MUSIC

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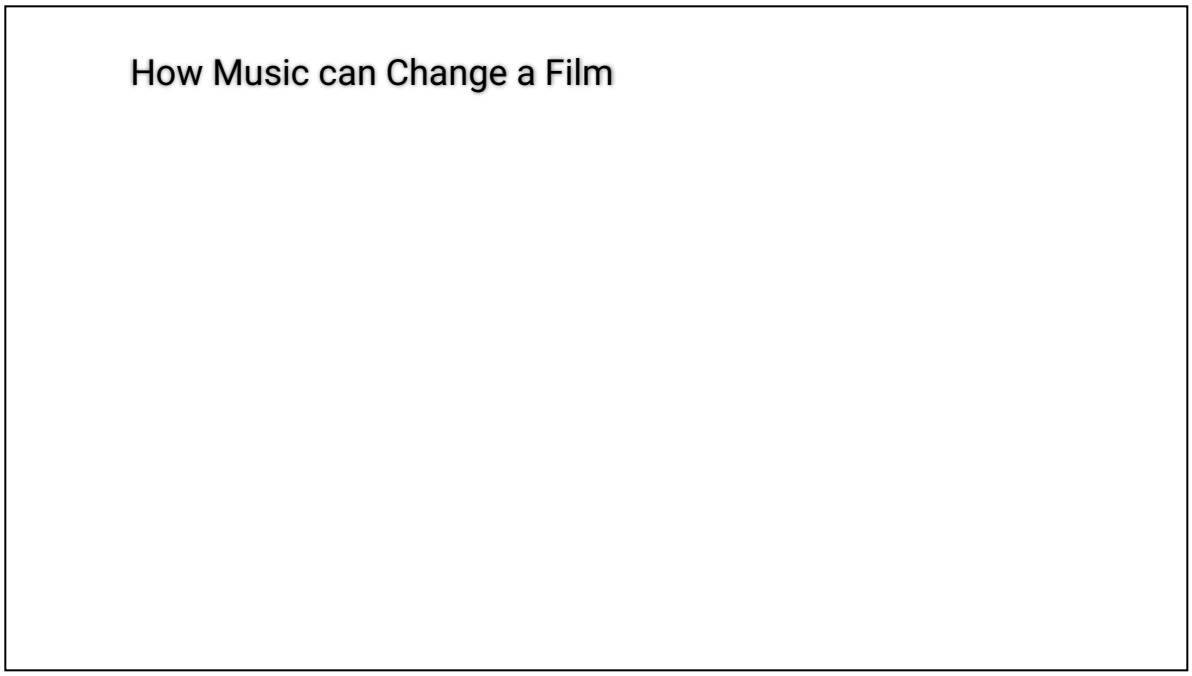
Why is music important for virtual reality?

Virtual reality experiences are dominated by the visual and auditory senses. These two senses are also the senses available to filmmakers in the medium of film. Although virtual reality is a relatively new medium, we can look to how film has used these two senses for emotional effect.

Music is a big component of most film in the form of a soundtrack. Music is so effective at shaping our emotional response to images that it can bias the interpretation of images. Music can affect the emotion, mood and perception of the visual elements of film.

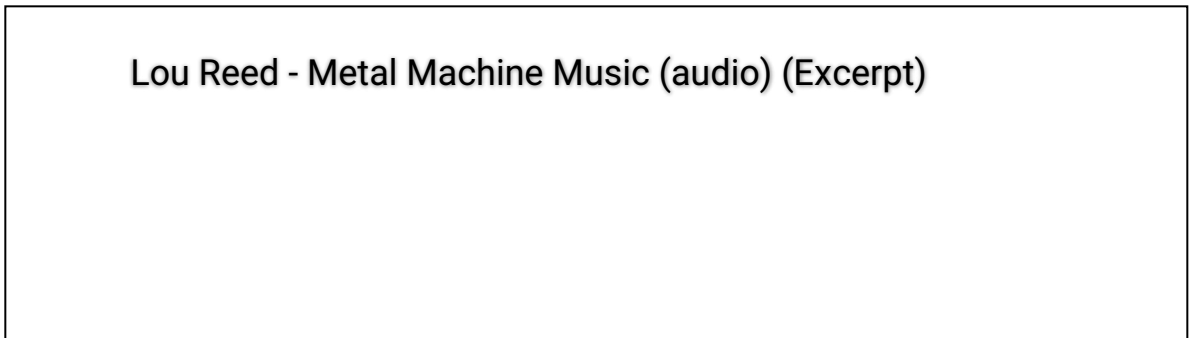
Music in virtual reality provides the same advantage. A virtual reality experience with music is much more likely to affect emotions than one without music.



Example of how music can change the interpretation of a scene: The Pirates of the Caribbean.

About music

Music is difficult to define. Most people would agree that music is an arrangement of sounds in sequence that aspires to beauty and has emotive qualities. However, with the advent of genres such as noise music in the early 20th-century, and differences in style and appreciation across cultures, music continues to evade a universal definition.



An example of noise music: Lou Reed – Metal Machine Music

With that said, we all have a fairly good idea of what music is. For the purposes of this entry, we will think of music as sounds arranged in sequence over time to express artistic intentions.

Music and the mind

Music can evoke emotional responses and studies have shown that it requires complex cognitive processing. Research into music has broadened our understanding of emotion, memory, attention, categorisation and perceptual organisation. Music is therefore a useful window into the way the mind works (Levitin & Tirovolas, 2010).

How the sound of music is perceived

Music is sound with certain attributes. These attributes can be characterised as the elements of:

- Loudness
- Pitch
- Duration
- Timbre
- Rhythm
- Spatial location
- Reverberation

(For more details see the entry on sound.)

Higher concepts of music

Music isn’t just the sounds we hear. It is the patterns that these sounds form and the meaning we associate with these patterns.

Different cultures will have different ways of employing sound to make music. The rules or conventions of music established in one culture can be different to those established in another culture.

In music, sound patterns are organised into meaningful concepts of style or form. Some examples of concepts of style or form include meter, mode, melody and harmony.

Researchers believe the way we process these patterns of music has an important role on the perception, understanding and emotion of music (Levitin & Tirovolas, 2010).

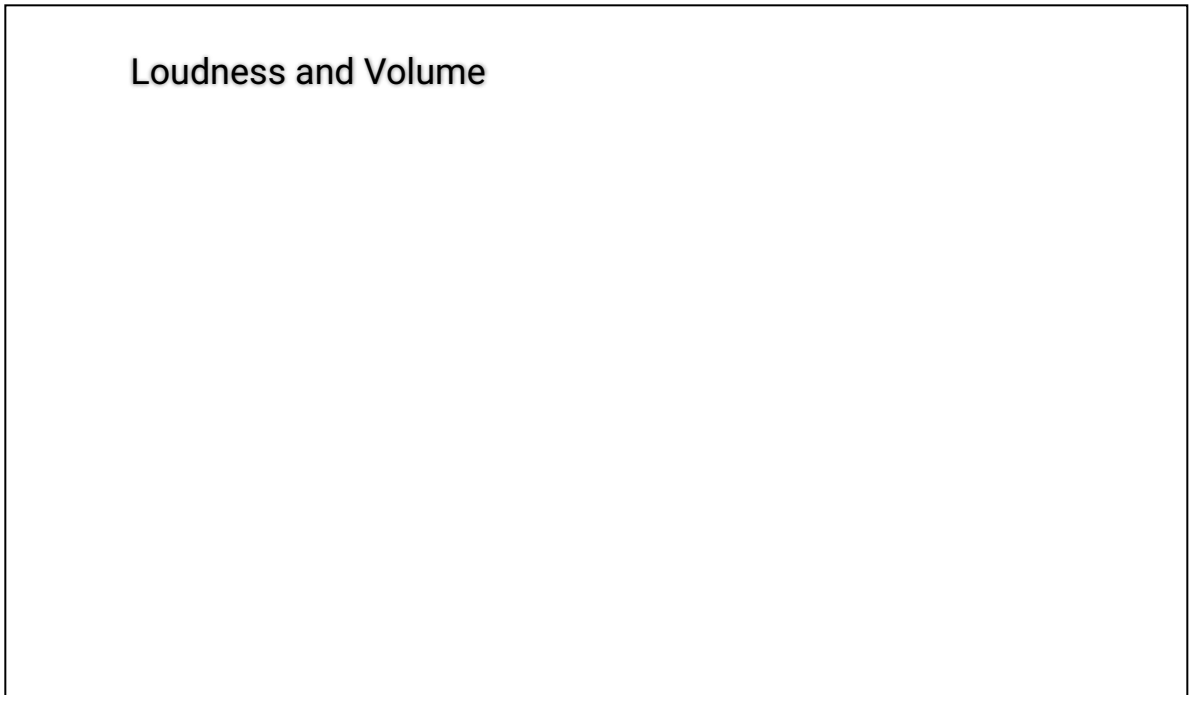
Understanding some key music terms

The elements of music structure that consistently have the most effect on emotion are:

- Loudness
- Tempo
- Rhythm
- Major and minor mode.

Loudness

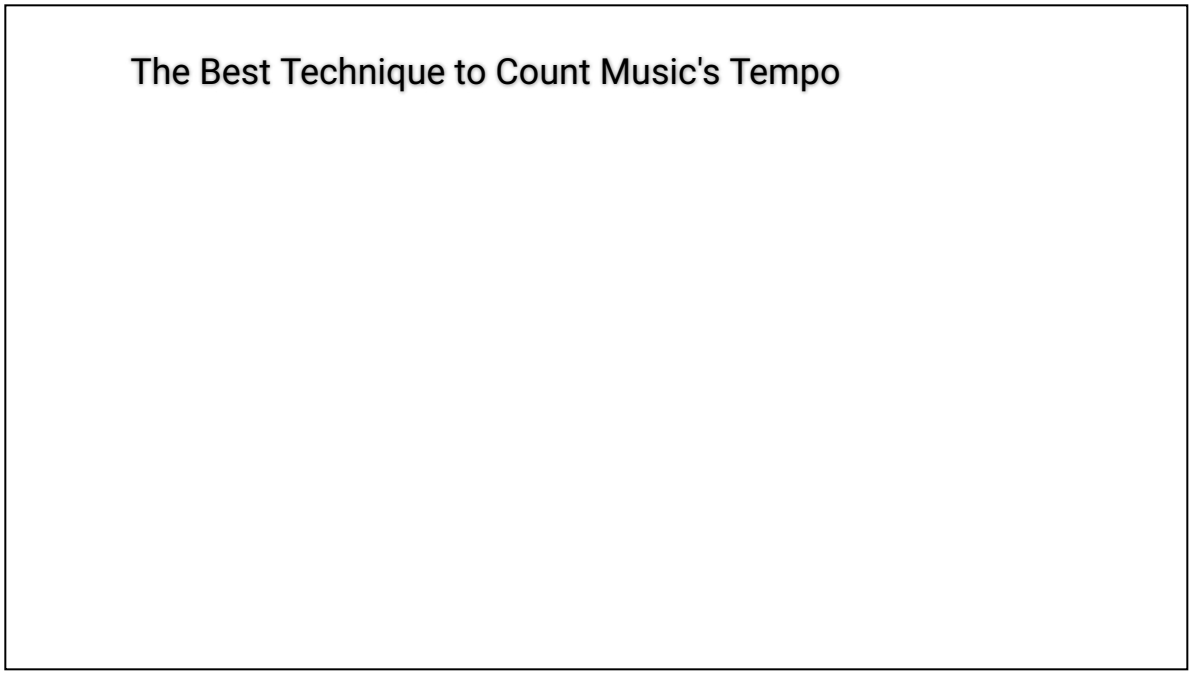
Loudness is the subjective perception of the physical energy of sound. The listener perceives the intensity (amplitude) of the sound energy carried by pressure waves. Loudness refers to how loud or soft music seems to the listener.



Loudness explained

Tempo

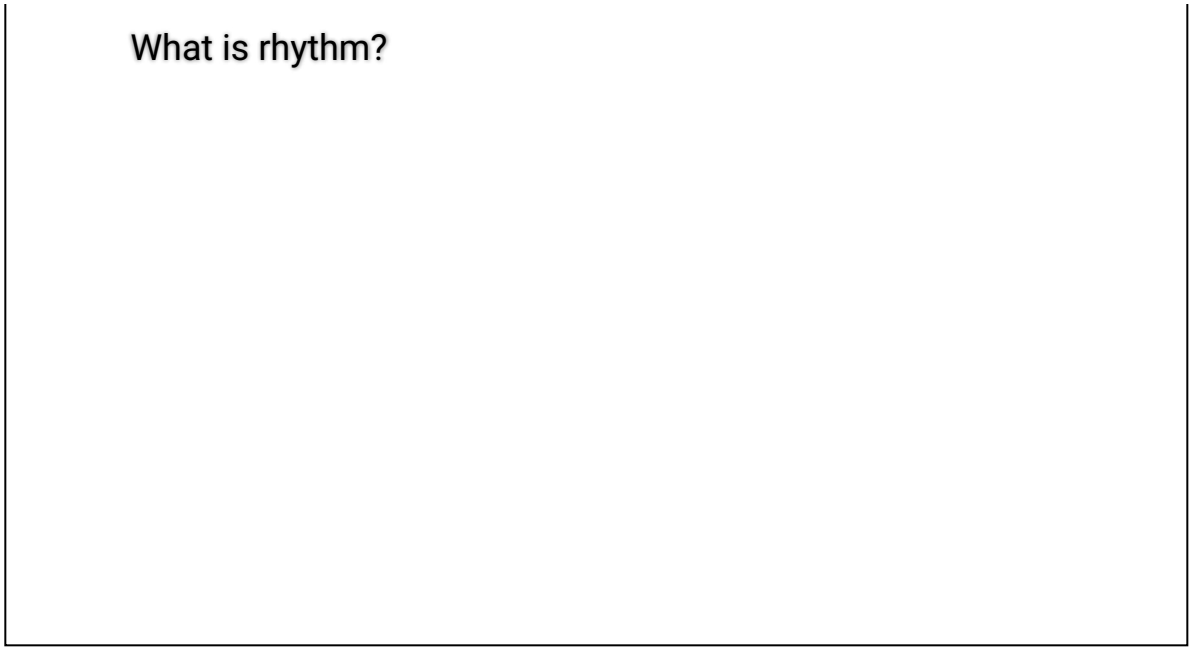
Tempo is the concept of how slow or fast music is played. Tempo can be loosely thought of as how fast you would tap your foot to music.



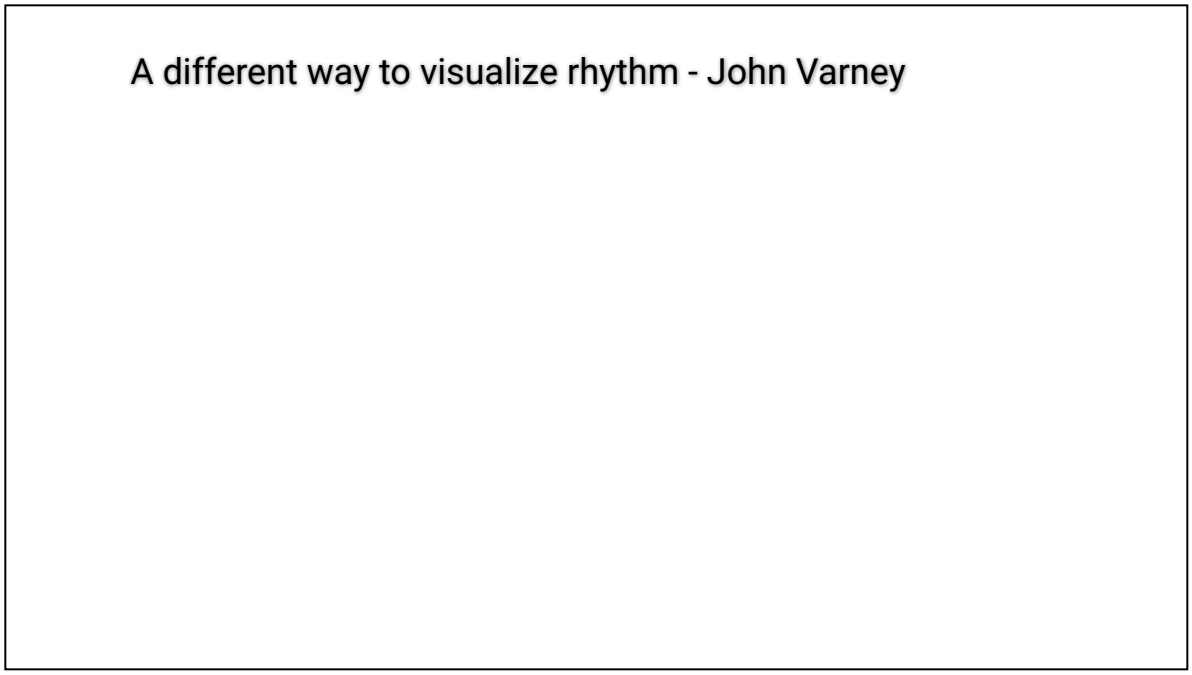
Tempo explained.

Rhythm

Rhythm is the concept of how sounds are arranged over time (in sequence) to create a pattern. The relative duration of the sounds (and silence) determines the pattern. This pattern is the rhythm.



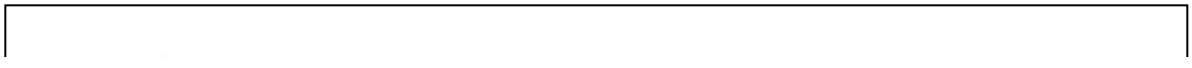
Rhythm explained

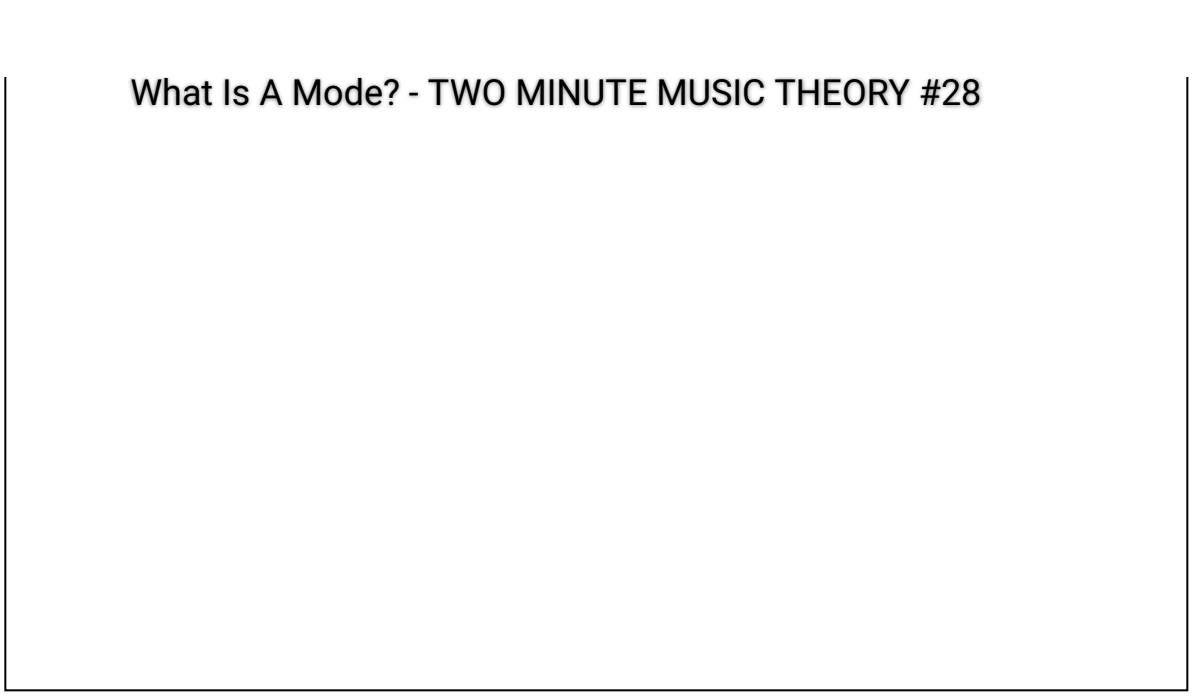


Rhythm visualised.

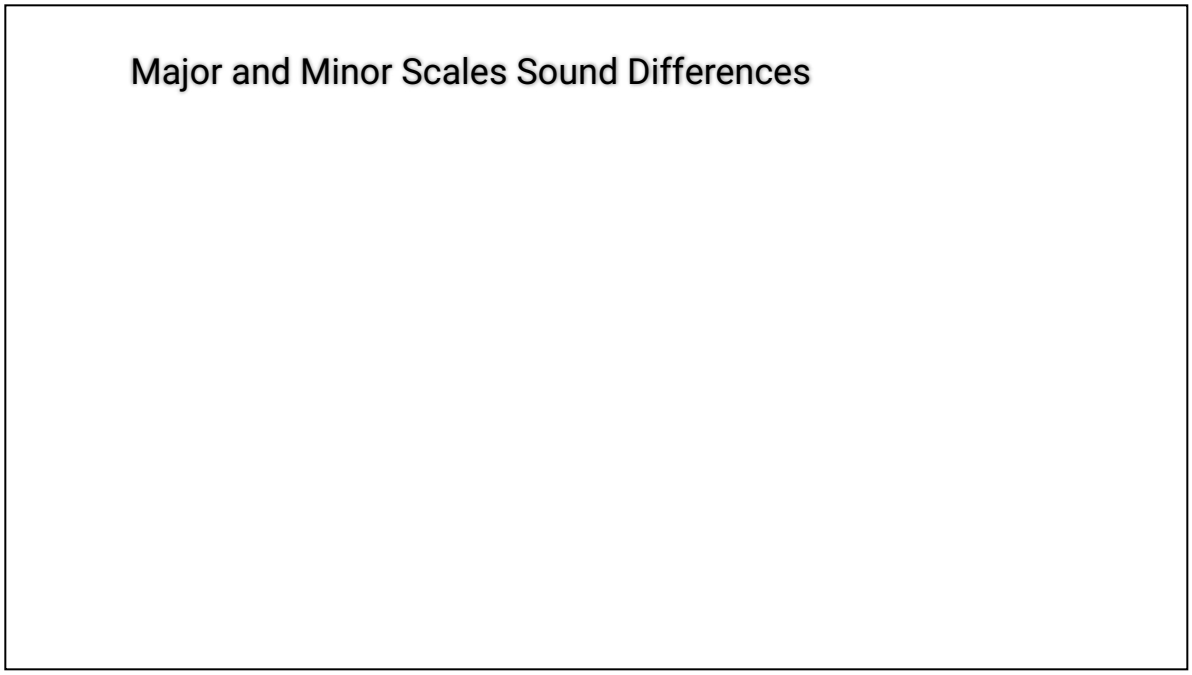
Major and minor mode

The group of pitches that forms the backbone for the composition of a piece of music is called a scale. A mode is determined by beginning and resolving a scale on a different tone within that scale. The video below explains mode in greater detail.





Mode explained.



Examples of major and minor scales.

Music and emotion

Understanding some key emotion-related concepts

Affect

Affect is the general term for positive or negative states that include emotion, mood or preference.

Emotion

An emotion is an affective state that lasts for a few minutes to a few hours, and focuses on a specific object.

Musical emotions

Musical emotions are emotions that have been induced by music.

Mood

A mood is an affective state that is not as intense as an emotion and does not associate with a specific object. Moods tend to last longer than emotions, from a few hours to a few days.

Feeling

A feeling is the experience of a physiological change brought about by an emotional stimulus.

Arousal

Arousal is the physical activation of the autonomic nervous system. Arousal is a component of an emotional response. However, physiological arousal can be experienced during exercise and independent from an emotional response.

Preference

Preference is an affective evaluation. When we 'like' an object or person, this is a preference. Preferences are characterised by long duration and low intensity.

Aesthetic judgement

Aesthetic judgement is a subjective evaluation of music and other art forms.

Aesthetic emotions or everyday emotions?

An aesthetic emotion is the concept that art can evoke an emotion that is special to that engagement with art. This emotion is different to "everyday" emotion that can occur in the absence of art.

Music-specific emotions

Some researchers have claimed that there are aesthetic emotions specific to music. They argue that music can evoke feelings such as wonder, nostalgia, tenderness and tension.

However, these emotions can occur in an everyday context in the absence of music.

It is therefore unlikely that there are emotions specific to a music, or that emotions can be categorised as either aesthetic or everyday.

Juslin (2015) argues that aesthetic emotions refer to everyday emotions that are induced by the aesthetic properties of art. A person may experience an everyday emotion, yet it is caused by the specific circumstance of engaging with art and, in this context, can be called an aesthetic emotion.

Music-specific emotions and the listening setting

The setting in which a person listens to music can impact on what emotions they experience, or whether they experience emotion at all.

Juslin et al. (2008) explored how common some specific emotions occurred during everyday situations over a two-week period.

Researchers took note of the social setting (spending time with friends listening to music, or alone listening to music) and included settings that didn't include listening to music.

They found that the emotions of happiness and nostalgia happened most frequently when listening to music. The emotions of anger, anxiety and boredom were more commonly experienced in non-musical occasions.

Different settings were found to affect emotions which were most commonly experienced. The emotions of calm, sadness and nostalgia occurred more frequently when people were alone. In social settings, pleasure, anger and happiness were the emotions that occurred more frequently.

Relative frequency of felt emotions for non-musical emotion episodes (dark bars) and musical emotion episodes (striped bars) during a two-week period as indexed by experience sampling in everyday life. (Juslin et al., 2008)

Music, musical properties and emotion

Loudness, tempo, pitch, and emotion

Ilie and Thompson (2006) investigated how the different acoustic cues of intensity, rate and frequency affected emotion. (These acoustic cues are perceived by humans as loudness, tempo and pitch.)

Music of different intensity, rate and frequency was played to participants. Participants judged the different music according to three perceived qualities:

1. How pleasant or unpleasant (valence).
2. How awake or tired (energy).
3. How tense or relaxed (tension).

Participants rated:

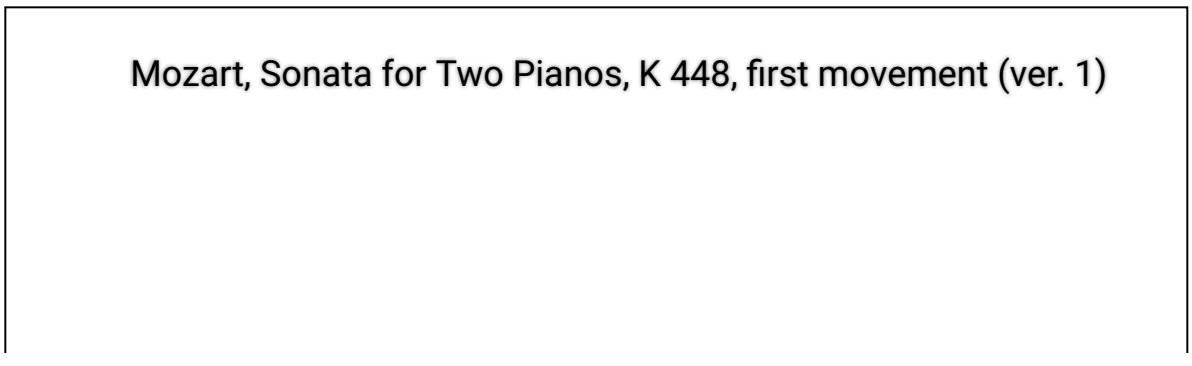
- loud music as more pleasant, energetic and tense than soft music
- fast music as more energetic and more tense than slow music
- low-pitched music as more pleasant than high-pitched music.

Significant main effects of intensity, rate, pitch height on valence, energy arousal, and tension arousal for music and speech.

For Liminal's Ion experience, the elements of loudness and tempo are used to energise users. As each phase of the experience transitions to a new one, the music increases in tempo and loudness.

Tempo, mode, and emotion

Husain et al. (2002) used different versions of a Mozart sonata to test how tempo and mode affected mood, arousal and spatial ability.



Mozart music used in the experiment.

Participants listened to a variation of the sonata (versions were varied by tempo and mode) and were then asked to rate their feelings.

Variations in the sonata tempo showed that:

- fast tempo increased arousal
- slow tempo decreased arousal.

Variations in the sonata mode showed that:

- major mode caused a positive shift in mood
- minor mode caused a negative shift in mood.

Researchers noted that different combinations had different effects on enjoyment. The combination of a fast tempo played in a major mode caused a much higher enjoyment rating. The combination of a slow tempo played in a minor mode correlated with a slight increase in enjoyment.

Liminal's Ion experience uses the combination of fast tempo and major mode. This combination aims to increase user enjoyment and to assist a positive shift in mood.

Music, colour and emotion

Munsell's colour system

Munsell's colour system provides a representation of the colour spectrum. The system arranges colours in a 3-D space using the three chromatic dimensions of:

1. Hue
2. Chroma
3. Value

Hue

The hue dimension is represented as a series of horizontal layers in the 3-D colour space. Each layer is divided into five principal hues:

1. Red
2. Yellow
3. Green
4. Blue
5. Purple

With further division into five intermediate hues (located halfway between adjacent principal hues):

1. Red-yellow
2. Yellow-green
3. Green-blue
4. Blue-purple
5. Purple-red.

Chroma

The chroma dimension represents the purity of a colour, and is related to saturation. Lower chromas represent less pure and more washed colours, such as pastel colours.

The chroma dimension is measured radially from the vertical axis of the solid.

Value

The value dimension represents the lightness of a colour and varies along the vertical axis of the colour solid. Value ranges from black at the bottom to white at the top, with neutral greys in between.

Diagram of the Munsell Colour System. (Jacob Rus © 2007)

3-D colour space. (Michael Horvath © 2009)

Music and colour

There is a relationship between the characteristics of music and the characteristics of colour. The Munsell colour system divides colour into measurable characteristics of hue, chroma (measured by saturation) and value (measured by lightness). These characteristics allowed researchers to test associations with the characteristics of music, such as tempo, mode and pitch.

Music associations with colour

One strong association that has been shown is colour lightness with music pitch.

Lighter shades of yellow and green were associated with higher pitches, darker shades of blue and violet were associated with lower pitches, while intermediate shades of the colours red and orange were associated with mid-level pitches (Palmer et al., 2013).

There is also evidence of other associations between music timbre and colour saturation, and between music loudness and colour brightness.

Additional evidence suggests that music played in a major mode is associated with lighter colours, while music played in a minor mode is associated with darker colours.

Emotional mediation hypothesis

This hypothesis suggests that there are shared emotions that certain music and a certain colour will evoke. When people hear music, they have an emotional response. Also, when people see colours, they have an emotional response. If people are asked to choose colours they associate with a sample of music, they tend to choose colours that are known to evoke a similar emotional response to the music, and vice versa.

Because we can map the emotions people associate with types of music, and because we can map the emotions people associate with types of colours, we can see in a diagram which emotions certain music and colour share.

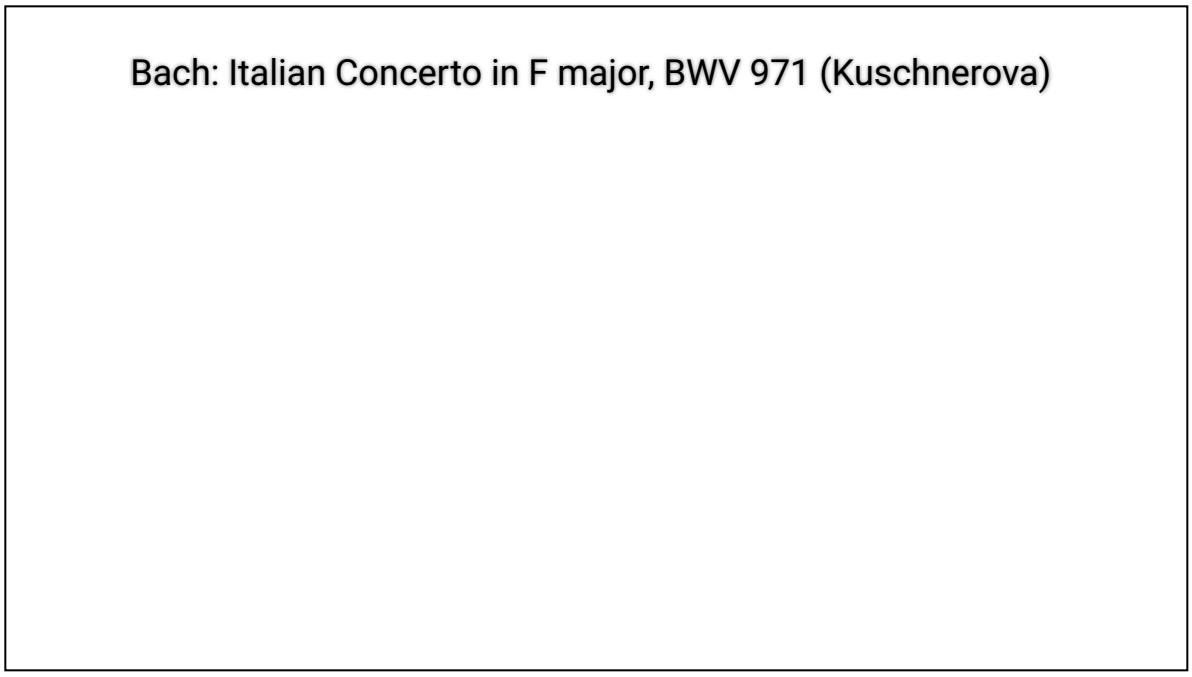
Charts showing emotions shared by certain colours and music.

Music–colour associations

Palmer et al. (2013) tested the emotional mediation hypothesis.

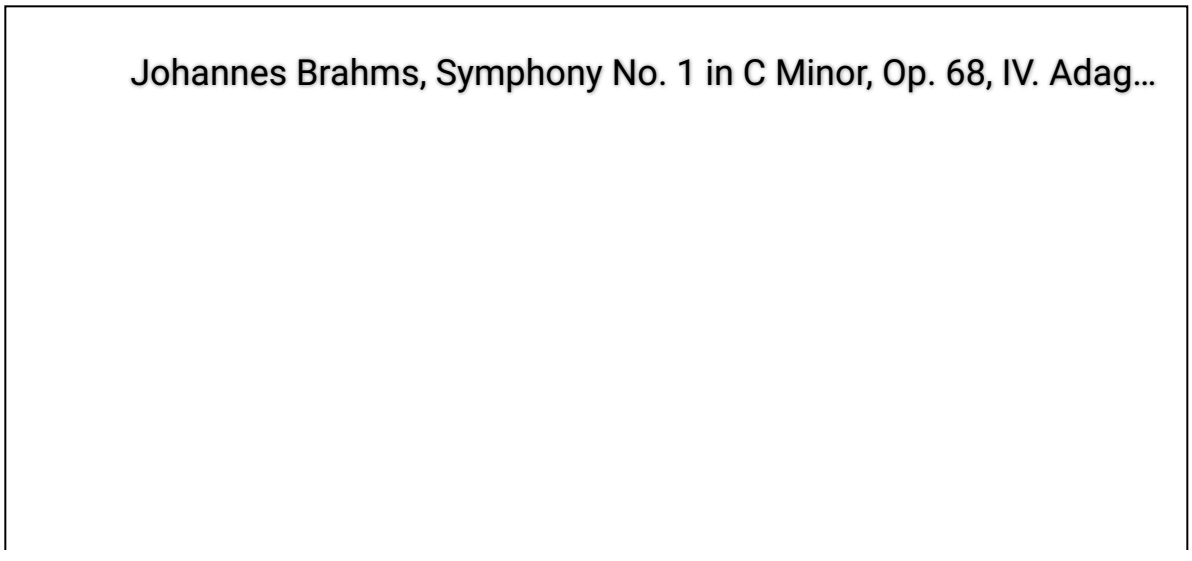
Participants were asked to associate colours, and then music pieces, with a list of emotions provided by researchers. Then, participants listened to music pieces by Bach, Mozart and Brahms that varied in tempo and mode. While listening to the music, participants viewed a chart of 37 colours. They were then asked to choose the colours that most closely matched the music.

A fast-paced piece of music in F-major key by Bach conveyed happy and energetic emotions. These happy and energetic emotions were the same emotions associated with happy and energetic colours, such as saturated light yellows.



The F-major Bach piece used in the experiment.

In contrast, a slow-paced piece of music in C-minor by Brahms conveyed sad emotions. These sad emotions were the same emotions associated with sad and depressed colours, such as black and dark grey.



The C-minor Brahms piece used in the experiment.

Overall, results showed that fast and major mode music was associated with colours that were:

- Saturated
- Lighter
- Yellower

Slow and minor mode music was associated with colours that were:

- Desaturated
- Darker
- Bluer

Liminal's Ion experience increasingly uses saturated, light yellow colours as the experience progresses. This increase complements a transition of the major mode music to a fast tempo. This is designed to enhance the emotional effect of the experience by way of music–colour associations of happy and energetic emotions.

Music, physiology and emotion

Not only can music elicit emotional reactions; it can also elicit physiological changes.

Gomez and Danuser (2007) observed that musical features of fast tempo and staccato rhythm produced intensely positive emotions and correlated with increases in respiration and heart rate.

One possibility for the cause of physiological changes produced by musical features is that music synchronises, or entrains, some physiological functions.

Bernardi et al. (2005) observed that musical rhythm can have a modulatory effect on heart and respiration rate. These effects were observed across participants regardless of musical preference and with few differences in effect resulting from musical training.

Liminal's Ion experience uses fast-tempo staccato music to increase respiration and heart rate with the aim of inducing positive emotions.

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