The Emotional Link Between Color and Music

Information Visualization Class, Spring 2023

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1. Links

Website: https://nithinnadig1997.wixsite.com/emotioncolorandmusic

- Video recording of the website

Observable links:

- Scatterplot
- Animated/Interactive bar chart
- Radar charts
    - Tonal Joyful music: E1-E4
    - Tonal Sad music: E5-E8
    - Atonal Joyful music: E9-E12
    - Atonal Sad music: E13-E16

2. Project Goals

The way we experience the world is highly influenced by our perception. We are interested in focusing on a few aspects of human perception: color, music and emotion, to learn how diverse or similar these aspects are, and how they influence each other. The broad goal of our visualization is to show the perspective of the data while bringing up intriguing questions about diversity of human perception and self reflection. More specifically, our goals for this project are:

A. **Engaging introduction and learning:**
   Learn about the relationship between color and music, particularly how certain music can evoke specific emotions or connections to colors. Introduction to the fundamental terms and measurement scales that one needs to know to evaluate emotion, color perception and emotional perception of music.

B. Presenting the data:
Show how people perceive color and music through analyzing existing data sets to identify patterns and correlations between color, music, and emotions:
- How people link color to emotions.
- How people link different music to colors.
- How people link music and color to emotions.

C. Exploring the data:
Intrigue thinking about diversity in human perception through exploring the data in the visualization, gaining insights and reflecting on one's own perception.

3. Related Work

The broad motivation of this work is to explore effects on the variations of human perception, and specifically: color perception, music perception and its link through the emotions they evoke. Vision and color perception is widely used across nature for communicating information such as social cues, attraction, warning, camouflage and more. Research in this area shows that multiple variables affect color perception of an individual human. These variables go beyond evolution of genetics and physical traits and include natural environments (Josserand et al., 2021), culture and language (Kay et al., 2009). In 1969 Berlin and Kay created the World Color Survey (Berlin and Kay, 1969) which surveyed color perception among different cultures and spoken languages and showed that there is a relationship between the two. They proved that the human cultural and physical environment can influence color perception. This topic is widely studied and explored throughout the history of humanity, yet still remains subjective and influenced by diversity and changing dynamics of human perception. We are interested in using this tension between the data and results from the study (Valdés-Alemán et al., 2022) and its highly-subjective nature, to trigger thought-provoking questions about commonalities, diversity, and uniqueness of human perception.

The study that produced the dataset we used from Valdés-Alemán et al. draws heavily on color theories produced from Palmer's et al.'s 2013 study on how emotion mediates music and color associations. In this study, Palmer et

al. used a color scale called the Berkeley Color Project, which they developed in previous studies (Palmer & Schloss, 2010). The Berkeley Color Project published a 37 color scale to measure people's color preferences (Palmer & Schloss, 2010) and associations with colors (Schloss et al., 2011). Valdés-Alemán used the 37 colors from the Berkeley Color Project to measure participants' associations with music. In addition to using data based on this color system to create our visualizations, we also used this color system throughout our entire website. All of our visualizations use the colors provided in the Berkeley Color Projects's 37 colors. We also refer to the different colors in our visualizations according to the organization and naming convention provided in the Berkeley Color Project (Palmer & Schloss, 2010).
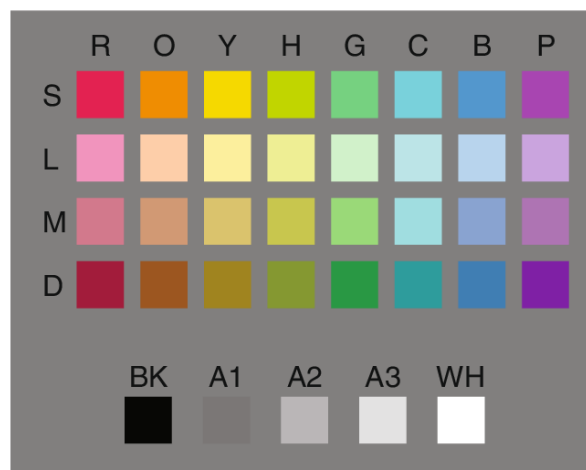

Figure from Schloss et al. (2018)

We wanted to include the relationship between music and emotion, specifically the idea that certain colors can be associated with specific musical emotions. Barbiere, Vidal, and Zellner (2007) conducted a study that found that participants consistently associated certain colors with specific musical emotions, such as red with anger and blue with sadness. Similarly, Lindborg and Friberg (2015) used a CIE Lab interface to test the relationship between color and music and found that participants' associations between color and emotion were consistent across different musical genres. Zentner, Grandjean, and Scherer (2008) take a more comprehensive approach to the emotional impact of music, characterizing and classifying the emotions that can be evoked by music and offering a measurement tool to quantify emotional responses. The paper highlights the importance of music in eliciting a range of emotional responses and its potential for use in therapeutic contexts. Our study "The Emotional Link Between Color and Music: What Happens With

Atonal Music?" by Valdés-Alemán, Zamudio-Gurrola, and Téllez-Alanís (2021) builds on this existing research by specifically exploring the relationship between atonal music and color associations. The study found that participants were still able to associate colors with the emotional content of atonal music, despite its lack of tonality or traditional musical structure. This suggests that the emotional impact of music may not be solely based on its tonality or musical structure, but rather on the emotions that the music is able to elicit. Overall, the existing research on the relationship between color and music provided us with a compelling motivation for the study of the emotional link between atonal music and color. By exploring the emotional impact of atonal music, this study contributes to a broader understanding of the relationship between music and emotion and may have implications for therapeutic contexts or artistic expression.

4. Visualization Explanations

- [Video recording](#) of website

1. **Narrative design**
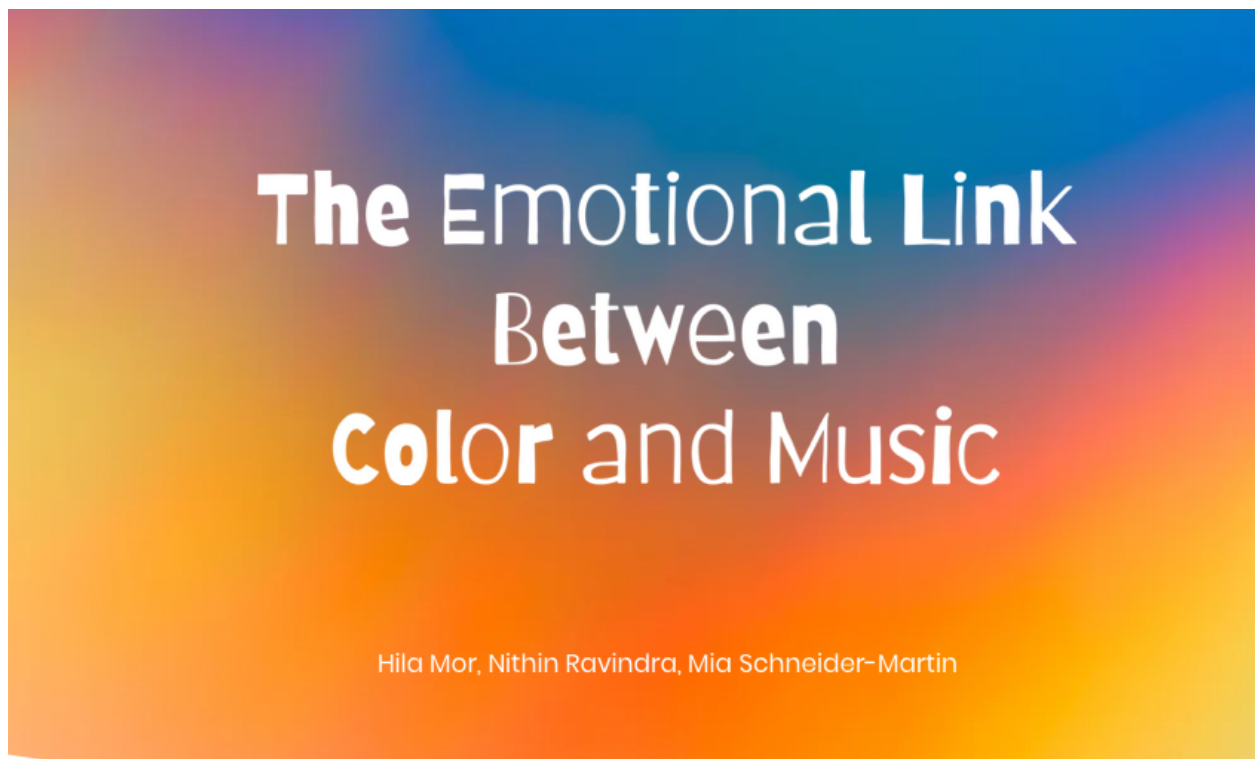
To create a uniform design that supports the context of the narrative, we faced the challenge of using multiple colors from all parts of the palette, since our data maps to these colors. We decided to use a color-palette that is changing through the website and using the actual light-shade colors and dark colors to create a consistent narrative throughout. We used a colorful background for the main title, and from then onwards we used background color, title and text colors that change in hue along the color scale (from reds all the way to purples).

2. Setting the context

How does a walk in a lush green forest make you feel?
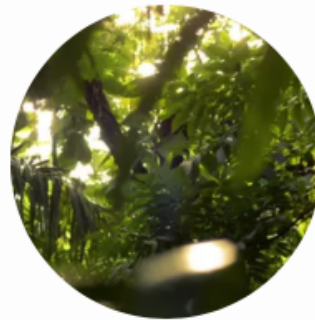
How about a dip in the clear blue ocean on a sunny day?

How does waking up to a white snowy morning make you feel?

How does this music make you feel?
Which would you play in each of the previous scenarios?

Symphony no. 39 / W. A. Mozart

Edo Lullaby Kotos / Bells, Biw...

We created a section with colorful videos and music accompanied with questions to get users engaged and curious. We wanted them to start imagining, and think more generally about what color and music mean for them in their life.

3. Introduction

Music and color have the power to evoke emotions in us.

So how are our emotions affected by the type of music we listen to?

What kind of emotion does each color evoke?

A brief introduction: color, music, emotions

This visualization is based on a study of human perception and the link between color and music and the emotions they evoke. But how can one measure the relationship between color, music or emotion? We will start with a brief introduction to the fundamental variables we need to think about when we come to understand our perception of color, music and emotions.

Music and color have the power to evoke emotions in us. Before getting to the data, we wanted to introduce the ways in which we measure the fundamental elements we are working with: color, emotion, and music. How these are both explained and evaluated in the research.

4. Color

First, we introduce color and its division by categories in the way it is evaluated in the paper. This is important because the categories are not 'obvious' across cultures and some users might not think that chartreuse could be a color on its own for example.

5. Music

Music

To learn about peoples' perception of music, researchers picked 16 songs from 2 different musical systems (tonal and atonal), a variety of cultures, and tempos.

Tonal Music is music that is composed around a tonal center, has major-minor chords, traditional harmonies, and sounds more uniform.

Atonal Music is music that lacks tonal center, major-minor chords, traditional harmonies and sounds more chaotic.

Example of tonal music

W. A. Mozart, concierto para ...

▶ ·

Example of atonal music

Bartok Concerto for Orchestra...

▶ ·

To evaluate how people's emotions relate to the music, the researchers analyzed the survey through looking at measures of musical **familiarity** and musical **pleasure**.

Musical Familiarity
To measure familiarity, participants were asked to rank 'how close is the music to music you usually listen to? on a scale of 1-100.
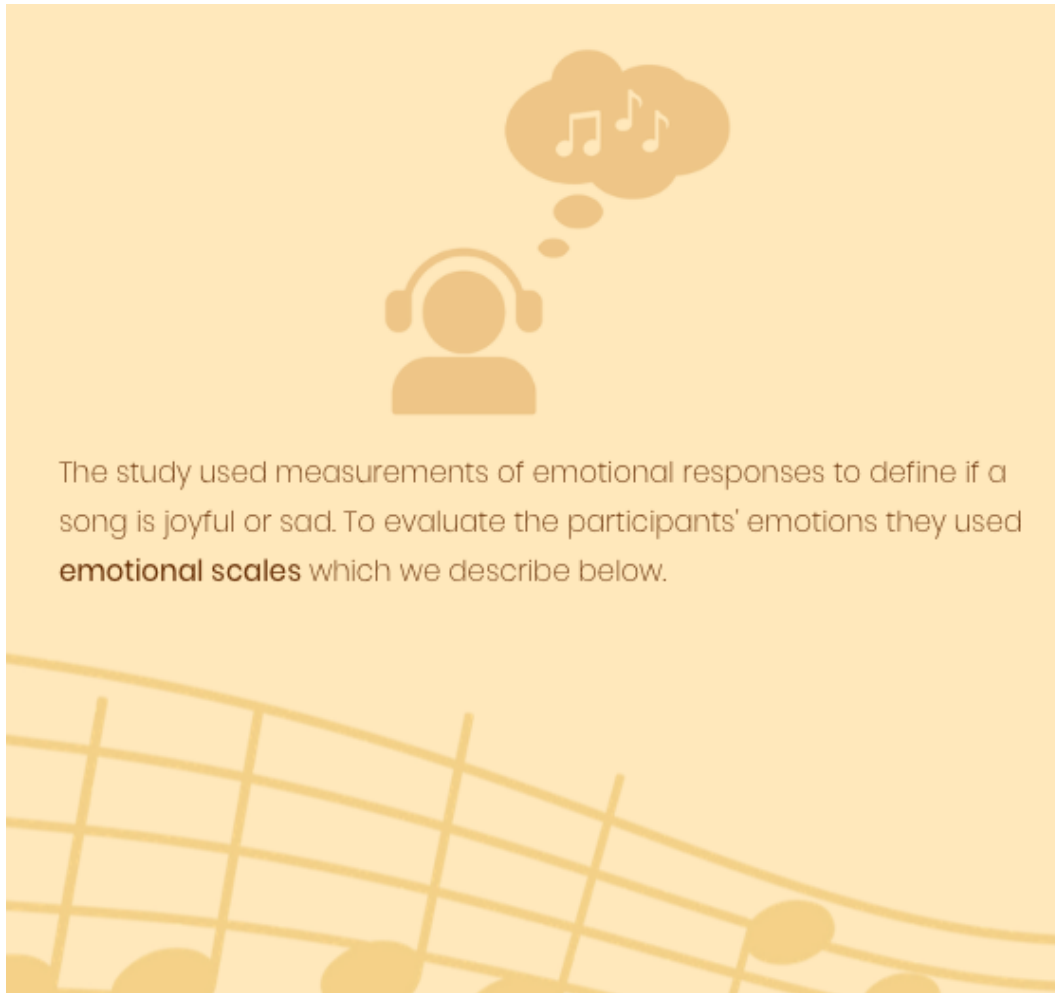
Musical pleasure
To evaluate pleasure participants were asked to rank 'how pleasant is this music?' on a scale of 1-100.

Next we introduce the two types of music and the parameters that are used to evaluate if a music is familiar and evokes pleasure. We use this part to transition to

emotional scales that are also used to evaluate music. Throughout this section, it was important for us to make clear that we introduce this information as part of introducing the study because the way of evaluating such a subjective topic is very important for putting the data in context.


The study used measurements of emotional responses to define if a song is joyful or sad. To evaluate the participants' emotions they used **emotional scales** which we describe below.

6. **Emotion**

Emotions

Based on Russel et al.'s multidimensional emotional scale, emotions can be measured by two dimensions: valence, and arousal.

Emotional Valence

Describes the extent to which an emotion is positive or negative.

Negative emotions ⟷ Positive emotions
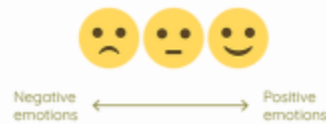
Emotional Arousal

Arousal refers to the intensity of valence, the strength of the associated emotional state.

Arousal

100%

50%

0%

Valence − ⟷ Valence +

Multidimensional Emotional Scale

To understand music's association with emotions, we combine arousal and valence into a single multidimensional scale. In this scale, positive valence and arousal refer to **joyful music**; and negative valence and arousal refer to **sad music**.

Joyful Music

Arousal

100%

50%

0%

Sad Music

Valence − ⟷ Valence +

Just like the section of colors and music, here we share the basics of various dimensions of emotions. We first define valence, then arousal, then describe

multidimensional emotional scale where the result of aggregation of arousal and valence would give us emotions like sad and joyful.

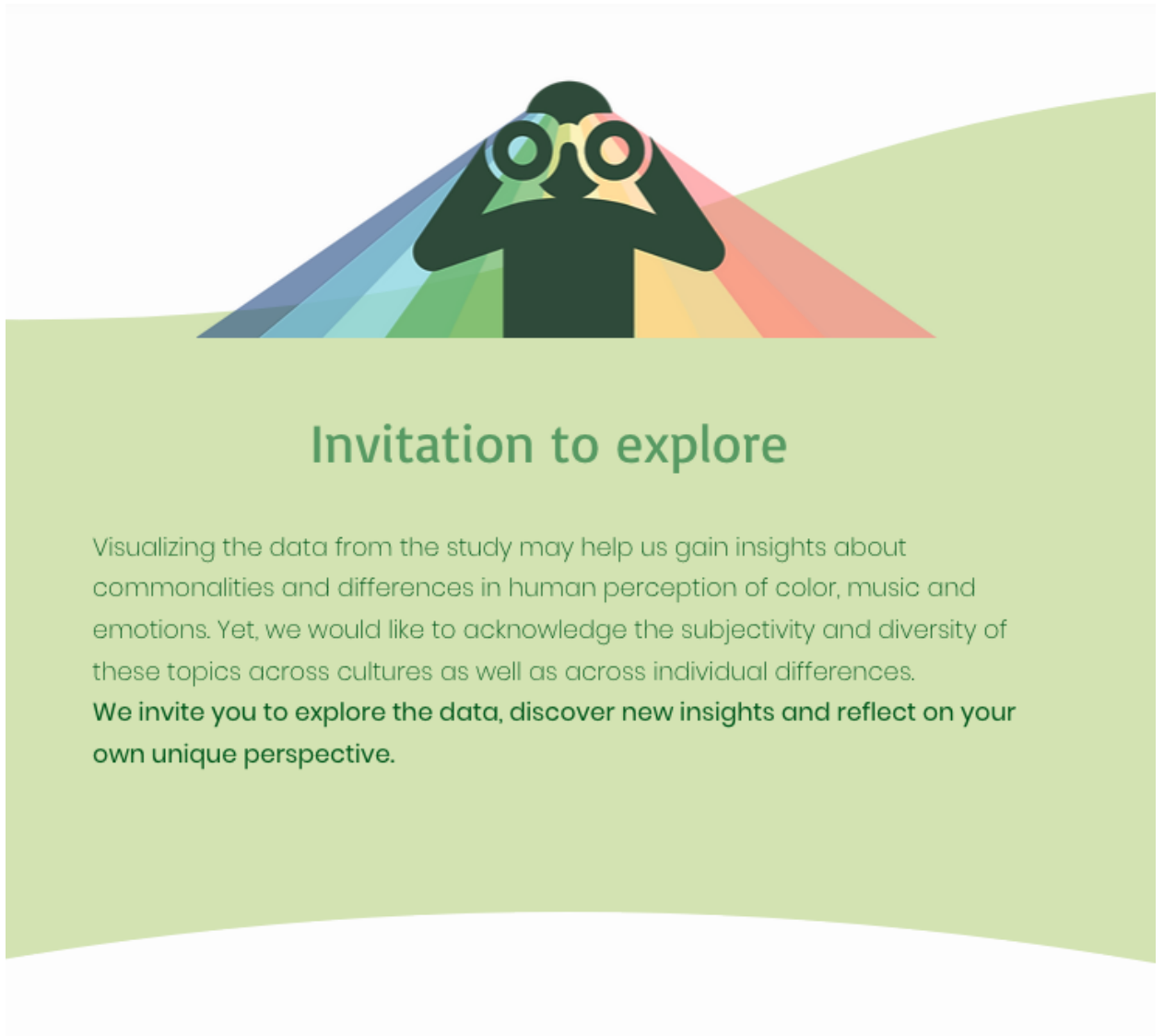### 7. Linking the dots...

Linking the dots...

To visualize the emotional link of color and music, we use the data from the Valdés-Alemán, Zamudio-Gurrola & Téllez-Alanís (2022) study that surveyed 60 participants, using 37 colors and 16 musical tracks to measure their perception of music and color and how that relates to their emotions.

To show this relationship, we visualize the data in three parts:

Linking color and emotions	Linking music and color	Linking emotions to color and music
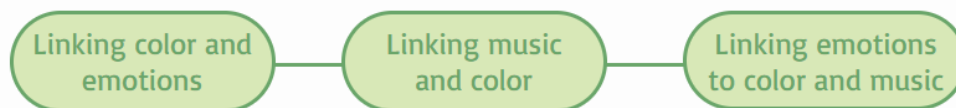
Now that the basics of all 3 (color, music, emotion) are understood, we then start to draw connections between these 3. We gave a brief explanation of the research that was conducted from which we got the data. Then we laid out the three different approaches we take to make everyone understand the relationship between color, music, and emotion.

8. Invitation to explore

Invitation to explore

Visualizing the data from the study may help us gain insights about commonalities and differences in human perception of color, music and emotions. Yet, we would like to acknowledge the subjectivity and diversity of these topics across cultures as well as across individual differences.
We invite you to explore the data, discover new insights and reflect on your own unique perspective.

Here, we want to create an invitation for the user to explore the website through observing and playing with visualization. We wanted to encourage reflection and acknowledge the diversity in human experience.

9. Linking color to emotion

Linking Color to Emotion

Emotions Evoked by Colors

In the study, participants were asked to rank each color by the emotional **valence:** are the emotions positive or negative? And by the emotional **arousal:** how intense are the emotions?

The scatterplot shows distribution of the 37 colors on the emotional scale of valence and arousal.

To explore the data, click the legend and filter the colors by categories: Can you find the most extreme and negative positive emotions? Do you see similarities and difference across color categories? Which colors stand out and evoke different emotions than the other colors within each category?

As mentioned above, we are maintaining a fluid color theme which gradually changes throughout the website. This is the correlation which is 'Linking color to emotion'. We are maintaining a common context theme throughout our visualizations. First we start with the name of the viz, followed by a brief introduction on the topic, then about the visualization. Finally, the way they should explore for maximum potential, accompanied by few thought provoking questions which users can analyze in the visualization.

Here, we are working on 'emotions evoked by colors', we briefly talked about how the data was collected giving information on participants and data collection method. We then mentioned a fact that is related to the visualization. Finally, we are giving some basic information about navigation through the chart followed by thought provoking questions which would help users make use of visualization's full potential.
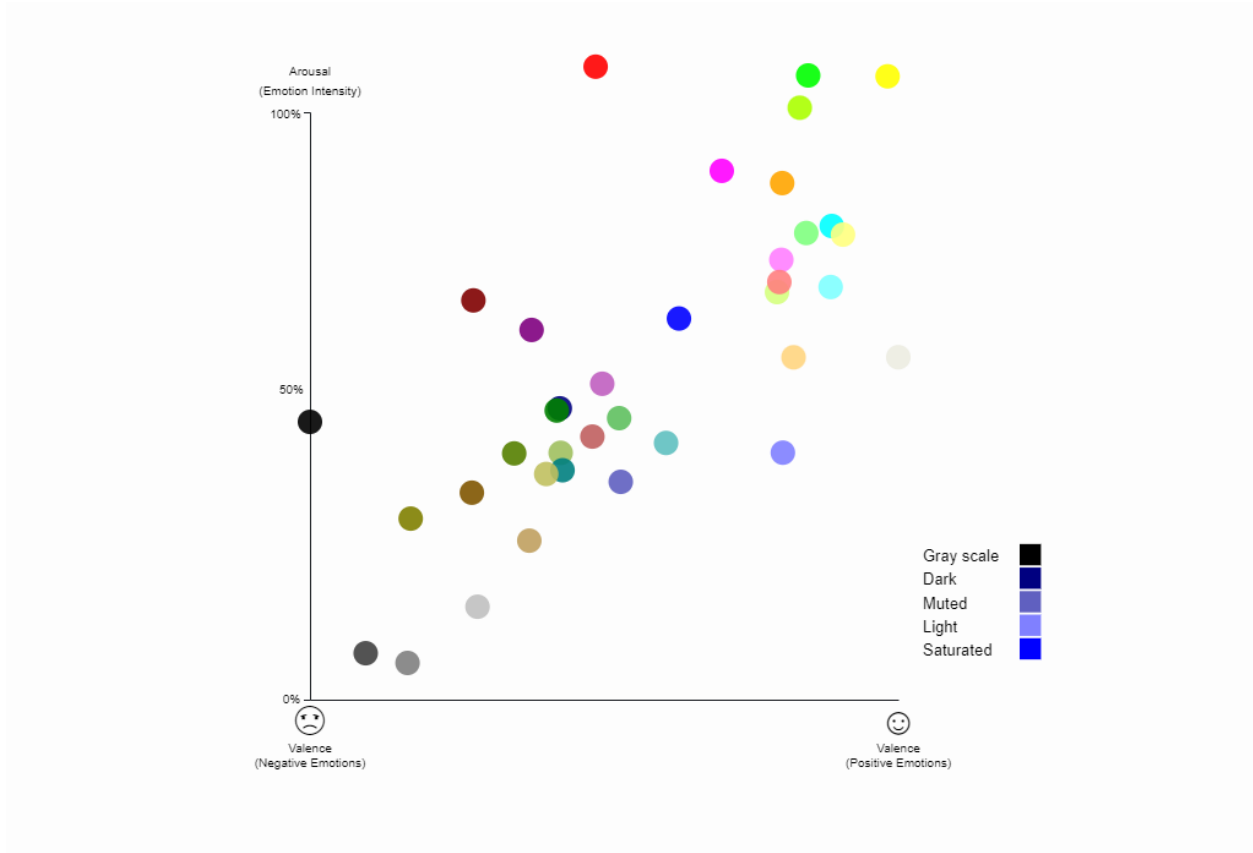
We used the scatterplot to overlay the color associations on the multidimensional emotional space. The Emotional space as described in the literature(as well as in the introduction of the website), is constructed by valence (emotional scale from positive emotions to negative emotions) and arousal (intensity of those emotions that ranges from 0% to 100%). To allow users to explore the meaning of the color-emotion association in the context of the color categories, we created an interactive legend to filter by color category. We also added a tooltip when hovering the colors so that it will be more accessible for color blind, or for people with different color perception.

- The colors correlated with **highest intensity of positive emotions** are within the **saturated** and **light** categories.
- Among the saturated colors, **yellow and green** represent the **most positive emotions**.
- **Saturated red** is an exception, since it represents the **highest emotional intensity**, yet the **least positive emotions** among the category. **Saturated blue** is also an exception since it is **lower in intensity** and relatively more **negative** among the category.
- **Dark and muted colors** represent **less intense** emotions that tend to be more negative or neutral.
- Grayscale colors part into three, black and white - which represent two edges of emotional valence, **white is on the most positive side** and **black is on the most negative side**. Gray colors represent negative emotions however with less intensity than black and white.

At the end of every visualization, we are adding a few insights which users can get from analyzing the visualization. The main reason for adding this is to provoke the user to understand the visualization in case they just skimmed through it.

10. Linking Music to Emotion

Linking Music to Color

Music Categories

The music in the study includes **x16 tracks** from two music categories, **x8 tonal music** tracks and **x8 atonal music** tracks. Half of which are **joyful music**, and half are **sad music**.

Which Colors are Associated with the Music?

Music and color are often intertwined in our minds. In the study, participants were asked to listen to the music and pick the colors that most represented the music for them. Results showed that each piece of music evoked a unique set of colors.
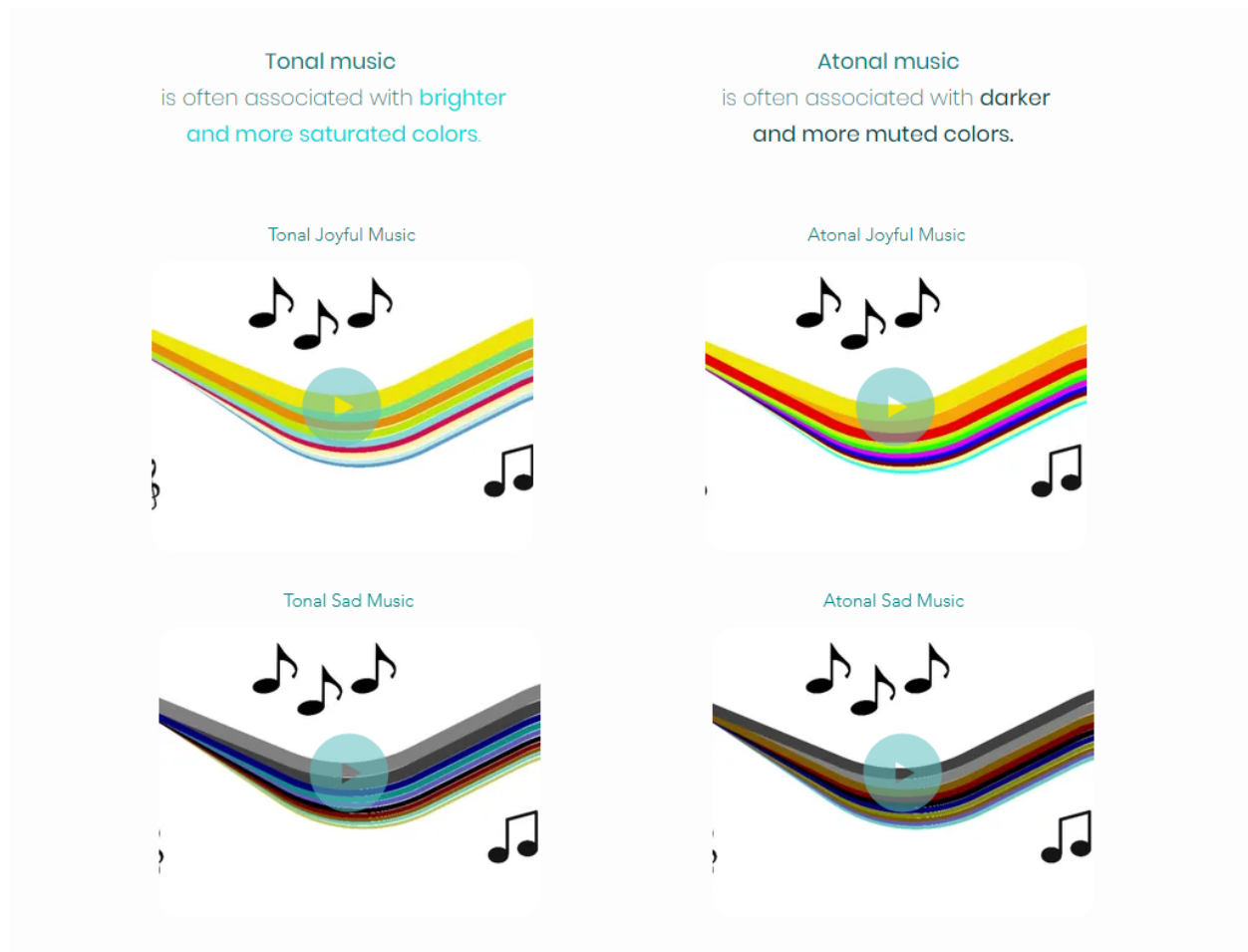
This video visualization portrays the 10 most representative colors for each of the music categories. The thickness of each band on the chart represents the number of people who chose that color; the greater the thickness, the more people chose that color.

Listen to each type of music while observing the associated colors. Reflect what colors you associate with each piece of music.

Similar to the previous section, we follow the same template of flow of information. At the beginning we have an introduction talking about the research experiment that was conducted, below which we have emojis and isotypes indicating the emotional link for tonal and atonal music. This is where we link music to emotion and talk about what colors are associated with what type of music. We give a little introduction to the data and then

introduction to the visualization they will be seeing below. Again, followed by some instructions and what the visualization is.

Tonal music
is often associated with **brighter and more saturated colors**.

Atonal music
is often associated with **darker and more muted colors**.

Tonal Joyful Music

Atonal Joyful Music

Tonal Sad Music

Atonal Sad Music

Here we have added 4 videos, 'tonal joyful', 'atonal joyful', 'tonal sad', and 'atonal sad'. These are 4 different categories which we explore the relationship throughout the website. Coming to the videos, so it is an artistic visualization of color representation of music. There are more than 1 dimensions here. First, they can hear the music when they play, which is linked to the waves of colors they see. In the waves, if we go from top to bottom, we observe the thickness reduces. What we have done here is, we have chosen the top 10 colors that the participants chose while here the particular category and mapped it in the form of a wave. Another detail is the thickness of the band represents the number of people who chose that color while listening to the music. Greater the thickness of the band, the more people chose that color. For example, if we consider atonal joyful, yellow is the most picked, and cyan is the least chosen color while listening to atonal joyful music. The reason why we went ahead with this form of visualization is because, this is a topic of music which

is basically a form of waves, so we wanted to bring in aspects of art as well, along with the analytical aspect of visualization. This is actually inspired by the [Flickr Flow / Fernanda Viegas & Martin Wattenberg](#), although it is not similar, we started with a creative way of merging colors and music.
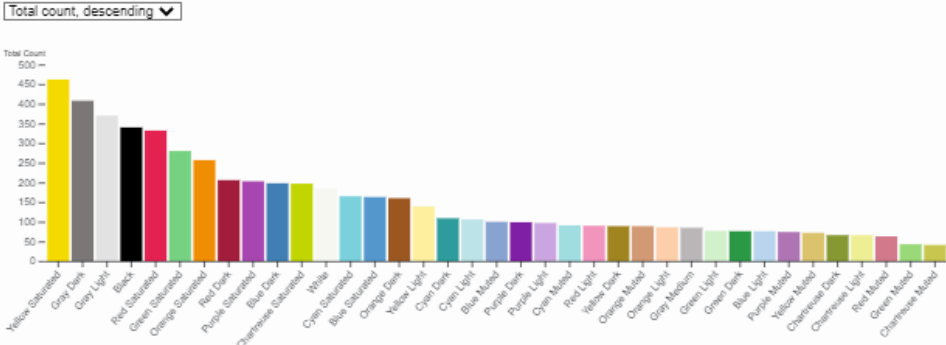
11. Distribution of Color-Music Associations

Here we talk about the relationship between color and music of the overall playlist which is all 16 songs, which colors are most frequently selected in association with all the music tracks that were studied in the research. This helps set the stage and give a broad overview of the findings. There is again instruction and thought provoking questions before the visualization.

After the visualization, there are some insights which users can get from the visualization.

12. Color-Music Association per Music Category

Color-Music Associations per Music Category

In the study participants were asked to select which color most represents the music (above the line) and which colors **least represents the music** (below the line).

Explore and compare the different color representations per each type of music.
Can you spot differences among color selection of tonal and tonal music? What are commonly selected colors for joyful music or sad music?

Most and Least Associated Colors with Tonal Music
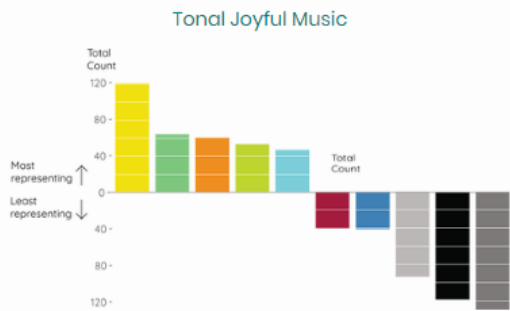
Most and Least Associated Colors with Atonal Music

Tonal Joyful Music

Atonal Joyful Music

Tonal Sad Music

Atonal Sad Music

- All **sad music** is highly associated with **darker colors**, whether it's atonal or tonal.
- Saturated colors, especially **red and yellow** are the **least representative of sad music**.
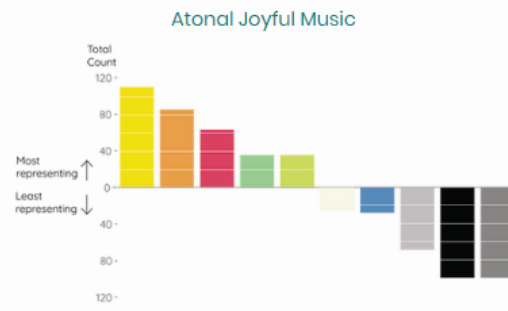- **Tonal sad** music was more closely associated with **blues** than atonal sad music.
- All **joyful music** is highly associated with **saturated** colors, whether it's atonal or tonal.
- There was the most agreement over **saturated yellow representing tonal joyful music**. It was selected nearly twice as often as any other color.
- Black, medium gray, light gray and dark blue are **least representative of joyful music** whether it's atonal or tonal
- Similarly, sad music, whether it's tonal or atonal is **least represented by saturated yellow, green, red and purple**

This section talks about most and least representing color for each of the 4 music types. This reinforces the ideas in the video player, while also giving additional quantitative information about the popularity of each color. It also gives insight into which colors were least associated with each type of music, which helps the user have a deeper understanding of the relationship of color to music type.

13. Emotional Link between Color and Music

The Emotional Link between Color and Music

Different songs evoke different emotions in people, from feelings of joy and happiness to sadness and sorrow. This emotional link is caused by the way certain songs evoke different dimensions of emotion, such as **valence**, **arousal**, **familiarity**, and **pleasure**.

Valence reflects the degree of positivity or negativity conveyed by a song.
Arousal measures the level of emotional intensity a song elicits.
Familiarity describes how well-acquainted a user is with a given musical piece.
Pleasure corresponds to the extent to which music is enjoyable to the listener.

Emotions and Colors Evoked per Music Category

The radar charts illustrate which dimension of emotions are most frequently evoked while listening to the different types of music that were studied in the research.

| Tonal Joyful Music | Tonal Sad Music | Atonal Joyful Music | Atonal Sad Music |
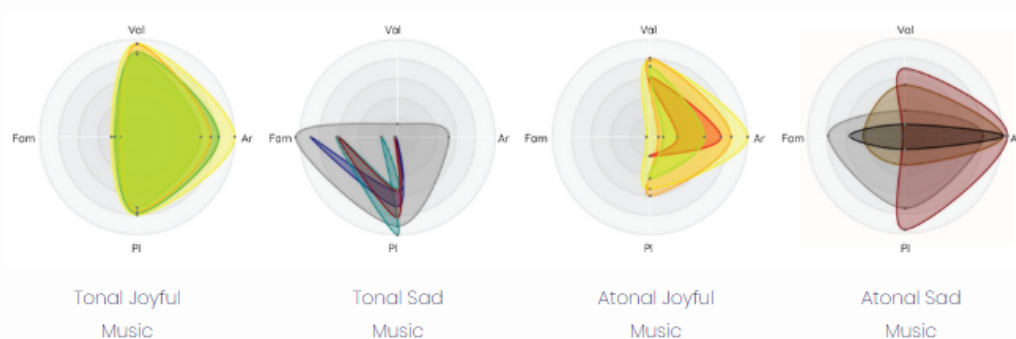
Explore the following radar charts by hovering over the blobs while you listen to the music which evokes that emotion. The music player's background color corresponds to the relevant blob's color.

Do you notice any pattern in specific dimension of emotion being triggered for all types of music? Which dimension of emotion do you think is evoked for all?

Here we first started with a basic introduction on how emotion and music are related and how music can evoke different emotions in different people. We have added an image to indicate that the music will be mapped based on the 4 dimensions. An exploration tip is also mentioned so they can make use of the full potential of the charts. Additionally, we have also recapped the definition of the 4 dimensions of emotions which was talked about in the beginning of the webpage. We recapped so that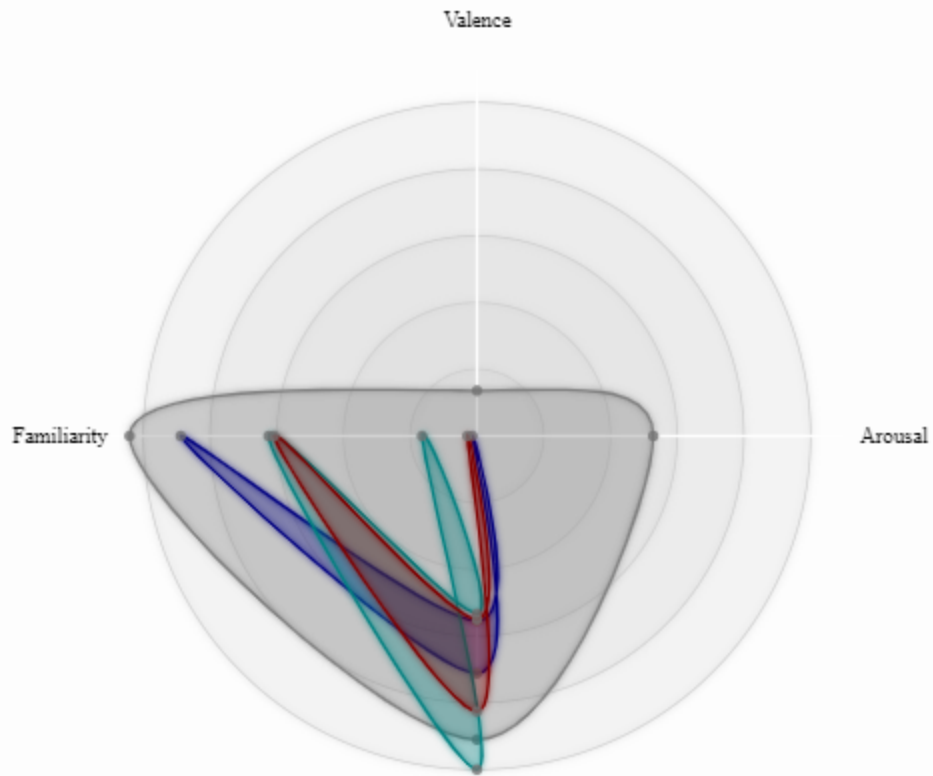 they don't need to scratch their head trying to remember what those mean. A small musical tone logo indicating this is important to understanding the below charts.

Emotions and Colors Evoked by Tonal Joyful Music

Valence

Familiarity

Arousal

Pleasure

W. A. Mozart, Symphony no. 39 ...
▶ ·——————

J. S. Bach, Violin Partita No. 3 in...
▶ ·——————

W. A. Mozart, concierto para pi...
▶ ·——————

J. S. Bach, Cello Suite No. 1, Co...
▶ ·——————
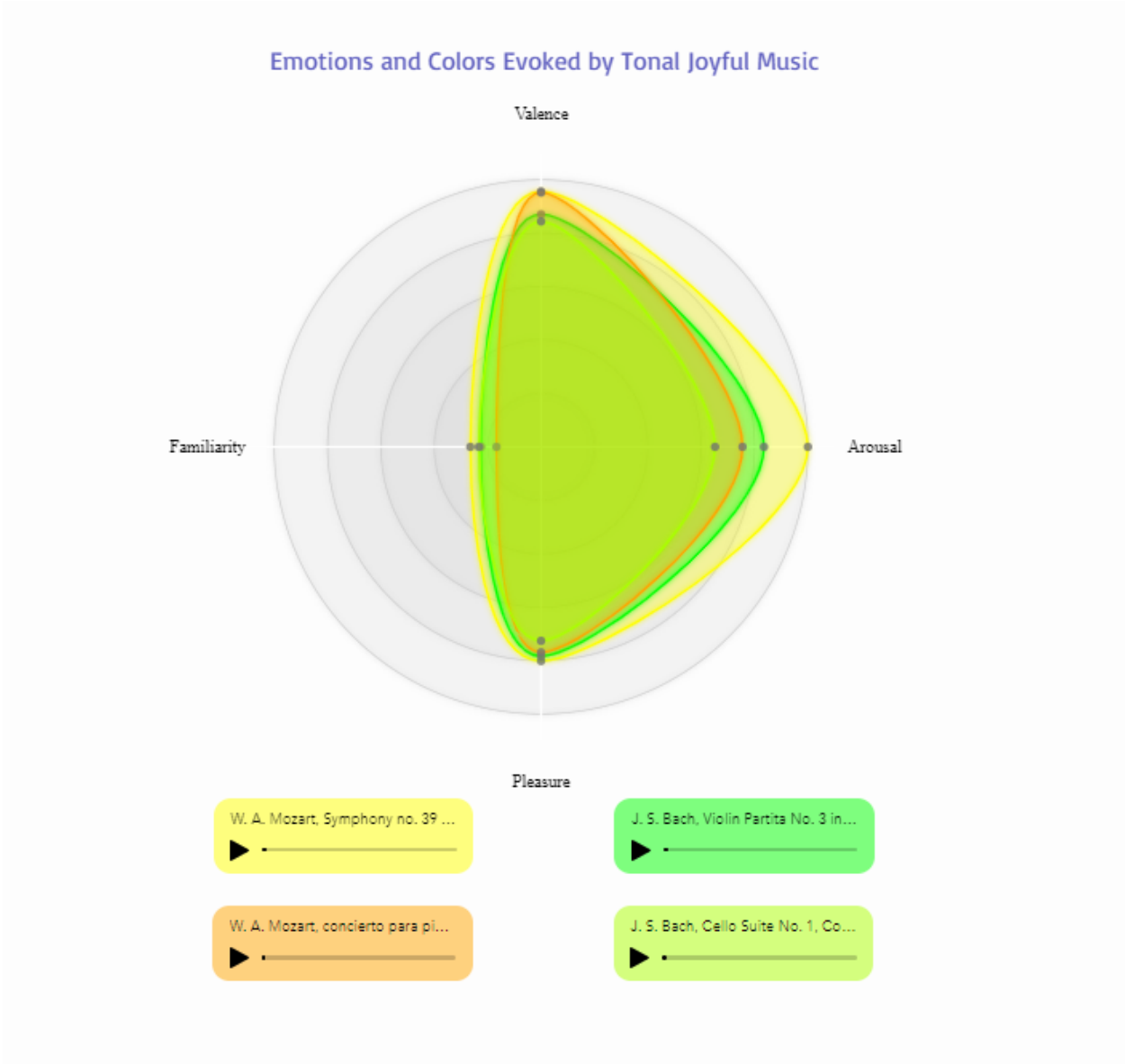
Emotions and Colors Evoked by Tonal Sad Music

Valence

Familiarity

Arousal

Pleasure

J. S. Bach, BWV 1,011 - Cello Su...
▶
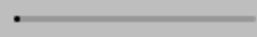
Adagio for Strings, Barber
▶

The Portrait of a Lady, no. 33
▶

J.S. Bach: Sonata for Violin Solo...
▶

Emotions and Colors Evoked by Atonal Joyful Music

Valence

Familiarity

Arousal
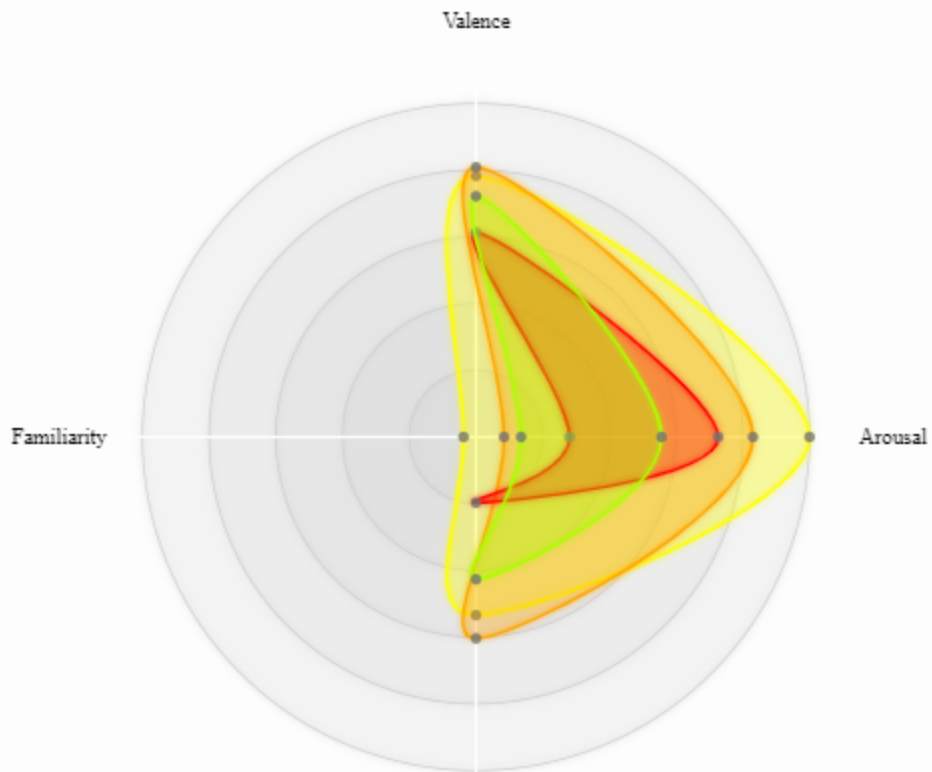
Pleasure

Bartok Concerto for Orchestra, ...

▶ •————————

Traditional (Classical) Arabic Mu...

▶ •————————

01 shamisen a japanese three st...

▶ •————————

Oistein Sommerfeldt - Divertim...

▶ •————————

Emotions and Colors Evoked by Atonal Sad Music
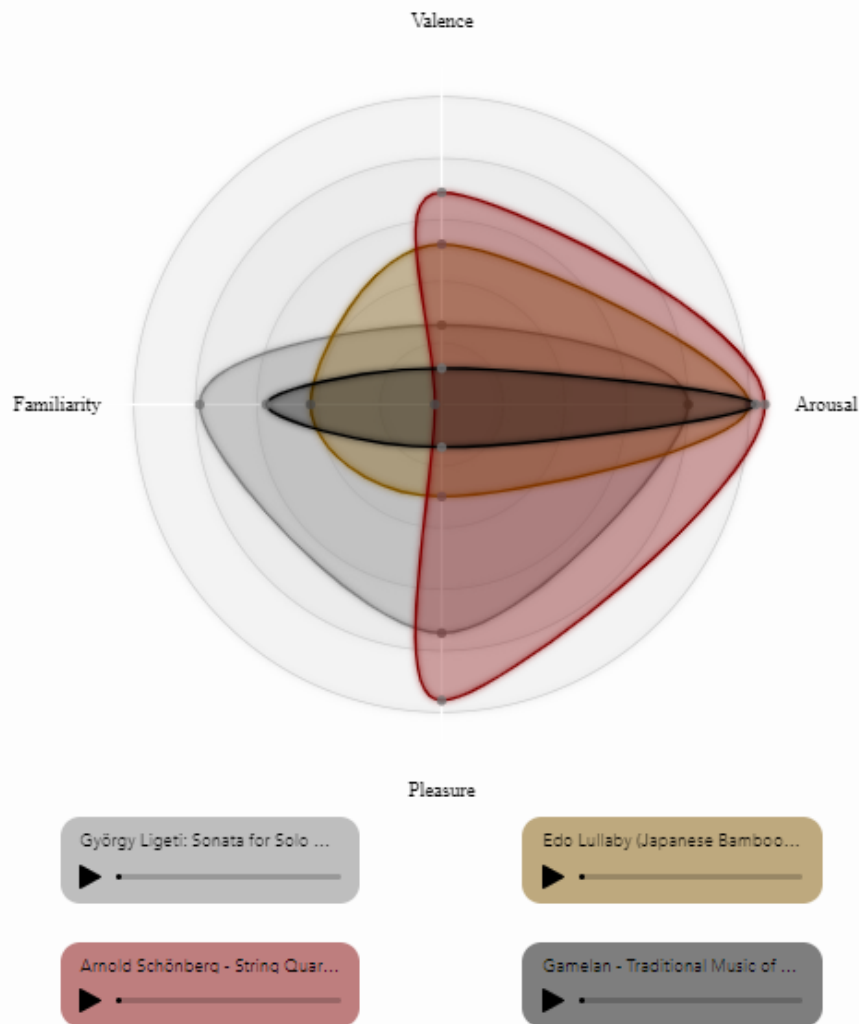
The above 4 screenshots are basically radar charts of 4 types of music we have: 'tonal joyful', 'atonal joyful', 'tonal sad', and 'atonal sad'. Here, each chart has 4 blobs representing the 4 music in that type and each of those musics are also added in the audio player right above it. Additionally, blobs and music in the music player are also color coded so that the association is easier. We have added a music player because these music are not well known to everyone for users to relate to it deeply they need to listen to it and then see which will augment the effectiveness of the chart. So, they can play the song while hovering over the blob which will highlight.

- For **Joyful music, familiarity has the lowest** overall scores across, indicating that participants are less familiar with these music.
- Participants rated music with a wide range of valence, arousal, pleasure, and familiarity scores, indicating that there is **no single emotion that dominates in the music.**
- There is a **moderate correlation between valence and arousal** ratings, suggesting that participants tend to rate songs that they **found positive as also highly arousing.**

At the end of all 4 charts, we have some valuable insights which users can gain from analyzing these charts

14. Conclusion

"You create a universe by perceiving it, so everything in the universe you perceive is specific to you" – Douglas Adams

It is very likely that while scrolling this website you notice that you perceive a certain color, music or emotion differently than presented in the data. There are myriad physical and cultural parameters that affect perception of each of us. How does that affect the way we communicate or understand others? What are the differences or similarities that we might take for granted?

We wanted to have a meaningful conclusion where we wanted to let them know that each individual is entitled to their own emotions and there is no right or wrong answers here.

15. Poll

Do you sense what I sense?

Listen to the music and answer the poll based on the emotions evoked in you.

Elektronomia - Sky High [NCS Release]

How negative or positive is the emotion evoked by this music?

Negative

Neutral

Positive

Votes 3

opinion stage – create your own poll

What color did the music evoke in you?

Red

Green

Dark Blue

Yellow

Votes 1

opinion stage – create your own poll

At the end we have a poll based on what was discussed in the webpage. This is done as a thought provoking activity.

5. Data

The data we used is based on a study by Valdés-Alemán et al. that conducted a study with 60 participants over 18 years old (M = 32.7 years, SD = 12.6). From the paper: "From this sample, 32 participants were female and 28 were male;

28 participants declared null musical education, whereas 32 declared to have some degree of musical education."

The data is divided into 3 parts as follows:

Part A: Music-to-color association

Participants replied by selection of color (out of the 37 colors defined by Berlin and Kay, as can be seen in the Fig. 1)
For each musical stimulus participants were asked to :
1. Choose the three colors that most represented the music
2. Choose three colors that least represent that same music

To collect this information, authors assigned an alphanumeric code (ID) to each color on the board, where the letter represented the color and the number its quadrant.

We used this data in multiple parts of our visualization, to visualize from different perspectives and to gain multiple insights across the three data parts (A-C): First, linking music to emotion- videos; second, bar chart of distribution of color-music associations; lastly, we used it in bar charts representing most and least representative colors per musical category.

Figure 1. The 37 colors, labeled by categories as presented in the data from Valdés-Alemán et al., 2022.

Part B: Color perceptual and emotional assessment

To measure how participants' emotional perception of each color from the 37 colors, the study followed a protocol based on Russel et al. 's method using valence and arousal parameters. The chart below presents the questions asked in this section:

Questions 1-4: These questions were asked in order to gain information about the visual perception of users. We didn't use this data in our visualization. Questions 5-6: these questions evaluate the emotional perception of each color: "Emotional valence describes the extent to which an emotion is positive or negative, whereas arousal refers to its intensity, i.e., the strength of the associated emotional state (Feldman Barrett & Russell, 1999; Lang, Bradley, & Cuthbert, 1997; Russell, 2003)." Fig. 2 Describes this emotional scale.

|	questions	Slider per question	Data use in our visualization
Questions correspond to the four perceptual characteristics of color proposed by Palmer et al. (2013)	(1) How green or red is this color?	Red–Neutral–Green	n/a
	(2) How yellow or blue is this color?	Yellow–Neutral–Blue	n/a
	(3) How dark or light is this color?	Dark–Neutral–Light	n/a
	(4) How saturated is this color?	Unsaturated–Neutral–Saturated	n/a
Questions correspond to the two emotional dimensions—valence and arousal—of Russell's (1980) multidimensional model of emotion.	(5) How negative or positive is the emotion evoked by this color? (Valence measure)	Negative–Neutral–Positive	Scatterplot: linking color to emotion
	(6) How passive or active would you consider this emotion? (Arousal measure)	Passive–Neutral–Active	Scatterplot: linking color to emotion
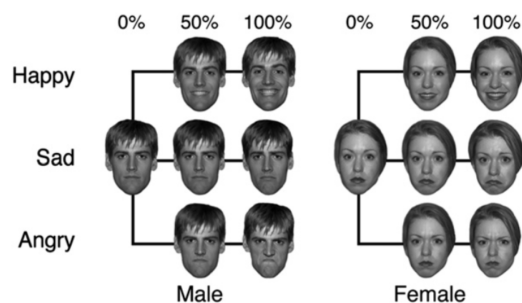
Figure 2. Emotional scale (Russell et al. 1999)

Part C: Music emotional assessment

The study measured the emotional assessment of music using valence and arousal measurements (as described above, in part B), with additional measures (that were proved as high influence on musical emotional perception in past research) of familiarity with the music, and pleasure of hearing the music. The questions to collect the data are described in the chart below.

Questions per each musical stimulus:	Participant reply in sliders:	Data use in our visualization
(1) How negative or positive is the emotion evoked by this music?	Negative–Neutral–Positive	Radar chart: Valence
(2) How passive or active would you consider this emotion?	Passive–Neutral–Active	Radar chart: Arousal
(3) How pleasant is the music you are listening to?	Little–Neutral–Very	Radar chart: Joyful / sad
(4) How close is what you are (currently) listening to, to the music you usually listen (to)?	Little–Neutral–Very	Radar chart: Familiarity

6. Tools

- Visualization with interaction and/or animation
  - D3.js: animated and interactive scatterplot, bar chart and radar charts
  - Audio-video of music waves: Design in figma and video editing in iMovie
  - Observable notebook
- Visualization without interaction
  - Excel for 4 static bar charts

- Website
    - Wix
    - Opinion stage (for poll)
- Design
    - Illustrator and Figma

7. Results

During our usability test with our prototype, participants were interested in learning about music, color and emotions. They liked the overall design, so we kept the same flow and general look and feel for the final product. Our participants were excited about being able to hear the music and interact with the website. Because of this, for our final product we created multiple opportunities to listen to music throughout the site and encourage exploration. They also were interested in understanding the results from the study so they could compare the findings to their own perspectives. To meet this need, we created a poll at the end so users could compare their perspective to that of the rest of the viewers. We also added more information about the subjectivity of perception to support our motivation to promote understanding of the diversity in human perception.

During our usability test, some of our participants were confused about the context of our visualizations, so we improved and expanded on the background information to provide more context. For our final product, we directly referenced the study the data came from, and provided more details on how the data was collected.

After the introduction, we wanted to create a better flow between the sections on color, music and emotion, and find ways to connect all three. Because of this, we created clear heading titles and transition sentences to connect the topics. We also wanted to have more direct connections between how color maps on to music, based on feedback from our usability tests. Because of this, we added a feature to play music while seeing the most representative colors. This is an engaging and fun way to hear the music from the study, while also making a connection between music and color.

In the usability study we observed that users could grasp relatively well the emotional scale, however, they were confused because it was divided into four quadrants to include negative arousal and valence. This made us realize that representing arousal with negative values is misleading. In the final version of the scatterplot, we represented arousal in measures of percentage from 0-100% that represents emotional intensity more clearly.

During our usability test, some of our participants were confused about the purpose of the bar chart and how they could interact with it. To help reduce this confusion,

we added more context information on the purpose of the bar chart, in addition to adding instructions for how to filter it. We also updated the filters based on feedback from users that the color aspect filtering would be meaningful for comparison with the scatterplot data. We added a color aspect filter, as well as removed an ascending order filter, since users said this filter was redundant.

We updated the dot plot in the prototype that showed the most and least representative colors for each category of music, to a bar chart. The bar chart fits our data better since it is a mix of qualitative and quantitative data. They created four of these charts to give deep insight into the relationship between color and music.

The feedback we got for the radar charts is that it would help the users if we provide some context around what the chart is supposed to do and what are the terms used in the charts, so we added more context before the chart. Second feedback was, they were confused about what the color indicated, (we didn't have completed radar charts, but we showed them how it would be, with colored blobs) so we changed it to color most representing the type (eg: tonal joyful). Then they said it will be difficult to relate to the blobs because they don't know what music it is portraying, so we added all 4 music for each of the 4 radar charts and color coded (blob-music player) for easy association.

8. Work division

Working on the project we consulted, iterated and got ideas and advice from each other throughout the work. There are different sections of this project where we worked in collaboration and the work was divided or moved back and forth among us based on our skill sets and interests. In the chart below we mark the section that each of us were involved in, and we follow with a more detailed description of the work.

Section	Subsection	Mia	Nithin	Hila
Website	Introduction: color, music, emotions	Implemented story outline in Wix, added design elements	Provided feedback on design and content that is added here. Helped in implementing	Leader on this, created the outline story and design outline, Created the icons and visualizations. Implemented in illustrator and wix.

			the 'music' and 'emotion' section	Wrote the content for introduction.
	Linking color to emotion	Proofread text	Proofread text Provided feedback on the plot	Leader on this, implemented the scatterplot in observable and this section in the website. Wrote the content and insights.
	Linking music to color	Cleaned data for all visualizations Proofreading, ideating on design strategy with music videos Wrote code for animated bar chart in Observable and implemented it in website Created four bar charts in Excel Wrote and implemented data insights	Implemented the website for this section till the bar charts. Ideated and created the 4 videos through multiple iterations. Wrote the content (introduction, exploration and insights)	Created the isotypes. Helped Mia with creating the bar charts for most and least associated colors First iteration as a scatter plot.
	The emotional link between color and music	Proofreading, ensuring design consistency in this section with rest of site	Created the website for this entire segment. Wrote the content (introduction,	Created the icons and the view of four radar charts.

			exploration and insights)
		Coded and built the 4 radar charts.	
		Ideated the color coding of blobs representing most representing for each of the types of music	
		Ideated and created the music player color coding with radar chart blobs.	
	Conclusion and poll	Created perception icon	Created the poll and implemented it on the website.	Created the conclusion section with quote
	Website design / other	Designed title area Ensured consistency and grammar	Made sure, the website is coherent throughout in its font style, size, color matching Took the initiative to start the website through wix.	Throughout the website - worked on the design theme, color theme, text formatting and overall alignment, to make sure content is uniform and follow the design theme and story.

Charts	Audio-video (Artistic representation)	Helped ideate on Nithin's design	Iterated through multiple ways for the video creation. Built the complete video/visualization.	Helped in ideation
	Bar chart	I created and wrote the code for this in Observable	Provide feedback on design and interaction	-
	Most and least representing colors - bar chart	I created these in Excel, wrote insights	Helped in brainstorming the creation of the chart	Helped in early iteration through implementation as scatterplot. Helped in implementation using illustrator.
	Scatter plot	Provide feedback to Hila on design	Provide feedback on design and interaction	Created these in observable notebook (wrote the code)
	Radar chart	Provide feedback to Nithin on design	Coded and built the 4 radar charts. Ideated and coded the color coding of blobs representing most representing for each of the types of music	Helped with feedback on the design
Writeup	Goals	Minimal,	Minimal,	Wrote this

		proofreading	proofreading	section
	Related work	Wrote a paragraph and discussed 3+ related sources	Wrote a paragraph discusses 3 related work	Wrote a paragraph discusses 3 related work
	Description/ Visualization Explanations	Discussed purpose of charts I created	Wrote the complete description of the website Discussed the purpose and inspiration for radar charts	Discussed purpose of charts I created
	Data	Found dataset	Proofread it and made sure everything is covered Also had the dataset among my suggestions	Wrote this section
	Tools	Used all tools, contributed which tools I used	Wrote the section talking about all tools we used to create the visualizations, design and website	Minimal proofread
	Results	Lead on writing the results section. Wrote all except for sections on dot plot and radar chart.	Proofread it and made sure everything is covered	Minimal proofread

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494–521.

Through the visualization we used:

- Royalty-free Icons from The Noun Project
- Royalty-free images from Unsplash
- Royalty-free videos from Wix
- [Flickr Flow / Fernanda Viegas & Martin Wattenberg](#)

10. Appendix
a. Thumbnail image

Can be downloaded [here](#).

b. Software

- Dataset: https://data.mendeley.com/datasets/x5sxsnprbd/1
- Website created through Wix.
- Charts created through Observable notebook (links available at the top of this document).