sad***, ***happy,*** and ***calm*** (Figure 4.5).

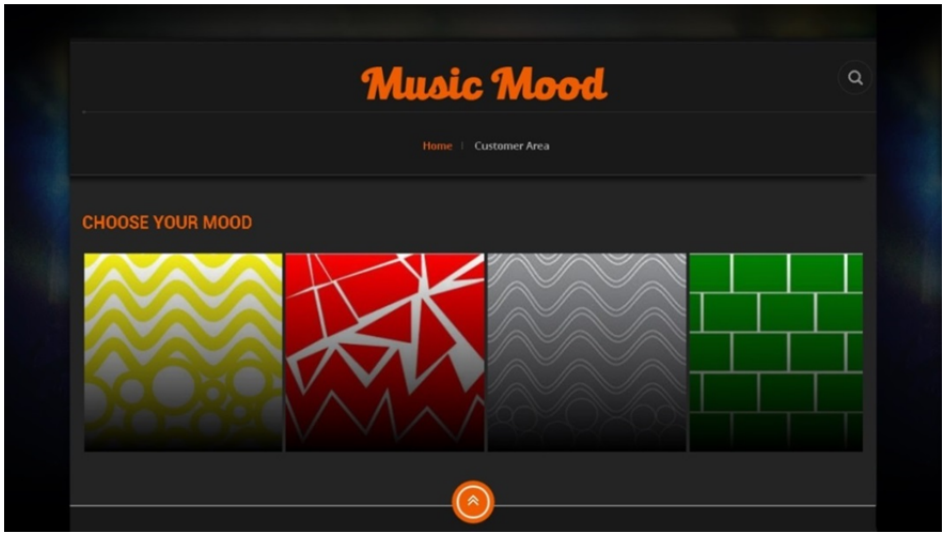


Figure 4.5: The main page of music application sample website – Moodbytexture.com

When a participant clicks on any of the ***visual textures***, one will get a list of songs (comprising of 20 songs) for a particular type of mood (Figure 4.6).

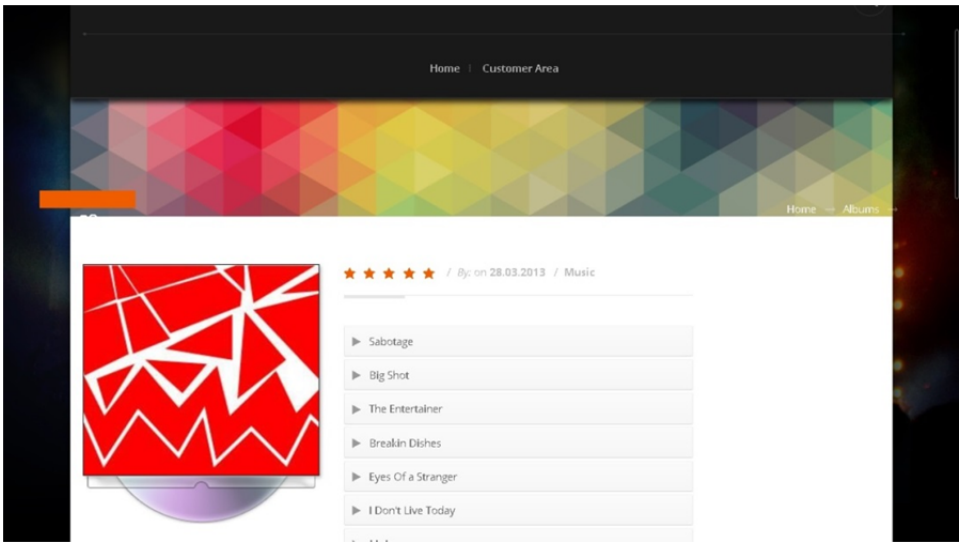


Figure 4.6: List of suggested songs for Angry mood

4.7 Summary

This chapter contains the descriptions of the activities involved in designing four types of ***visual textures*** to represent four types of ***music moods***. The selected design elements such as line, shape, colour, and colour value were combined using appropriate design principles to come out with a ***visual texture*** that is suitable to represent a particular ***music mood***. The ***visual texture*** for each mood was applied in a music application sample website to represent the particular mood segment.

In the next chapter, the processes of evaluating the usability of browsing songs using ***visual texture*** are discussed.

5 PHASE 4: THE EVALUATION PHASE

5.1 Introduction

This chapter discusses the processes in Phase 4: The Evaluation Phase (Figure 5.1). The objective of this phase is to achieve Research Objective 3 (RO 3). RO 3 is to validate the proposed framework by conducting usability testing on a music collection sample. Two outcomes were gathered from this usability testing. The first is the feedback on the suitability of ***visual textures*** that represents each of the ***music moods*** (RO 3a). Secondly, it is the usability of the music collection sample website via the measurements of ***effectiveness***, ***efficiency***, and ***satisfaction*** (RO 3b).

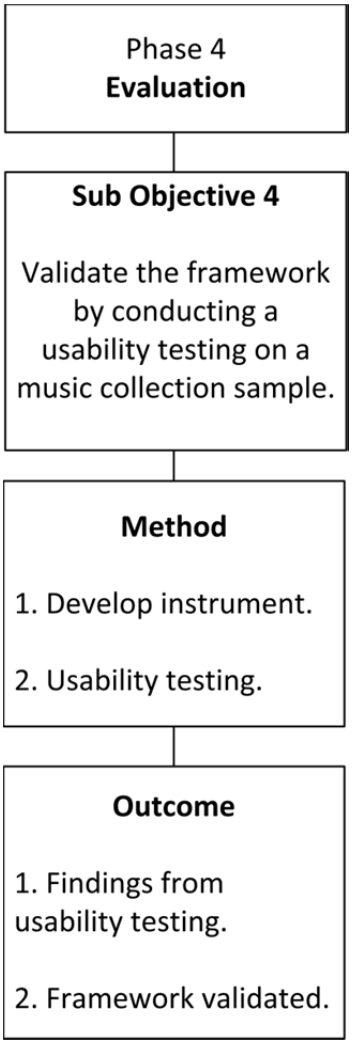


Figure 5.1: Phase 4 – Evaluation

5.2 Conducting usability testing

Once the ***visual texture*** for each mood was designed in Phase 3: The Development Phase (see Chapter 4), it was applied in a music collection website sample to represent the relevant mood category. In studying how well the ***visual texture*** matches the musical mood and whether the ***visual texture*** is usable for browsing songs in the mood category, a usability test was conducted. Using the music collection website sample, participants selected a ***visual texture*** that represented a certain ***music mood*** and gave feedback by answering a few questionnaires.

Usability testing was organised into two sessions. In Session 1, participants browsed a music application sample and answered a questionnaire. In the second session, they browsed the music application website from home for two weeks and responded to questionnaires on the ***ease of use*** and ***satisfaction*** at the end of the session. Session 1 was conducted according to the steps shown in Figure 5.2.

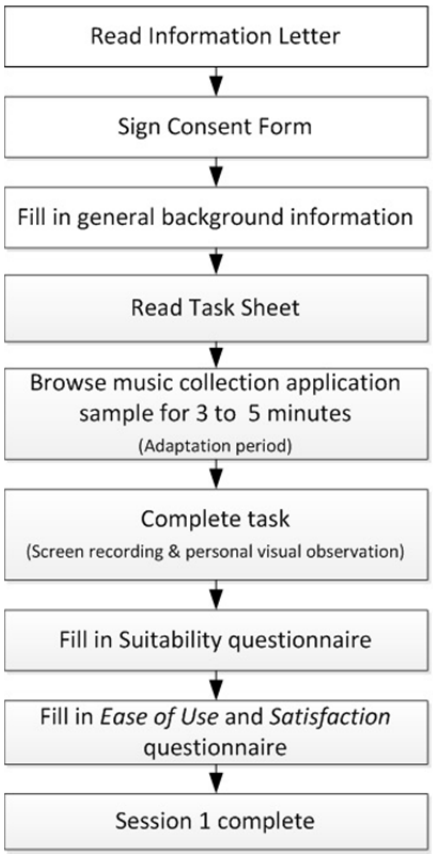


Figure 5.2: Flowchart for Session 1

In Session 1, the participant signed the consent form and fill in a short background information questionnaire. Then, they were given a task sheet. Four tasks were given to the participants for each mood, which are ***angry***, ***calm, sad,*** and ***happy***. These tasks were handed out randomly to each participant.

After they have read the task sheet, participants browsed the digital music collection website sample for 3 to 5 minutes to familiarise themselves with the application. This adaptation period is to let the participants understand the function and features of the website's interface. It is to avoid any effect of stressful behaviour for not knowing how the website functions. Once they were ready, they started to complete the task, and the area of the screen was recorded using the screen recording software.

After each task was completed, they answered a set of questions on the suitability of the design elements in the ***visual texture*** used to recommend the particular ***music mood***. This questionnaire allows the participants to assess whether the design elements such as line, shape, colour, and colour value match the ***music mood***. The same process was repeated in random for another three types of moods. After the tasks were completed, the participants filled in another two sets of questionnaires to rate the ***ease of use*** and ***satisfaction*** towards browsing particular ***music moods*** using ***visual textures***.

Session 2 was conducted online. Two days after completing Session 1, participants received a reminder email that contained a few simple tasks for them to complete. Session 2 was performed according to the steps shown in Figure 5.3.

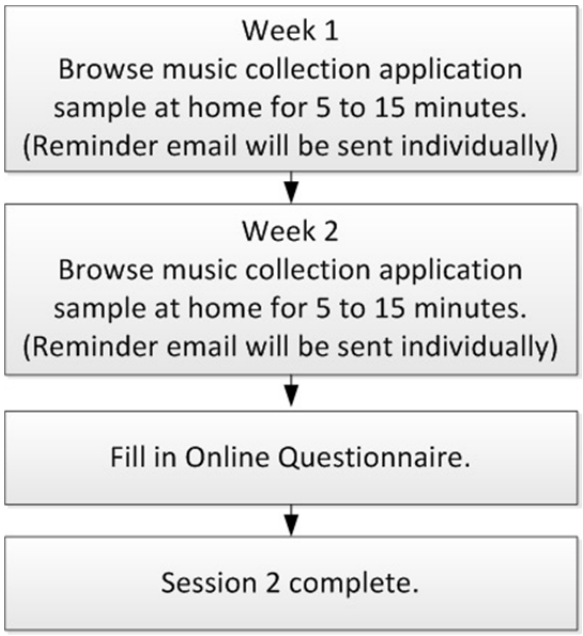


Figure 5.3: Flowchart for Session 2

As soon as Sessions 1 and 2 of the usability testing were completed, all data were prepared and organised for the data analysis process. In the next section, the data analysis and editing processes are presented.

5.3 Data analysis processes

In order to interpret the data that were collected, the data needed to be edited. The data editing process involves the process of coding the data, categorising and entering the data into a computer programme (Cavana et al., 2001). Statistical Package for the Social Science (SPSS) 11.5 for Windows was used to analyse the edited data. According to Cavana et al. (2001), this phase involves the process of handling missing data, testing for the goodness of data, data screening and transformation, and getting the feel of the data. Figure 5.4 illustrates the data analysis process (Creswell, 2015).

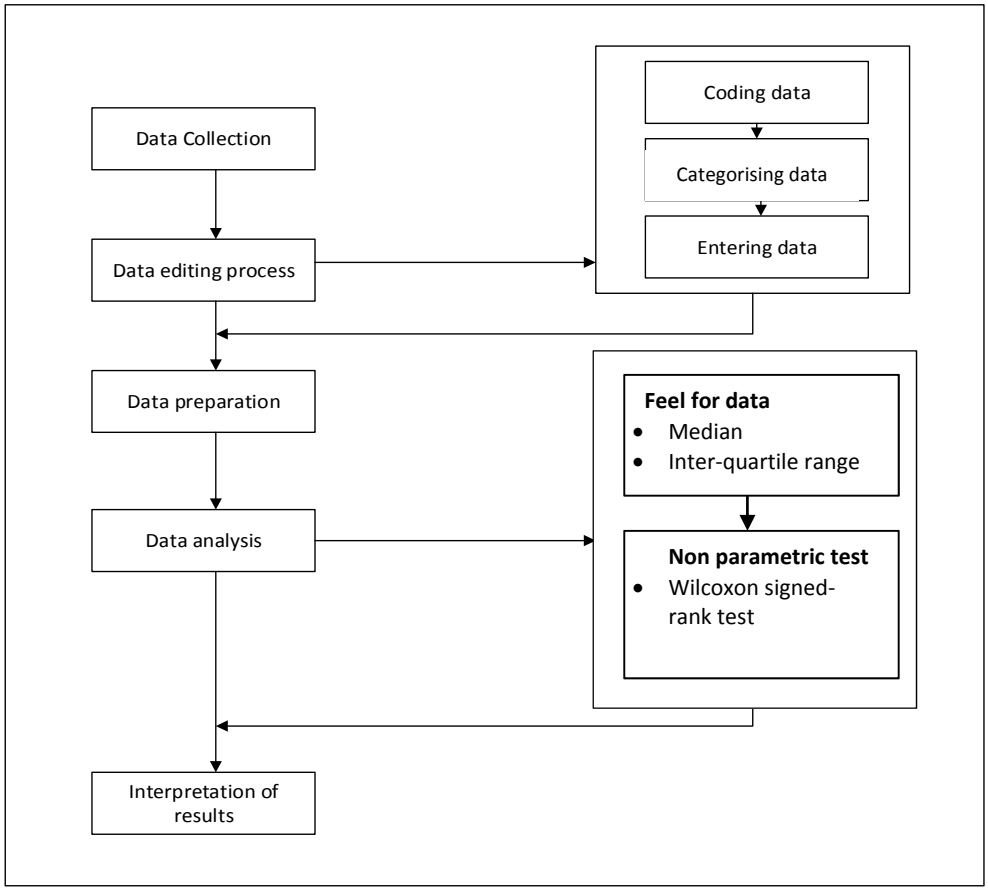


Figure 5.4: Data Analysis Process (adapted from (Creswell, 2015)

5.4 Data Editing Process

Cavana, Delahaye, and Sekaran (2001) suggested that data editing needs to be completed after the data collection process. This is to ensure that any error from the data collection process could be identified and corrected at an early stage. Hence, the process of data editing of the usability testing in this research began right after the data collection for both Sessions 1 and 2 were completed.

Before continuing with the data coding, the incompleteness and consistency of the data were verified. According to Cavana et al. (2001), if 25% of the questionnaire were not answered, it would be recorded as a defect response. In order to transcribe the data from the questionnaire, a coding data sheet was prepared, and after that, all the data would be entered into the SPSS program.

Next, all raw data were coded by referring to the datasheet. This process is crucial to avoid error, confusion, and misplaced data, especially when there are many items in the questionnaire. The data coding process would increase the accuracy of the process of data entering (Cavana et al., 2001).

Next, the process of categorising the variables was conducted after the data coding process. This process is to make sure that the measuring items were grouped. Lastly, all the raw data were keyed in manually into the computer systems. This process is to make sure that the raw data are in control and totally understood. In the next section, the results obtained from the usability testing are presented.

5.5 Demographic data

This section presents the demographic data of the participants.

Table 5.1: Participant Age

Age	No. of participants
18-23	2
24-29	21
30-35	11
36-41	4
42-47	1
48-53	1

Table 5.2: Gender

Gender	No. of participants
Male	17
female	23

Table 5.3: Education

Education level	No. of participants
Undergraduate diploma	4
Bachelor degree	15
Postgraduate	21

Table 5.4: Hours spent listening to music

Hours spent	No. of participants
under an hour a day	10
1-3 hours a day	17
3-5 hours a day	7
more than 4 hours a day	6

Table 5.5: How participants searched for a song

Music search	%
by artist name/band name	70
by song title	55
by genre	28
by mood	45
by occasion	28

Table 5.1 until 5.5 presents the demographic data of the participants. There are 40 participants from various educational backgrounds involved in this user study. 17 (43%) participants are male, and 23 (57%) are female. Most of the participants are university postgraduates and undergraduate students of universities around Perth, namely Murdoch University, Curtin University, and the University of Western Australia (UWA). All participants love to listen to music and are computer literate. Most of them listen to at least 1 to 3 hours of music daily. 70% of the participants browse music by artist or band name, 55% by song title, 28% by genre, 45% by mood, and 28% by occasion. When asked if they searched for music based on their mood at a particular moment, 75% of participants chose 'Yes.' 80% of them also agreed that music does affect their mood.

In the next subsection, the results on the suitability of the ***visual texture*** are discussed. This activity was carried out to answer Research Objective 3a (RO 3a).

5.6 Research Objective 3a (RO 3a) - Suitability

In measuring the suitability of the ***visual texture***, participants were asked to answer a questionnaire soon after they completed each task. It was measured on a 7-point Likert scale ranging from strongly disagree (denoted by 1) to strongly agree (denoted by 7). The objective of the questionnaire is to let the participants further clarify the suitability of the ***visual texture*** that represents each of the ***music moods***. This activity was carried out to achieve Research Objective 3a (RO 3a).

Because Likert scales produce ordinal data, the median and Inter-Quartile Range (IQR) of each item was calculated. The median shows the average response of the participants, while the IQR shows whether the responses are clustered together or scattered across the range of possible responses. A relatively small IQR is an indication of consensus, and a larger IQR might suggest that opinions are polarised. The median and IQR for each type of mood are presented in the next section.

5.6.1 *Angry* Mood

Soon after looking for a song with the title "Mandatory Suicide" from the ***angry*** mood category, participants rated the suitability of the design elements in the ***visual texture*** by answering the questionnaire. The following are the median and IQR for each item.

Table 5.6: Median and IQR for each item in Task 1

No.	Item	Median	IQR
1.	It is easy to look for the song in Task 1.	**7**	**1**
2.	The visual texture matched the song that I found in Task 1.	**7**	**1**
3.	The type of line used in the visual texture matched the song that I found in Task 1.	**7**	**1**
4.	The type of shape used in the visual texture matched the song that I found in Task 1.	**7**	**1**
5.	The type of colour used in the visual texture matched the song that I found in Task 1.	**7**	**1**
6.	The colour value (tone) in the visual texture matched the song that I found in Task 1.	**7**	**1**

Table 5.6 shows that most participants indicated an agreement with the idea that looking for a song in the given task is easy (median=7, IQR=1). Most participants considered that the ***visual texture*** used to represent the ***angry*** mood matched the song given (median=7, IQR=1). Also, most participants agreed that the type of line, shape, colour, and colour value integrated into the ***visual texture*** matched the given song in Task 1 (median=7, IQR=1).

5.6.2 *Calm* Mood

Next, in Task 2, after looking for a song with the title "Kiss of Life" from the ***Calm*** mood category, participants rated the suitability of the design elements in the ***visual texture*** by answering the questionnaire. The following are the median and IQR for each item.

Table 5.7: Median and IQR for each item in Task 2

No.	Item	Median	IQR
1.	It is easy to look for the song in Task 2.	**6**	**1.75**
2.	The visual texture matched the song that I found in Task 2.	**5**	**3.75**
3.	The type of line used in the image matched the song that I found in Task 2.	**5**	**3.00**
4.	The type of shape used in the image matched the song that I found in Task 2.	**5**	**2.00**
5.	The type of colour used in the image matched the song that I found in Task 2.	**6**	**2.00**
6.	The colour value (tone) in the image matched the song that I found in Task 2.	**6**	**3.75**

Table 5.7 shows that most participants seemed to agree with the idea that looking for a song in the given task is easy (median=6, IQR=1.75). Most participants somewhat agree that the ***visual texture*** suggested in the digital music collection website sample matched the song given in Task 2 (median=5, IQR=3.75). For the design elements, most participants showed an agreement that the type of line (median=5, IQR=3.00), shape (median=5, IQR=2.00), colour (median=6, IQR=2.00), and colour value (median=6, IQR=3.75) in the ***visual texture*** matched the song given in Task 2. As shown in the

above table, the IQR for items 3 and 6 are quite big. This implies that opinion seems to be divided with regards to the agreement on the type of line and colour value used in the ***visual texture*** that matched the ***calm*** mood.

Many respondents (N=9, 23%) expressed strong disagreement or disagreement. Still, a roughly equal number (N=14, 35%) indicated that they agreed or strongly agreed that the type of line used in the image matched the ***calm*** mood.

5.6.3 *Happy* Mood

Soon after looking for a song with the title "Two of us" from the ***happy*** mood category, participants rated the suitability of the design elements in the ***visual texture*** by answering a questionnaire. The following are the median and IQR for each item.

Table 5.8: Median and IQR for each item in Task 3

No.	Item	Median	IQR
1.	It is easy to look for the song in Task 3.	**7**	**0.25**
2.	The visual texture matched the song that I found in Task 3.	**6**	**1**
3.	The type of line used in the visual texture matched the song that I found in Task 3.	**6**	**1**
4.	The type of shape used in the visual texture matched the song that I found in Task 3.	**6**	**1**
5.	The type of colour used in the visual texture matched the song that I found in Task 3.	**7**	**1.75**
6.	The colour value (tone) in the visual texture matched the song that I found in Task 3.	**6**	**2**

Table 5.8 shows that majority of the participants (75%, N=30) strongly agreed with the idea that looking for a song in the given task is easy (median=7, IQR=0.25). They also agreed that the ***visual texture*** suggested in the digital music collection website sample matched the song given in Task 3 (median=6, IQR=1). On the design elements, participants also considered that the type of line (median=6, IQR=1), shape (median=6, IQR=1), colour (median=7, IQR=1.75), and colour value (median=6, IQR=2) in the ***visual texture*** matched the song given in Task 3.

5.6.4 *Sad* Mood

Soon after looking for a song with the title "Ain't No Way" from the ***Sad*** mood category, participants were asked to rate the suitability of the design elements in the ***visual texture*** by answering the questionnaire. The following are the median and IQR for each item.

Table 5.9: Median and IQR for each item in Task 4

No.	Item	Median	IQR
1.	It is easy to look for the song in Task 4.	**7**	**1**
2.	The visual texture matched the song that I found in Task 4.	**6**	**2**
3.	The type of line used in the visual texture matched the song that I found in Task 4.	**6**	**1**
4.	The type of shape used in the visual texture matched the song that I found in Task 4.	**5**	**1**
5.	The type of colour used in the visual texture matched the song that I found in Task 4.	**7**	**1**
6.	The colour value (tone) in the visual texture matched the song that I found in Task 4.	**6**	**1.75**

Table 5.9 shows that most participants indicated an agreement with the idea that the ***visual texture*** suggested in the digital music collection website sample matched the song given in Task 4 (median=6, IQR=2). Most participants also agreed with the idea that the type of line (median=6, IQR=1), shape (median=5, IQR=1), colour (median=7, IQR=1), and colour value (median=6, IQR=1.75) in the ***visual texture*** matched the song given in Task 4.

5.6.5 Summary for suitability of the *visual texture* for each mood

Table 5.10: Median and IQR for each mood

	Angry		***Calm***		***Happy***		***Sad***	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**	**Median**	**IQR**
Line	7	1	5	3.00	6	1	6	1
Shape	7	1	5	2.00	6	1	5	1
Colour	7	1	6	2.00	7	1.75	7	1
Colour Value	7	1	6	3.75	6	2	6	1.75

From the results in Table 5.10, it can be concluded that the design elements suggested for each ***visual texture*** is acceptable and suits the assigned mood.

The small IQR value for the ***angry***, ***happy,*** and ***sad*** moods indicate that majority of the participants agreed that the ***visual textures*** are suitable for the ***music mood***. However, the IQR for the ***calm*** mood is slightly bigger, which indicates that participants' opinions might be divided. These results suggest that half of the participants might think that the ***visual texture*** for a ***calm*** mood is suitable, and the rest thinks it is not. Based on the results in Section 5.6.2, the selection of lines and colour values is the cause of this confusion.

In the next section, the results for the usability of browsing ***music mood*** using ***visual texture*** are presented. This part of the test was carried out to answer Research Objective 3b (RO3b).

5.7 Research Objective 3bn (RO 3b) - Usability

In this usability testing, the ISO 9241-11 standard (Bevan, 2001) was employed to operationalise the concepts of three usability elements. According to the ISO 9241-11 standard model, usability consists of three elements –***efficiency, effectiveness***, and ***satisfaction***. Each element can be defined and measured according to the following:

- ***efficiency***: resources used in completing a task
- ***effectiveness***: level of completeness at which users achieve specified goals; and
- ***satisfaction***: positive attitudes towards using the system (ISO, 1998).

Another element that was measured in this research is the ***ease of use***.

- ***ease of use***: a basic concept that describes how easily users can use a product

By adopting Jeng (2006) usability assessment model, measurement scales were developed for each usability element:

- ***efficiency*** – time spent to complete the tasks;
- ***effectiveness*** – the proportion of successfully completed tasks; and
- ***satisfaction*** – seven-point Likert scale from "not satisfied at all" to "very satisfied."

In the next subsection, the task time for each task is presented. This measurement is required to evaluate the ***efficiency*** of each ***visual texture*** in representing a particular mood.

5.7.1 *Efficiency*: Task time

Efficiency is a measure of how quickly and easily a task can be accomplished. In this test, task time was used as a primary indicator to evaluate the efficiency of using ***visual texture*** to browse for a song in the ***music mood*** category. Task time refers to the length of time it takes the participant to complete a task.

5.7.1.1 Task 1 – *Angry* Mood

In Task 1, each participant was given a situation of which they were required to search for a song in the ***angry*** mood category by choosing a ***visual texture*** that they think represents an ***angry*** mood. Their activities were recorded using the Camtasia screen recorder. Each participant's time was taken to complete the task, and the number of attempts was logged.

Table 5.11: Task time (time spent in completing Task 1) for 40 participants

Participant	Time (seconds)	Participant	Time (seconds)
1	81	**21**	39
2	253	**22**	35
3	21	**23**	45
4	26	**24**	50
5	29	**25**	58
6	29	**26**	87
7	37	**27**	124
8	29	**28**	27
9	38	**29**	32
10	23	**30**	34
11	26	**31**	30
12	24	**32**	35
13	48	**33**	28
14	40	**34**	32
15	27	**35**	31
16	25	**36**	28
17	60	**37**	35
18	31	**38**	63
19	34	**39**	27
20	36	**40**	21
Average time: 44.45 seconds **Std Dev: 39.41**			

Table 5.11 shows the time spent (in seconds) for 40 participants to complete Task 1. The completion times ranged from 21 seconds to 253 seconds. On average, the participants took 44.45 seconds to complete the task. This concludes that with 95% confidence, users will take between 32 and 57 seconds to find the right song.

5.7.1.2 Task 2 – *Calm* Mood

In Task 2, each participant was given a situation of which they were required to search for a song in the ***calm*** mood category by choosing a ***visual texture*** that they think represents a ***calm*** mood. Their activities were recorded using the Camtasia screen recorder. Each participant's time for completion and the number of attempts were logged.

Table 5.12: Task Time (time spent in completing Task 2) for 40 participants

Participant	Time (seconds)	Participant	Time (seconds)
1	151	**21**	39
2	137	**22**	130
3	61	**23**	47
4	72	**24**	85
5	95	**25**	208
6	97	**26**	7
7	142	**27**	27
8	95	**28**	23
9	76	**29**	157
10	97	**30**	74
11	39	**31**	73
12	29	**32**	71
13	83	**33**	69
14	151	**34**	78
15	30	**35**	74
16	84	**36**	26
17	74	**37**	46
18	77	**38**	73
19	78	**39**	60
20	73	40	67
Average time: 81.38 seconds **Std Dev: 40.57**			

Table 5.12 shows the time spent (in seconds) for 40 participants to complete Task 2. The completion times ranged from 23 to 208 seconds. On average, the participants took 81 seconds to complete the task. This concludes that with 95% confidence, users will take between 66 and 93 seconds to find the right song.

5.7.1.3 Task 3 – *Happy* Mood

In Task 3, each participant was given a situation of which they were required to search for a song in the ***happy*** mood category by choosing a ***visual texture*** that they think represents a ***happy*** mood. Their activities were recorded using the Camtasia screen recorder. Each participant's time for completion and the number of attempts were logged.

Table 5.13: Task time (time spent in completing Task 3) for 40 participants

Participant	Time (seconds)	Participant	Time (seconds)
1	62	**21**	61
2	38	**22**	33
3	63	**23**	33
4	20	**24**	78
5	17	**25**	45
6	17	**26**	73
7	73	**27**	26
8	26	**28**	26
9	68	**29**	82
10	68	**30**	77
11	65	**31**	77
12	66	**32**	70
13	31	**33**	82
14	73	**34**	33
15	27	**35**	80
16	68	**36**	29
17	32	**37**	77
18	68	**38**	35
19	38	**39**	74
20	38	**40**	60
Average time: 52.73 seconds **Std Dev: 21.78**			

Table 5.13 shows the time spent (in seconds) for 40 participants to complete Task 3. The completion times ranged from 17 to 82 seconds. On average, the participants took 53 seconds to complete the task. This concludes that with 95% confidence, users will take between 46 and 60 seconds to find the right song.

5.7.1.4 Task 4 – *Sad* mood

In Task 4, each participant was given a situation of which they were required to search for a song in the ***sad*** mood category by choosing a ***visual texture*** that they think represents a ***sad*** mood. Their activities were recorded using the Camtasia screen recorder. Each participant's time for completion and the number of attempts were logged.

Table 5.14: Task time (time spent in completing Task 4) for 40 participants

Participant	Time (seconds)	Participant	Time (seconds)
1	33	21	189
2	75	22	34
3	26	23	76
4	26	24	34
5	22	25	73
6	82	26	34
7	63	27	28
8	92	28	28
9	19	29	40
10	94	30	73
11	70	31	60
12	75	32	62
13	24	33	76
14	65	34	39
15	24	35	62
16	73	36	25
17	74	37	67
18	66	38	23
19	67	39	62
20	73	40	64
Average time: 57 seconds Std Dev: 30.97			

Table 5.14 shows the time spent (in seconds) for 40 participants to complete Task 4. The completion times ranged from 19 to 189 seconds. On average, the participants took 57 seconds to complete the task. This concludes that with 95% confidence, users will take between 47 and 67 seconds to find the right song.

5.7.1.5 Summary of average task time for each task

Table 5.15: Average task time for each task

	Task 1: *Angry*	**Task 2: *Calm***	**Task 3 *Happy***	**Task 4 Sad**
Average time to complete (secs)	44.45	81.38	52.73	57.30

Overall, Table 5.15 presents that the time taken to complete Task 1: ***Angry*** was significantly faster (44.45 seconds) than the other tasks, while Task 2: ***Calm*** was the slowest (81.38 seconds). The average time taken to complete Task 3 is 52.73 seconds and 57.30 seconds for Task 4. From these results, it indicates that the participants took a longer time to complete Task 2: ***Calm***, as compared to the other tasks. The reason for this is half of the participants only managed to complete Task 2: ***Calm*** after the second attempt.

When the participant clicked on the wrong **visual texture** on the first attempt, they will not find the song given in the task sheet. The participant has to go back to the main page and select other **visual texture** until they find the right song. This process is what causing task time for Task 2: ***Calm*** to be longer than other tasks.

Overall, even though task time for Task 2: ***Calm*** is relatively slow compared to other tasks, all task time is acceptable, and this shows that participants can browse ***music mood*** using ***visual texture*** quickly and easily. Therefore, this method is considered efficient.

5.7.2 *Effectiveness*: Completion rate

In the previous section, the results for the ***efficiency*** of using ***visual texture*** to browse for songs from four types of mood were presented. Next, the ***effectiveness*** of using ***visual texture*** to browse for songs for each mood is discussed. ***Effectiveness*** can be calculated by measuring the completion rate. It is the percentage of tasks that users complete correctly. Referred to as the fundamental usability metric, the completion rate is calculated by assigning a binary value of '1' if the participant manages to

complete a task, and '0' if they didn't manage to complete the task. The average completion rate is 78%. ***Effectiveness*** can thus be represented as a percentage by using this simple equation, as shown in Equation (1).

$$\text{Effectiveness} = \frac{\text{Number of tasks completed successfully}}{\text{Total number of tasks undertaken}} \times 100\% \quad (1)$$

Table 5.16: Task completion rate for each task

Participant	Task 1: *Angry*	Task 2: *Calm*	Task 3: *Happy*	Task 4: *Sad*
1	1	0	1	1
2	0	0	1	1
3	1	0	1	1
4	1	0	1	1
5	1	0	1	1
6	1	0	1	1
7	1	0	1	1
8	1	0	1	1
9	1	0	1	1
10	1	0	1	1
11	1	1	1	1
12	1	1	0	1
13	1	1	1	1
14	1	0	1	1
15	1	1	1	1
16	1	1	1	1
17	0	1	1	1
18	1	0	1	1
19	1	0	1	1
20	1	1	1	1
21	1	1	1	0
22	1	0	1	1
23	1	1	1	1
24	1	1	1	1
25	0	0	1	0
26	1	1	1	1
27	0	1	1	1
28	1	1	1	1
29	1	0	1	1
30	1	1	1	1

31	1	0	1	1
32	1	1	1	1
33	1	1	1	0
34	1	0	1	1
35	1	1	1	1
36	1	1	1	1
37	1	1	1	1
38	0	0	1	1
39	1	0	1	1
40	1	1	1	1
Task Completion Rate (%)	**87.5**	**50**	**97.5**	**92.5**

Table 5.16 shows the task completion rate for each task. In total, there were 40 attempts observed for each task. Of those attempts in Task 1, 35 participants were successful, and 5 were unsuccessful, and the completion rate for Task 1: ***Angry*** is 87.5%. In Task 2, an equal number of participants were successful and unsuccessful, so that makes the completion rate for Task 2: ***Calm*** 50%. In Task 3, 39 participants were successful, and only 1 was unsuccessful. Thus the completion rate for Task 3: ***Happy*** is 97.5%. In Task 4, 37 participants were successful, and only 3 were unsuccessful, and the completion rate for Task 4: ***Sad*** is 92.5%.

Overall, the completion rates for the tasks: ***angry***, ***happy,*** and ***sad*** are above the average rate. As expected, the completion rate for Task 2: ***Calm*** is the lowest and below average rate due to the reason mentioned in Section 5.6.5. However, results for all tasks are acceptable.

5.7.3 *Effectiveness*: Success rate

Besides the completion rate, the success rate was also used to measure ***effectiveness***. The success rate is the percentage of participants who were able to complete the task given in their first attempt. For this usability testing, the success rate refers to whether or not the participant is successfully able to click on the right ***visual texture*** to search for a song in the particular mood category. A task will be considered a "success" if it

was completed on the first attempt and will be given one point. Then, a task will be considered "partially success" if it was completed on the second attempt and will be given half a point. The task was considered a failure if the participant completed the task on the third attempt (Nielsen, 2001; Wetzlinger, Auinger, & Dörflinger, 2014). The success rate of each task is presented in the next section.

5.7.3.1 Task 1 – *Angry* Mood

Table 5.17: Success Rate for Task 1

Number of attempts	Participant (N)	Percentage (%)	Score
1 attempt	35	88	Success (35 x 1 = 35 point)
2 attempts	3	8	Partially success (3 x 0.5 = 1.5 point)
3 attempts	2	5	Fail
Total	**40**	**100**	**36.5 (91.25%)**

Table 5.17 presents the success rate for Task 1. In total, 40 attempts were undertaken. Of those attempts, 35 (88%) were successful, 3 (8%) were partially successful, whereas 2 (5%) failed. In measuring the success rate, each success was given 1 point, and partial success was given 0.5 point. Therefore, the total score is 36.5 points, and the success rate for Task 1 is 91.25%.

5.7.3.2 Task 2 –*Calm* Mood

Table 5.18: Success Rate for Task 2

Number of attempts	Participant (N)	Percentage (%)	Score
1 attempt	20	50%	Success (20 x 1 = 20 point)
2 attempts	14	35%	Partially success (14 x 0.5 = 7 point)
3 attempts	6	15%	Fail
Total	**40**	**100**	**27 (67.5%)**

Table 5.18 presents the success rate for Task 2. In total, 40 attempts were undertaken. Of those attempts, 20 (50%) were successful, 14 (35%) were partially successful, whereas 6 (15%) failed. The total score for Task 2 is 27 points; therefore, the success rate is 67.5%.

5.7.3.3 Task 3 –*Happy* Mood

Table 5.19: Success Rate for Task 3

Number of attempts	Participant (N)	Percentage (%)	Score
1 attempt	37	93%	Success (37 x 1 = 37 point)
2 attempts	3	8%	Partially success (3 x 0.5 = 1.5 point)
3 attempts	0	0%	Fail
	40	100	**38.5 (96.25%)**

In total, 40 attempts were undertaken. Table 5.19 shows that 37 (93%) were successful, and 3 (8 %) were partially successful. Also, it is worth noting that no one failed to complete Task 3. The total score for Task 3 is 38.5 points; therefore, the success rate is 96.25%.

5.7.3.4 Task 4 – *Sad* Mood

Table 5.20: Success Rate for Task 4

Number of attempts	Participant (N)	Percentage (%)	Score
1 attempt	36	90%	Success (36 x 1 = 36 marks)
2 attempts	3	8%	Partially success (3 x 0.5 = 1.5 marks)
3 attempts	1	3%	Fail
	40	100	**37.5 (93.75%)**

In total, 40 attempts were undertaken. Table 5.20 shows that 36 (90%) were successful, 3 (8%) were partially successful, whereas 1 (3%) failed. The total score for Task 4 is 37.5 points; therefore, the success rate is 93.75%.

5.7.3.5 Summary of success rate for each task

Table 5.21: Success Rates for each task

	Task 1: Angry	Task 2: *Calm*	Task 3: *Happy*	Task 4: *Sad*
Success rate (%)	91.25%	67.5%	96.25%	93.75%

Table 5.21 shows the success rate for each task. The success rate is measured to understand how well ***visual texture*** can be used to browse for songs in the mood category in a music collection application or website.

These results show that the success rate for Task 2 was the lowest among other tasks. Most participants can easily find songs for ***angry***, ***happy,*** and ***sad*** mood according to the task given in just one attempt. For Task 2, some participants (35%) were successful after the second attempt, and the rest (15%) were failed to complete the task. However, success rates and completion for all tasks are acceptable, and these results indicate that browsing ***music mood*** using ***visual texture*** is effective.

In the next section, the results of the ***ease of use*** are presented. ***Ease of use*** is another measure of usability. It was evaluated by giving the participants a four items questionnaire to fill in. This questionnaire measured how easy it is for the ***visual texture*** to be used to browse music according to mood.

5.7.4 The ease of use for first-time use

Once all tasks in Session 1 were completed, the participant subsequently filled in a questionnaire to rate the ***ease of use*** towards browsing ***music mood*** using ***visual texture***.

Table 5.22: Median and IQR for Ease of Use Session 1

No.	Item	Median	IQR
1.	Browsing music according to mood by using visual texture is easy.	**6**	**2**
2.	Browsing music according to mood by using visual texture is clear and understandable.	**6**	**2**
3.	It is easy to become skillful at browsing music according to mood by using visual texture.	**6**	**2**
4.	Overall, browsing music using visual texture is easy for me.	**6**	**2**

Table 5.22 shows that most participants agree with the idea that browsing music according to mood by using ***visual texture*** is easy (median=6, IQR=2). They also have the same agreement that browsing music according to mood by using ***visual texture*** is clear and understandable (median=6, IQR=2). Most participants find that it is easy to become skilful at browsing music according to mood by using ***visual texture*** (median=6, IQR=2). Overall, most participants find that browsing music using ***visual texture*** is easy for them (median=6, IQR=2).

In Session 2, the participants browsed through the online versions of the digital music collection website sample for approximately two weeks. On average, the participants browsed the website for 3 - 4 times for about 5 to 15 minutes each time. At the end of Session 2, the participants rated their ***ease of use*** using the same questionnaire as in Session 1. This activity was arranged to investigate if there were any changes in the ***ease of use*** rating between the first-time and longer-term use.

Table 5.23: Median and IQR for Ease of Use Session 2

No.	Item	Median	IQR
1.	Browsing music according to mood by using visual texture is easy.	**6**	**1**
2.	Browsing music according to mood by using visual texture is clear and understandable.	**6**	**1.75**
3.	It is easy to become skilful at browsing music according to mood by using visual texture.	**6**	**1**
4.	Overall, browsing music using visual texture is easy for me.	**6**	**1**

In Table 5.23, it is clear that most participants still agree with the idea that browsing music according to mood by using ***visual texture*** is easy (median=6, IQR=1). They also have the same agreement that browsing music according to mood by using ***visual texture*** is clear and understandable (median=6, IQR=1.75). Most participants find that it is easy to become skilful at browsing music according to mood by using ***visual texture*** (median=6, IQR=1). Overall, most participants find that browsing music using ***visual texture*** is easy for them (median=6, IQR=1).

Next, the scores of ***ease of use*** from Sessions 1 and 2 are compared and discussed in the next section.

5.7.5 The ease of use for longer-term use

In order to understand if there are any differences between the score of ***ease of use*** for the first time and longer-term use for browsing music using ***visual texture***, the Wilcoxon signed-rank test was conducted. The results from the test are as follows.

Table 5.24: Descriptive Statistics for Ease of Use

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
easeofuse1	40	5.9188	.85558	3.75	7.00	5.3125	6.0000	6.7500
easeofuse2	40	6.0625	.85062	3.50	7.00	5.7500	6.1250	6.9375

Table 5.25: Ranks for Ease of Use

		N	Mean Rank	Sum of Ranks
easeofuse2 - easeofuse1	Negative Ranks	13(a)	16.42	213.50
	Positive Ranks	20(b)	17.38	347.50
	Ties	7(c)		
	Total	40		

a easeofuse2 < easeofuse1
b easeofuse2 > easeofuse1
c easeofuse2 = easeofuse1

Table 5.26: Test Statistics (b) for Ease of Use

	easeofuse2 - easeofuse1
Z	-1.205(a)
Asymp. Sig. (2-tailed)	.228

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

The data from the Ranks table (Table 5.25) shows the comparison of ***ease of use*** score for the first time and longer-term use (2 weeks). From Table 5.25, 13 participants had higher ***ease of use*** score in Session 1. This increases to 20 participants in Session 2, while 7 participants saw no change in their scores.

A Wilcoxon signed-rank test (Table 5.26) showed that browsing music for two weeks did not elicit a statistically significant change in ***ease of use*** for first-time use and longer-term use (Z = -1.205, p = 0.228). This is confirmed as the median rating for ***ease of use*** was 6.0 for both sessions.

These results indicate that after browsed through the digital music collection website sample for another two weeks, participants still give positive feedback toward the ***ease of use***. There are increments of higher ***ease of use*** score from 13 to 20 participants.

5.7.6 Satisfaction for first time use

Next, after the participants have filled in the ***ease of use*** questionnaire, they then filled in the ***satisfactio***n towards browsing ***music mood*** using ***visual texture*** (Session 1).

Table 5.27: Median and IQR for Satisfaction Session 1

No.	Item	Median	IQR
1.	I am satisfied using visual texture in browsing music according to mood.	**6**	**2**
2.	I would recommend it to a friend.	**6**	**1.75**
3.	Browsing music according to mood using visual texture is fun.	**7**	**1**
4.	It works the way I want it to work.	**6**	**1**
5.	Browsing music according to mood using visual texture is wonderful.	**6**	**2**
6.	It is pleasant to use visual texture in browsing music according to mood.	**6**	**1**

In Table 5.27, most participants were satisfied using ***visual texture*** in browsing music according to mood (median=6, IQR=2), and they would recommend it to their friends (median=6, IQR=1.75). Most participants found that browsing music according to mood by using ***visual texture*** is fun (median=7, IQR=1). They agreed that the digital music collection website sample works the way they want it to (median=6, IQR=1). Most participants indicated an agreement with the idea that browsing music according to mood using ***visual texture*** is wonderful (median=6, IQR=2) and pleasant to use (median=6, IQR=1).

In Session 2, the participants browsed through the online versions of the digital music collection website sample for two weeks. On average, they browsed the website for 3 - 4 times for 5 to 15 minutes each time. At the end of Session 2, the participants rated the same satisfaction questionnaire as in Session 1. This activity was arranged to investigate if there were any changes in the satisfaction rating between the first-time and longer-term use.

Table 5.28: Median and IQR for Satisfaction Session 2

No.	Item	Median	IQR
1.	I am satisfied using visual texture in browsing music according to mood.	**6**	**1**
2.	I would recommend it to a friend.	**6**	**1.75**
3.	Browsing music according to mood using visual texture is fun.	**6.5**	**1**
4.	It works the way I want it to work.	**6**	**2**
5.	Browsing music according to mood using visual texture is wonderful.	**6**	**2**
6.	It is pleasant to use visual texture in browsing music according to mood.	**6**	**1**

In Table 5.28, most participants were satisfied using ***visual texture*** in browsing music according to mood (median=6, IQR=1), and they would recommend it to their friends (median=6, IQR=1.75). Most participants find that browsing music according to mood by using ***visual texture*** is fun (median=6.5, IQR=1). They agree that the digital music collection website sample works the way they want it to (median=6, IQR=2). Most participants indicated an agreement with the idea that browsing music according to mood using ***visual texture*** is wonderful (median=6, IQR=2) and pleasant to use (median=6, IQR=1).

Then, the scores of satisfaction from Sessions 1 and 2 are compared and discussed in the next section.

5.7.7 Satisfaction for longer-term use

In order to understand if there are any differences between the score of satisfaction between the first time and long time use for browsing music using ***visual texture***, the Wilcoxon signed-rank test was conducted. The results from the test are as follows.

Table 5.29: Descriptive Statistics for Satisfaction

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
satisfaction 1	40	5.9167	.97694	2.50	7.00	5.5417	6.0000	6.7917
satisfaction 2	40	5.9208	1.02878	2.67	7.00	5.5000	6.0833	6.7917

Table 5.30: Ranks for Satisfaction

		N	Mean Rank	Sum of Ranks
satisfaction2 - satisfaction1	Negative Ranks	10(a)	17.85	178.50
	Positive Ranks	17(b)	11.74	199.50
	Ties	13(c)		
	Total	40		

a satisfaction2 < satisfaction1
b satisfaction2 > satisfaction1
c satisfaction2 = satisfaction1

Table 5.31: Test Statistics (b) for Satisfaction

	satisfaction2 - satisfaction1
Z	-.254(a)
Asymp. Sig. (2-tailed)	.800

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

The data from the Ranks table (Table 5.30) shows the comparison of ***satisfaction*** scores between the first time and longer-term use (2 weeks). Ten participants had a higher ***satisfaction*** score in Session 1, and this increases to 17 participants in Session 2, while 13 participants saw no change in their scores.

A Wilcoxon signed-rank test table (Table 5.31) showed that browsing music for two weeks did not elicit a statistically significant change in ***satisfaction*** for first-time and long term uses ($Z = -0.254$, $p = 0.800$). This is confirmed as the median rating for ***satisfaction*** was 6.0 for both sessions.

These results indicate that though the participants browsed through the digital music collection website sample for another two weeks, they still give positive feedback toward ***satisfaction.*** There are increments of higher ***satisfaction*** scores from 10 to 17 participants.

5.8 Summary

This chapter presents the processes in Phase 4: The Evaluation Phase. The objective of this phase is to achieve Research Objective 3 (RO 3). RO 3 is to validate the proposed framework by conducting usability testing on a music collection sample. Two outcomes from this usability testing were gathered and presented in this chapter: first, the feedback on the suitability of ***visual texture*** that represents each of the ***music mood*** (RO 3a) and the usability of this music collection sample website by measuring the ***efficiency, effectiveness***, ***ease of use*** and ***satisfaction*** (RO 3b).

For suitability, the majority of the participants agreed that the ***visual textures*** are suitable for the ***angry, happy,*** and ***sad*** mood. However, for a ***calm*** mood, participants' opinions might be divided. This finding suggests that some of the participants found that **visual texture** used to represent a ***calm*** mood was relevant, and some found it quite unfitting. This situation is due to the choice of line and colour value.

For efficiency, the average time to complete Task 1: ***Angry*** was significantly faster than the other task, while Task 2: **Calm** was the slowest. This result indicates that participants can quickly identify ***visual texture*** that represents ***angry, happy,*** and ***sad*** mood. Some of the participants might have a little bit of confusion while choosing ***visual texture*** for a ***calm*** mood.

For effectiveness, completion rate and success rate were measured. The completion rates for the tasks: ***angry***, ***happy,*** and ***sad*** are above 78%, which is the average rate. However, the number of participants who were successful and unsuccessful is equal for Task 2- Calm, so that makes the completion rate for Task 2 was 50%.

For the success rate, most participants were successful in completing Task 1,3 and 4 in their first attempt. For Task 2, most participants (35%) were successful after the second attempt, and the rest (15%) were failed to complete the task. Success rates for all tasks are acceptable, and this indicates that browsing ***music mood*** using ***visual texture*** is effective.

Next, for ***ease of use***, most participants find that browsing music according to mood by using ***visual texture*** is easy, clear, and understandable. It is also easy to become skilful at browsing music using this method.

For ***satisfaction***, most participants were satisfied using ***visual texture*** in browsing music according to mood and would recommend it to their friends. They agreed to the idea that this browsing method is fun, pleasant to use, wonderful, and it works the way they want it to.

In the next chapter, the findings are interpreted and elaborated in detail regarding the Research Questions (RQ) and Research Objectives (RO). Also, the proposed framework for visualising ***music mood*** using ***visual texture*** was validated.

6 DISCUSSION OF RESULTS

The purpose of this research is to explore the feasibility of visualising ***music mood*** using ***visual texture***. In this chapter, the insights of the findings will be discussed concerning the Research Questions (RQs) and Research Objectives (ROs) that have been specified in Chapter 1 (Sections 1.4 and 1.5).

Table 6.1: Mapping Research Question, Research Objective, and Results

Research Question	Phase	Research Objective	Results Table
RQ1: Which of the ***visual texture*** characteristics are suitable to be associated with a certain ***music mood?***	**Phase 1:** Awareness of Problem	**RO1:** Identify suitable ***visual texture*** characteristics in associating with a certain ***music mood.***	Table 6.2 (Chapter 6)
RQ2: How can we incorporate suitable ***visual texture*** characteristics and other components in the construction of the proposed framework?	**Phase 2:** Suggestion	**RO2a**: To construct a proposed framework	Figure 3.4 (Chapter 3)
	Phase 3: Development	**RO2b**: To design a ***visual texture*** for each mood and apply it in a music application sample website to represent the ***music mood*** category	Figure 3.5 (Chapter 3) Figure 3.6 (Chapter 3)
RQ3: How well does the ***visual texture*** match the ***music mood***?	**Phase 4:** Evaluation	**RO3:** Validate the framework by conducting usability testing on a music collection website sample.	**Suitability:** Table 5.6, Table 5.7, Table 5.8, Table 5.9, Table 5.10 (Chapter 5)
RQ4: How can we evaluate the usability of browsing music according to mood using ***visual texture***?			**Efficiency:** Table 5.11, Table 5.12, Table 5.13, Table 5.14, Table 5.15, Figure 5.4 (Chapter 5) **Effectiveness:** i) Task completion rate

			Table 5.16, Figure 5.5 (Chapter 5) ii) Success rate Table 5.17, Table 5.18, Table 5.19, Table 5.20, Table 5.21, Figure 5.6 (Chapter 5) **Ease of use** Table 5.22, Table 5.23, Table 5.24, Table 5.25, Table 5.26 (Chapter 5) **Satisfaction** Table 5.27, Table 5.28, Table 5.29, Table 5.30, Table 5.31 (Chapter 5)

Table 6.1 shows an overview of the relationships. In the next section, all Research Questions and Research Objectives are discussed.

6.1 Discussion of RQ1 and RO1

RQ1*: Which of the* ***visual texture*** *characteristics are suitable to be associated with a certain* ***music mood****?*

RO1: *Identify suitable texture characteristics in associating with a certain* ***music mood.***

As mentioned in Chapter 1 (Section 1.4), a new and interesting way to represent musical metadata like mood and genre is by using visual forms. To date, ***visual texture*** has not been used as a visual form to represent ***music mood.*** Due to this fact, a framework for visualising ***music mood*** using ***visual texture*** was proposed. As mentioned in Chapter 3 (Figure 3.1), this research consists of five main phases, which include Phase 1: Awareness of Problem, Phase 2: Suggestion, Phase 3: Development, Phase 4: Evaluation, and Phase 5: Conclusion.

In Phase 1, an online survey was conducted to find the answers for Research Question 1 (RQ1). Based on the literature review, a few suggestions of design elements such as lines, shapes, colours, and colour values for each mood were identified. The suggested design elements were listed out in the answer options of the online survey. Respondents selected the type of element they think matches the particular mood.

Table 6.2: Results for online survey

Mood	Visual Elements	%
Angry	Line	Thick, jagged line - 85.6%
	Shape	Triangle – 89.7%
	Colour	Red – 94.1%
	Colour value	Bright – 84.2%
Sad	Line	Thin curved line - 49.8%
	Shape	Circle- 56.4%
	Colour	White – 52.8%
Happy	Line	Thick curved line – 38.7%
	Shape	Circle – 54.7%
	Colour	Yellow – 57.2%
	Colour value	Bright – 98.1%
Calm	Line	Thin horizontal line – 66.1%
	Shape	Rectangle -66.3%
	Colour	Green - 38.1%
	Colour value	Bright – 59.2%

The results in Table 6.2 shows 85.6% of the respondents chose the thick, jagged line, 89.7% chose the triangle, 94.1% chose the colour red, and 84.2% chose the bright colour value to represent the ***angry*** mood. To represent the ***sad*** mood, 49.8% of the respondents chose the thin curved line, 56.4% chose the circle, and 52.8% chose the colour white. As for the ***happy*** mood, 38.7% of the respondents chose the thick curved line, 54.7% chose the circle, 57.2% chose the colour yellow, and 98.1% chose the bright colour value. Finally, 66.1% of the respondents chose the thin horizontal line, 66.3% chose the rectangle, 38.1% chose the colour green, and 59.2% chose the bright colour value to represent the ***calm*** mood. From the results, the specific types of design element for each mood were confirmed, and Research Objective 1 was achieved.

In Phase 2: Suggestion, the proposed framework was developed. The ***visual texture*** for each mood was designed and applied in an online music collection website in Phase 3: Development. In the next section, the activities in Phases 2 and 3 are summarised.

6.2 Discussion of RQ2 and RO2

RQ2*: How can we incorporate suitable* ***visual texture*** *characteristics and other components in the construction of the proposed framework?*

RO2: *Incorporate the identified texture characteristics and other components in the construction of the proposed framework.*

Next, activities in Phase 2: Suggestion, was conducted to answer Research Question 2a (RQ2a), that is to construct the proposed framework. The proposed framework (Figure 3.4) is based on the visual mapping process in a Visualisation Reference Model by Card (1999). The model comprises of four main phases that are needed in mapping the raw data and transforming them into a visual form that can be viewed by the user. In this phase, the main focus is on the visual mapping process. In this process, design elements were mapped to the ***music mood*** to come out with a ***visual texture*** design that can represent a specific mood. Design principles such as repetition, alignment, and contrast were applied in the process of designing the ***visual texture***. With the development of the proposed framework, Research Objective 2 is achieved.

In Phase 3: Development, the ***visual texture*** for each mood was designed. These activities were conducted to answer Research Question 2b (RQ2b). The finalised ***visual texture*** designs for each mood are shown in Chapter 3 (Figure 3.5). Once the ***visual texture*** for each mood was designed, it was applied in a music application sample website to represent the relevant mood category. The music sample application was created using WordPress, which is an open-source Content Management System (CMS). A web hosting service is used to get this website up and running on the internet. On the main page, four visual textures are representing four types of ***music mood*** categories, namely ***angry***, ***sad***, ***happy,*** and ***calm***. When a participant clicks on any of ***visual textures***, one will get a list of songs for a particular type of mood, comprising of

20 songs. The lists of songs were taken from the first 20 out of 50 songs provided for each mood from the AMG website, allmusic.com. This website sample was used in the usability testing in Phase 4.

6.3 Discussion of RQ3, RQ4, and RO3

RQ3: *How well does the* ***visual texture*** *match the* ***music mood?***

RQ4*: How can we evaluate the usability of browsing music according to mood using* ***visual texture****?*

RO3: *Validate the framework by conducting usability testing on a music collection sample.*

In order to determine how well users can interact with the ***visual textures*** to browse for music, usability testing was conducted in Phase 4: Evaluation. There were two sessions in this usability testing. Session 1 was conducted face-to-face, while Session 2 was conducted online by the participants themselves. There were two objectives in usability testing, which is to answer Research Question 3 (RQ3) and Research Question 4 (RQ4). The first objective is to evaluate the suitability of design elements in the ***visual texture*** used to recommend mood. The second objective is to evaluate the usability of browsing music according to mood using ***visual textures*** that includes ***effectiveness***, ***efficiency***, ***ease of use,*** and **satisfaction**.

6.3.1 Research Question 3: Suitability

Participants were given four tasks to browse for songs in a particular mood category. After each task, they answered a set of questions to rate how much they agree with the suitability of the design elements in each ***visual texture***. Each response is based on a 7-point Likert scale ranging from strongly disagree (denoted by 1) to strongly agree (denoted by 7). Since Likert scales produce ordinal data, the Median and Inter Quartile Range (IQR) for each item of each mood was calculated. The median shows the average

response of the participant, while the IQR shows whether the responses are clustered together or scattered across the range of possible responses.

The summary of the median and IQR for each item is shown in Table 5.10 (Chapter 5). Most participants agreed that design elements such as the type of lines, type of shapes, colour choices, and colour value in the ***visual texture*** matched the mood. These results confirmed that the design elements that were chosen to design a ***visual texture*** for the ***angry***, ***sad***, and ***happy*** moods were suitable to represent the particular ***music mood.***

Contrary to the expectation, the IQR for the ***calm*** mood is slightly bigger, which indicates that participants' opinions might be divided. These results show that half of the participants might agree, and the other half might disagree on the choice of design elements used to design the ***visual texture*** for a ***calm*** mood. Based on the results in Section 5.6.2, the selection of lines (Item 3) and colour values (Item 6) is the cause of this disagreement. A possible explanation for this might be that colour related emotion is highly dependent on personal preference and experience with that particular colour (Kaya & Epps, 2004). Besides that, some colours may be associated with several different emotions, and some emotions are associated with more than one colour (Saito, 1996).

6.3.2 Research Question 4: Usability

According to the ISO 9241-11 standard model, usability consists of three elements – ***effectiveness***, ***efficiency***, and ***satisfaction***. Each element can be defined and measured according to the following:

- ***efficiency***: resources used in completing a task;
- ***effectiveness***: level of completeness at which users achieve specified goals; and
- ***satisfaction***: positive attitudes towards using the system (ISO, 1998).

Another element that was measured in this research is the ***ease of use***.

- ***ease of use***: a basic concept that describes how easily users can use a product

6.3.2.1 Efficiency

Efficiency is a measure of how quickly and easily a task can be accomplished. In this research, the task time was used as a primary indicator to evaluate the efficiency of using ***visual texture*** to browse for songs in the ***music mood*** category. Task time refers to the length of time it takes for the participant to complete a task. In the usability test, participants were given four tasks to complete. In each task, each participant was given a situation, of which they were required to search for a song in a particular mood category. Participants have to choose a ***visual texture*** that they think represents the mood. Their activities were recorded using the Camtasia screen recorder. Each participant's time for completion was also logged.

The time to complete Task 1: ***Angry*** was significantly faster (44.45 seconds) than other tasks, and Task 2: ***Calm*** was the slowest (81.38 seconds). The average time to complete Task 3 is 52.73 seconds and 57.30 seconds for Task 4. The results for average task time demonstrate that participants took a long time to complete Task 2 as compared to the other tasks. This situation is possible because the participants were confused by the design elements such as lines and colour value that were incorporated in the ***visual texture*** to represent ***Calm*** mood. In summary, the average task time for all moods was acceptable. Participants were able to choose the right **visual texture** to find for correct songs mostly on first and second attempts. These findings have confirmed that browsing music using ***visual texture*** is efficient.

6.3.2.2 Effectiveness

Effectiveness can be calculated by measuring the completion and success rates. From the recorded screen activities of each participant, the completion rate was calculated. The completion rate is the percentage of tasks that participants completed correctly. Referred to as the fundamental usability metric, the completion rate is calculated by assigning a binary value of '1' if the test participant manages to complete a task and '0' otherwise. 78% is an average completion rate. For Task 3: ***Happy*** obtained the highest completion rate, while for Task 2: ***Calm*** was relatively low as compared to the other

tasks. The results show that ***visual texture*** for ***happy*** mood is clear and easy to be identified by participants, followed by ***sad*** and ***angry*** mood. For Task 2: ***Calm***, some participants found it a bit confusing to guess which ***visual texture*** represents ***calm*** mood. Only 20 (50%) participants were able to click on the correct ***visual texture*** on their first attempt.

Next, the success rate was calculated. The success rate is the percentage of participants who were able to complete the given task in their first attempt. For this part of the research, the success rate refers to whether or not the participants are successfully able to click on the correct ***visual texture*** to search for a song in the particular mood category. The success rate for Task 1: ***Angry*** is 91.25%, Task 2: ***Calm*** 67.5%, Task 3: ***Happy*** 96.25%, and Task 4: ***Sad*** 93.75%. The average success rate for all four tasks is 87%. Most of the participants are able to choose the correct **visual texture** on their first attempt for ***angry***, ***happy,*** and ***sad*** mood.

As such, the completion and success rates for all moods were acceptable, and this finding indicates that browsing music using ***visual texture*** is effective.

6.3.2.3 Ease of use

After the ***efficiency*** and ***effectiveness*** of browsing music in the mood category using ***visual texture*** have been analysed; ***ease of use*** was measured next. In the usability testing, participants were asked to rate the ***ease of use*** towards browsing ***music mood*** using the ***visual texture*** on two separate occasions. The first is after they have completed Session 1, and the next is after they have completed Session 2. The results for both sessions were compared to see if there were any changes in the ***ease of use*** rating between the first-time use and longer-term use. Most participants agreed with the idea that browsing music according to mood by using ***visual texture*** is clear and understandable. They also found it easy to become skilful at browsing music according to mood by using the ***visual texture*** feature. From these findings, we can conclude that the participants find it easy to browse for music according to moods using ***visual texture***.

After using the music collection website sample for two weeks, the participants were asked to rate the ***ease of use*** again, and both results were subsequently compared. A Wilcoxon signed-rank test showed that browsing music for two weeks did not elicit a statistically significant change in ***ease of use*** for first-time versus long-term use. These results indicate that, even after browsing music using **visual texture** for a longer time, results for ease of use remain the same.

6.3.2.4 Satisfaction

Similar to ***ease of use***, the participants were also asked to rate their satisfaction (on two separate occasions) towards browsing ***music mood*** using ***visual texture***. The results for both sessions were compared to see if there were any changes in ***ease of use*** rating from the first-time use to the longer-term use.

Most participants were satisfied using ***visual texture*** in browsing music according to mood. They would recommend it to their friends, and they found that browsing music according to mood by using ***visual texture*** was fun. They also agreed that the music collection website sample worked the way they wanted it to, and browsing music according to mood using ***visual texture*** was wonderful and pleasant.

After using the music collection website sample for another two weeks, the participants were asked to rate their satisfaction again. The results from both sessions were then compared. A Wilcoxon signed-rank test showed that browsing music for two weeks did not elicit a statistically significant change in satisfaction for first-time use and long-term use. This finding signifies, even after browsing music using **visual texture** for a longer time, participants' satisfaction remains the same.

6.3.2.5 Final Framework

Once all of the phases were completed, the framework for visualising ***music mood*** using ***visual texture*** was finalised. The finalised framework is based on the Visualisation Reference Model by Card (1999) that traces the path of transforming raw data into a visual form that can be viewed by the user. The visual mapping process was focused

upon, where suitable types of design elements were mapped to specific moods. Design principles were applied in the process of designing the ***visual textures***. Once the ***visual texture*** for each mood was designed, we applied it in a music application sample website to represent songs in the specific mood category. Next, to better understand how users browse music via the mood category using ***visual texture,*** a usability test was conducted. There were two objectives in the usability test, which is to answer Research Question 3 (RQ3) and Research Question 4 (RQ4). The first objective is to evaluate the suitability (RQ3a) of design elements in the ***visual texture*** used to recommend mood. The second objective is to evaluate the usability (RQ3a) towards browsing music according to mood using ***visual texture*** that includes ***effectiveness***, ***efficiency***, ***ease of use,*** and ***user satisfaction***. With the development of the validated framework (Figure 6.1), Research Objective 3 is now achieved.

Figure 6.1: Final Framework for visualising *Music Mood* Using *Visual texture*

The final framework is an improvised and validated version of the proposed framework (Figure 3.4). There are two modifications done to the final framework. Firstly, the Design Elements and Design Principles in the Visual Structure section were combined as Visual Grammar. This is because the process of combining design elements using appropriate design principles to design a ***visual texture*** is part of visual grammar

(Leborg, 2006). Visual Grammar can be categorised into four parts, namely ***Objects***, ***Structures***, ***Activities,*** and ***Relations.*** By utilizing all four parts in Visual Grammar, ***Visual Texture*** to represents each mood will be obtained.

Secondly, the Usability Test section was added to the final framework. In this section, the ***visual texture*** for each mood was applied in a music application sample website (View). A usability test was conducted to better understand how users browse music using ***visual texture*** (Task). Outcome Results were added into this section. It consists of the Suitability results for the ***visual texture*** of each mood, and Usability towards browsing music according to mood using visual texture.

This framework traces the path of mapping music mood into a ***visual texture*** that can be used by the user to browse for a song in the mood category until it is tested. Usability testing is essential to observe if a system or method is usable when utilised by the actual user (Jeng, 2006). As a result, the final framework for visualising music mood using visual texture was established.

6.4 Research Contributions Summary

This thesis provides contributions to both academic researchers and developers of digital music services. The first contribution comprises a suggested visual variable, which is the ***visual texture*** for visualising ***music mood.*** The type of design elements such as line, shape, colour, and colour value that represents certain moods was studied in online surveys. By incorporating the selected design elements, four ***visual textures*** *were* designed and tested with an online music collection sample.

The research contributions can be summarised as follows:

1) **Certain types of design elements can be associated with certain *music moods.***

Findings from this research confirmed that certain design elements such as colour, colour value, lines, and shapes were able to represent certain ***music moods.***

Despite the positive feedback for ***angry***, ***happy,*** and ***sad*** mood, there is some issue with the design element for ***calm*** mood. Participants' opinions were divided about the

choice of lines (Item 3) and colour values (Item 6) for Calm mood. Possibly, the use of bright green gives a different meaning to individual participants. This situation is possible because colour related emotion is highly dependent on personal preference and experience with that particular colour (Kaya & Epps, 2004). Similarly, Saito (1996) points out that some colours may be associated with several different emotions, and some emotions are associated with more than one colour. Besides that, the selection of a thin, horizontal line also might be interpreted differently by some participants.

2) **Visual texture can be used as a method to browse music and explore new songs.**

Findings from this research have confirmed that ***visual texture*** is an associative visual variable and was able to be used to represent relevant ***music moods*** in a music collection application or website. By using this method of browsing music, users were able to explore new songs in their music libraries rather than search for familiar songs via song title or artist name.

3) **The establishment of the Framework for Visualising *Music mood* Using *Visual Texture.***

The establishment of the framework is the main aim of this research. Previous research made use of other visual variables to associate music metadata but did not focus explicitly on textures. Hence, this research contributed a framework that can be used by music player software developers or online music service providers to visualise ***music mood*** using ***visual texture***.

6.4.1 Conclusion

Many researchers have visualised music collection in various ways to make music browsing more interesting and efficient; this includes treemaps (Torrens et al., 2004), geographical maps (Kornhauser et al., 2009; S. Leitich & M. Topf, 2007), rainbows (Pampalk & Goto, 2006), 3D spirals (Lamere & Eck, 2007), graph-based visualisation (Hamasaki et al., 2014), self-organising map (Plewa & Kostek, 2015), interactive interface (Andjelkovic et al., 2016), collaborative jukebox (Allik et al., 2016) and many

more. However, there is no research focusing explicitly on ***visual textures*** (Holm, 2012; A. Husain et al., 2013). In this research, it has been proven that ***visual texture*** can be used to visualise ***music mood,*** and this method is found to be effective, efficient, easy to use, and pleasant.

The main outcome of this research is the development of the Framework for Visualising ***Music mood*** Using ***Visual Texture***. All relevant elements and components of this framework were considered and validated. This framework was specifically designed to help the designer choose the best design elements in designing ***visual texture*** that can represent specific ***music moods.*** In the next section, the limitations of the research and recommendations for future research are discussed.

6.4.2 Limitations and Recommendations for future research

There are several limitations to this research. The first limitation is the participant demographics. Participants who are involved in this research must be above 18 years old and love listening to music. These characteristics were chosen so that the participants will enjoy doing this experiment and familiar with music browsing activities. In the future, possibly, this research can focus on more exciting participant demographics such as specific ethnicity, gender, or younger age.

Besides that, practical issues and problems experienced by users can also be discussed in future research. For example, difficulties of browsing or interacting with music that is not associated with mood can be complicated as users can easily associate mood with music. This research can focus on the target group, such as a person with anxiety or stress disorder.

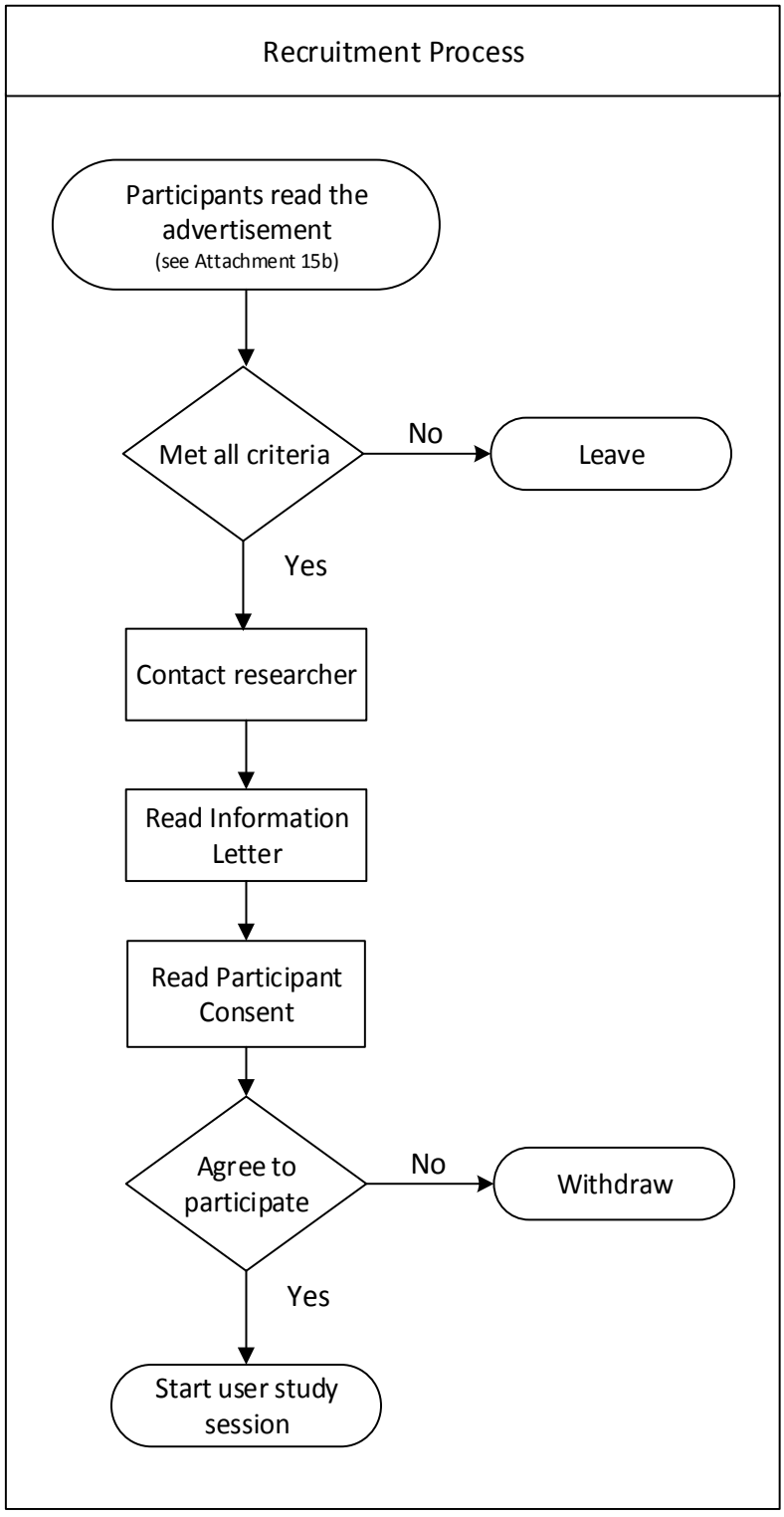
The second limitation is the use of visual or implied texture rather than actual texture. ***Visual textures*** that were used to represent moods were created using a graphic design application. Design elements such as lines and shapes were manipulated to create the feel of a particular texture. Then, the colours with a particular colour value were added to represent certain moods. In the future, it would be more interesting if actual or real textures such as glass, rugs, or tree barks are used to represent mood.

The third limitation is the lack of a ***visual texture*** option in usability testing. There were only four options given to the participants during the test. If a participant were given the tasks in sequence, this would allow the user to guess the answer for the last task. To overcome this problem, the tasks were given randomly. Therefore, in future research, extra design or dummy options should be included in the answers, so that participants cannot easily predict the answer.

The fourth limitation is the type of moods that were chosen to be visualised. In this research, only one mood from every quarter of Russell's model, which is ***angry***, ***sad***, ***happy,*** and ***calm,*** was chosen. In the future, perhaps, more types of mood can be visualised.

APPENDICES

Appendix A: Recruitment process flowchart


Recruitment Process
Participants read the advertisement
(see Attachment 15b)
Met all criteria
No
Leave
Yes
Contact researcher
Read Information Letter
Read Participant Consent
Agree to participate
No
Withdraw
Yes
Start user study session

Appendix B: Advertisement for participant recruitment.


Murdoch
UNIVERSITY
Are you...
18 years old and above?
like to listen to music?
We NEED you!
Participating in our survey will involve browsing music collection using texture image and fill in some simple questionnaire.
INTERESTED? please contact Adzira at
a.husain@murdoch.edu.au | Whatsapp 0406114961

Appendix C: Information Letter

User evaluation on the use of texture image to browse music by mood.

Dear participants,

We invite you to participate in this study to evaluate the concept of using texture image to browse music by mood. This study is part of my PhD research supervised by Dr Mohd Fairuz Shiratuddin and Associate Prof. Dr. Kevin Wong at Murdoch University.

Nature and Purpose of the Study

The traditional way of browsing music collections is by going through a textual list of song, and the search methods may not be sufficient to maintain an overview of the collection. A promising alternative for representing musical metadata is through information visualisation (Infovis). We have come out with a framework for visualising music mood using texture image.

Therefore, with the aim to validate the framework, we will conduct a user study to evaluate the concept of using texture image to browse music by mood.

If you consent to take part in this study, it is important that you understand the purpose of the study and the tasks you will be asked to complete. Please make sure that you ask any questions you may have, and that all your questions have been answered to your satisfaction before you agree to participate.

What the Study will involve

To participate in this survey, you must be 18 years old or above. You also must be an active listener which means you listen to music regularly and must use the computer on a daily basis, both for work and to listen to music.

If you decide to participate in this study, you will be asked to complete some tasks and fill in a questionnaire for two separate sessions. Session 1 will be conducted for 30 minutes. You will be given a task to search for songs based on mood by the given scenario and while you are completing the task, your steps will be recorded using video capture.

In session 2, you will need to use the music collection sample at home for two weeks. You will be given some tasks and you need to use the music collection sample for 3 to 4 times during this session. After two weeks, you will need to fill in the same questionnaire as in the first session.

Voluntary Participation and Withdrawal from the Study

Your participation in this study is entirely voluntary. You may withdraw at any time without discrimination or prejudice. All information is treated as confidential and no names or other details that might identify you will be used in any publication arising from the research. If you withdraw, all information you have provided will be destroyed.

Benefits of the Study
It is possible that there may be no direct benefit to you from participation in this research. Even though that there is no guarantee that you will personally benefit, the knowledge gained from your participation may help to provide an alternative method to browse digital music playlist using texture image to the community in the future.

If you have any questions about this project please feel free to email me at a.husain@murdoch.edu.au. We are happy to discuss with you on any concerns that you may have about this survey.

Once we have analysed the information from this survey we will put on our web site a summary of our findings. You can expect to receive this feedback in 6 months.

If you are willing to consent to participation in this survey, please read the Participant Consent in the next page.

Thank you for your support with this research project.

Sincerely

Adzira Husain

This study has been approved by the Murdoch University Human Research Ethics Committee (Approval xxxx/xxx). If you have any reservation or complaint about the ethical conduct of this research, and wish to talk with an independent person, you may contact Murdoch University's Research Ethics Office (Tel. 08 9360 6677 (for overseas studies, +61 8 9360 6677) or e-mail ethics@murdoch.edu.au). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.

Appendix D: Consent Form

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Consent Form

www.murdoch.edu.au

... User evaluation on the use of texture image to browse music by mood ...

1. I agree voluntarily to take part in this study.
2. I confirm that I meet the criteria for participation in this study:
   - ☐ I am over the age of 18 years.
   - ☐ I like to listen to music
3. I have read the Information Sheet provided and been given a full explanation of the purpose of this study, the procedures involved and of what is expected of me.
4. I understand that I will be asked to complete a few task by browsing music using music collection sample and fill in questionnaire at the end of the session.
5. The researcher has answered all my questions and has explained possible problems that may arise as a result of my participation in this study.
6. I understand I am free to withdraw from the study at any time without needing to give any reason.
7. I understand I will not be identified in any publication arising out of this study.
8. I understand that my name and identity will be stored separately from the data, and these are accessible only to the investigators. All data provided by me will be analysed anonymously using code numbers.
9. I understand that all information provided by me is treated as confidential and will not be released by the researcher to a third party unless required to do so by law.

Name of participant: _____

Signature of Participant: _____ Date: ...../...../.....

I confirm that I have provided the Information Letter concerning this study to the above participant; I have explained the study and have answered all questions asked of me.

Signature of researcher: _____ Date: ...../...../.....

Appendix D: Questionnaire for Usability Testing (Demographic)

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A
Demographic

Respondent no. ☐☐

Evaluating the use of visual texture to browse music by mood category.

SECTION A. General Background Information

This section is to gather your background information. Unless specified in the question, please select and tick (√) **only ONE appropriate answer** for each of the following questions.

1. Age :
   - ☐ 18 – 23 years old
   - ☐ 24 – 29 years old
   - ☐ 30 – 35 years old
   - ☐ 36 – 41 years old
   - ☐ 42 – 47 years old
   - ☐ 48 – 53 years old
   - ☐ 54 – 59 years old
   - ☐ 60 years old and above

2. Gender: ☐ Male ☐ Female

3. Education level :
   - ☐ Year 12 or equivalent
   - ☐ Vocational qualification
   - ☐ Associate diploma
   - ☐ Undergraduate diploma
   - ☐ Bachelor's degree (including honours)
   - ☐ Postgraduate

4. How often do you listen to music?

- ☐ Under an hour a day
- ☐ 1-3 hours a day
- ☐ 3-5 hours a day
- ☐ More than 4 hours a day

5. Where do you usually listen to music? (you can tick (√) more than 1 (ONE) answer)

- ☐ At home
- ☐ In the car / public transport
- ☐ At work
- ☐ At the gym
- ☐ At the library

6. Do you search for music based on your mood at that particular moment?

☐ Yes ☐ No

7. How do you usually search for music? (you can tick (√) more than 1 (ONE) answer)

- ☐ by artist / band name
- ☐ by song title
- ☐ by genre
- ☐ by mood
- ☐ by occasion or activity (e.g. reading, cooking, cleaning, partying)

8. Does the music you listen to affect your mood? (e.g. Listening to Rock music could make you angry)

☐ Yes ☐ No

Appendix E: Task Sheets for Session 1

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A1
Task Sheet
Session 1

Introduction: This music collection sample will let you browse music by mood. You will need to choose the type of music mood that you want by clicking on the visual texture.

Instructions:

Task 0 : Browse the music collection (3 minutes)
1. Click on any visual texture to get a list of songs.
2. Select any song and click on the Play button ( ).
3. Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
4. Select other song to listen to or click on the Home button to choose other visual texture to get a different list of songs.
5. Once the 3 minutes is up, click on the Home button and go to the Main page.
6. Continue with Task 1.

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A1
Task Sheet
Session 1

Task 1 : Angry mood
1. Read the scenario below: "You just had a hot argument with you friend and need to listen to an Angry song".
2. You want to look for a song with the title "Mandatory Suicide" from the Angry mood category.
3. Click on any visual texture that you think represents an Angry mood.
4. Look for the song from the list provided. If you can't find it, click on the Home button and try to click on other visual texture.
5. Once you have found the song, click on the Play button ( ) to listen to it.
6. Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
7. When you are ready, rate the suitability of visual elements in the visual texture in **Section B** in the questionnaire.
8. Once you have completed the questionnaire, click on the Home button and go to the Main page.
9. Continue with Task 2.

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A1
Task Sheet
Session 1

Task 2 : Calm mood
1. Read the scenario below: "You survived a dreadful traffic jam and willingly now listen to a Calm song".
2. You want to look for a song with the title "Kiss of Life" from the Calm mood category.
3. Click on any visual texture that you think represents a Calm mood.
4. Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on other visual texture.
5. Once you have found the song, click on the Play button ( ) to listen to it.
6. Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
7. When you are ready, rate the suitability of visual elements in the visual texture in **Section C** in the questionnaire.
8. Once you have completed the questionnaire, click on the Home button and go to the Main page.
9. Continue with Task 3.

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A1
Task Sheet
Session 1

Task 3 : Happy mood
1. Read the scenario below: "You start the week feeling zesty and you want to start if off with a Happy song."
2. You want to look for a song with the title "Two of us" from the Happy mood category.
3. Click on any visual texture that you think represents a Happy mood.
4. Look for the song from the list provided. If you can't find it, click on the Home button and try clicking on other visual texture.
5. Once you have found the song, click on the Play button ( ) to listen to it.
6. Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
7. When you are ready, rate the suitability of visual elements in the visual texture in **Section D** in the questionnaire.
8. Once you have completed the questionnaire, click on the Home button and go to the Main page.
9. Continue with Task 4.

Appendix F: Questionnaire

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B
Task 1

Participant number: PART

SECTION B. TASK 1

This section is to evaluate the suitability of visual elements in the visual texture used to recommend the Angry mood category.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

1.	It is easy to look for the song in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**
2.	The visual texture matched the song that I found in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**
3.	The type of line used in the visual texture matched the song that I found in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**
4.	Type of shape used in the visual texture matched the song that I found in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**
5.	Type of colour used in the visual texture matched the song that I found in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**
6.	The colour value (tone) in the visual texture matched the song that I found in Task 1.	**STRONGLY DISAGREE**	1	2	3	4	5	6	7	**STRONGLY AGREE**

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C
Task 2

Participant number: PART

SECTION C. TASK 2

This section is to evaluate the suitability of visual elements in the visual texture used to recommend the Calm mood category.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

7.	It is easy to look for the song in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
8.	The visual texture matched the song that I found in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
9.	The type of line used in the image matched the song that I found in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
10.	Type of shape used in the image matched the song that I found in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
11.	Type of color used in the image matched the song that I found in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
12.	The color value (tone) in the image matched the song that I found in Task 2.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**

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D
Task 3

Participant number: PART

SECTION D. TASK 3

This section is to evaluate the suitability of visual elements in the visual texture used to recommend the Happy mood category.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

13.	It is easy to look for the song in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
14.	The visual texture matched the song that I found in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
15.	The type of line used in the visual texture matched the song that I found in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
16.	Type of shape used in the visual texture matched the song that I found in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
17.	Type of colour used in the visual texture matched the song that I found in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
18.	The colour value (tone) in the visual texture matched the song that I found in Task 3.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**

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E
Task 4

Participant number: PART

SECTION E. TASK 4

This section is to evaluate the suitability of visual elements in the visual texture used to recommend the Sad mood category.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

19.	It is easy to look for the song in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
20.	The visual texture matched the song that I found in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
21.	The type of line used in the visual texture matched the song that I found in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
22.	Type of shape used in the visual texture matched the song that I found in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
23.	Type of color used in the visual texture matched the song that I found in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
24.	The color value (tone) in the visual texture matched the song that I found in Task 4.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**

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F
Ease of Use

Participant number: PART

SECTION F. Ease of use

This section is to evaluate the ease of use of browsing music according to mood using visual texture.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

25.	Browsing music according to mood by using visual texture is easy.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
26.	Browsing music according to mood by using visual texture is clear and understandable.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
27.	It is easy to become skillful at browsing music according to mood by using visual texture.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
28.	Overall, browsing music using visual texture is easy for me.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**

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G
Satisfaction

Participant number: PART

SECTION G. Satisfaction

This section is to evaluate the satisfaction of browsing music according to mood using visual texture.

Please use the following scale to indicate how much you agree with each statement. Circle your response.

1	2	3	4	5	6	7
Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

29.	I am satisfied using visual texture in browsing music according to mood.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
30.	I would recommend it to a friend.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
31.	Browsing music according to mood using visual texture is fun.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
32.	It works the way I want it to work.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
33.	Browsing music according to mood using visual texture is wonderful.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**
34.	It is pleasant to use visual texture in browsing music according to mood.	**STRONGLY DISAGREE**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**STRONGLY AGREE**

Appendix G: Task Sheets for Session 2

Dear participants,

This is a gentle reminder to ensure that you don't forget to carry out session 2.1. You are required to log in to the music sample application website at www.moodbytexture.com and complete the given task as described in the instructions below.

Note: Please use Internet Explorer or Mozilla Firefox.

Session 2.1	
No.	Instructions:
1	Log in to music application sample using Internet Explorer or Mozilla Firefox. Your login details are as follows: Login : Password :
2	Click on one visual texture.
3	Choose any song from the list and click on the Play button ( ).
4	Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
5	Click on the Home button.
6	Repeat step 2-5 for the remaining visual textures.
8	Log out.

Your time and help is much appreciated.

Warm regards,

Adzira Husain
PhD student,
School of Engineering & Information Technology,
Murdoch University,
Australia.
m : +61 406 114 961

Dear participants,

This is a gentle reminder to ensure that you don't forget to carry out session 2.4. For your information, this is the last session for the experiment. You are required to log in to the music sample application website at http://www.moodbytexture.com and complete the given task. At the end of the session, you will be asked to provide an evaluation on the ease of use and satisfaction of browsing music according to mood using texture image at https://www.surveymonkey.com/s/moodbytexture

Session 2.4	
No.	Instructions:
1	Log in to music application sample using Internet Explorer or Mozilla Firefox. Your login details are as follows: Login : Password :
2	Click on one visual texture.
3	Choose any song from the list and click on the Play button ( ).
4	Listen to the song for at least for 30 seconds. You may also listen to the whole song if you like.
5	Click on the Home button.
6	Repeat step 2-5 for the remaining visual textures.
8	Log out.
9	Click on the link provided to access questionnaire.
10	Evaluate the ease of use of browsing music according to mood using texture image in Section A.
11	Evaluate the satisfaction of browsing music according to mood using texture image in Section B.
12	Submit questionnaire.

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