COVID'19 and Mood of Spotify Users:
an intricate interplay

By
Asad Ahmad Khan
MS Data Visualization

"**Submitted in partial fulfillment of the requirements for the degree of Master Science in Data Visualization at Parsons School of Design.**"

Abstract

Music has a profound impact on our lives, calming and comforting our souls. Last few years the world has undergone tremendous changes. This project is a short and simple introduction of the basic principles of mood as defined by Spotify using the data from Spotify open API. My project focuses on the intricate interplay of four major covid events and the mood of spotify users. The four components of music as identified by Spotify are: valence, energy, danceability and tempo. Using the major events of COVID'19 these four elements are analyzed in the visualization using digital medium for the users to explore these elements against the timeline.

This topic mainly addresses the interesting fact that when individuals are sad, depressed or unmotivated they tend to listen to positive, high energy and danceable music. It covers a social and psychological aspect of Spotify users, contributing to the curiosity of the user base and how to better understand human behavior. My method is to allow users to identify the casual relationship and the coping mechanisms of the Spotify users during tough times like COVID'19. It is one of its kind of works as it represents the interplay of mood during COVID'19 and music. While mostly the published works are curtailed to trends but do not overlap with a global event like a pandemic.

Table of Contents

1. Introduction

Music is used across cultures and ages as a powerful mood regulator. We regularly use music to soothe our souls and comfort our pain. The emotional power of music is one of the main motivations why people devote so much time, energy, and money to it. People use music to achieve various goals, such as feeling more energized, maintaining focus on tasks, and reducing boredom. For example, we rely on music to help us power through workouts and tackle tasks we'd rather ignore, and we manipulate our moods with melodies.

COVID-19 pandemic has had a significant impact on people's moods during the course of two years from February 2020 to December 2022. While everyone's experience is unique, some common mood changes that people may have experienced during lockdown include anxiety, loneliness, boredom, irritability and depression. Many people may have felt anxious about the pandemic itself, as well as the uncertainty and changes it brought to their lives. Lockdowns and social distancing measures may have led to feelings of loneliness and isolation, as people were unable to socialize with friends and family as they normally would. The restrictions on activities and social gatherings during lockdowns may have led to feelings of boredom and restlessness, particularly for those who were used to being busy and active. The challenges of adjusting to new routines and restrictions, as well as the stress of the pandemic, may have led to feelings of frustration and irritability. For some people, the stress and isolation of lockdowns may have contributed to feelings of depression, which can include persistent sadness, feelings of hopelessness, and a loss of interest in activities. It's important to note that these mood changes are common and normal responses to a challenging and unprecedented situation.

Throughout this time one of the things which kept us going was music which tends to hit us on a deep level; whether it is sad music that helps us feel relatable when we are going through hard times or joyful music that adds an extra bounce to your step, music is incredibly powerful. As we all listen to music which can be so much more than the vocals and beat. Leo Tolstoy, a famous writer, stated: "Music is the shorthand of emotion" (Khadpe, 2019). We all experience music on a personal level where our emotions become involved, allowing the tempo of the music to impact us. However, in order for music to be as influential as it can be, it is important to first understand your own emotions and the ways in which music can be effective in the various circumstances in your life.

Through this research I want to examine how Spotify listeners' mood changes over a course of four years using the quantifiable measures which are tracked and published by Spotify for the tracks available. In order to make a comparison and explore how music helps to keep us motivated, focused and emotionally charged in the times of uncertainty.

1.1. Background

Psychologists classify music listening as either mood congruent, mood incongruent, or neither, depending on whether the music matches the mood or not. Lee, Andrade and Palmer documented that humans display a balance of mood-congruent to mood-incongruent aesthetic stimuli in their listening. Congruence is when we listen to songs similar to how we're feeling, while incongruence is the phenomenon of trying to lift ourselves out of a bad mood with upbeat music. (Lee, Andrado, and Palmer 2013)

Stratton and Zalanowski found that music and visual stimuli combine to influence mood more strongly than either stimulus alone. In that study happy or depressive music was paired with paintings intended to evoke positive or negative feelings. (Stratton and Zalanowski 1989) It was found that emotional changes always followed the music being played, but the visual stimulus was necessary to produce significant differences when being compared to a music-only control group. Music appears to be dominant in determining the direction of mood change, but music alone does not produce the change. It is suggested that stimuli that allow cognitive appraisal are necessary to create a strong mood change.

Like in 2020, when the pandemic hit the world and there was a haul on life, through this study I want to explore the relationship between music and worldly affairs. It had been an emotional time marked by startling daily counts of new cases and deaths that multiplied rapidly. More than 100 million people around the world have been infected by COVID-19 and more than 2.5 million people have died of the disease. (Katella 2021) Many of us mourned loved ones in the last year, and the grief, along with isolation to prevent infections, took a toll on our mental health. Through this study I will gauge the mood of the users through music they were listening to, whether they were happy or sad songs, or to stay motivated they were listening to more danceable and high beat music.

Furthermore, this analysis will paint a picture of how users on Spotify used music as a coping mechanism to get through rough times. Listening to music has been associated with direct effects on physiological aspects of stress.
In the study conducted by professors from Knox College and the University of Missouri, the researchers aimed to investigate the impact of music on an individual's mood. (Ferguson and Sheldon, 2013) The study found that individuals who were instructed to listen to positive music while trying to improve their mood reported more positive emotions than those who listened to music without any instruction. Study participants showed lower cortisol levels, heart rate, and blood pressure when they listened to music, helping to calm the body and promote relaxation. In addition, a meta-analysis of various studies on the connection between music and stress relief found that music had a psychological effect on stress in addition to a psychological effect. Study

participants experienced improvements in worry, anxiety, and restlessness when they listened to music.
It suggests that music has the potential to enhance an individual's mood, particularly if the intention is to be happier. The study's findings are particularly important because it highlights the role of music in improving mental well-being. Individuals who are experiencing negative emotions, such as sadness or anxiety, can use music as a tool to elevate their mood and reduce negative emotions. It also emphasizes the importance of intention in music listening. By intentionally selecting and listening to positive music, individuals can improve their mood and overall mental well-being.

These findings have practical implications for mental health professionals who can incorporate music therapy into their treatment plans for individuals experiencing negative emotions or mental health disorders. Additionally, individuals who are looking to improve their mental health can utilize music as a cost-effective and accessible tool for enhancing their mood. Overall, the study highlights the potential benefits of music on mental health and well-being.

1.2. Music and Mood

Interestingly, music can affect our mood even if we can’t recognize or replicate the notes and rhythm. Science has documented numerous instances of people who suffered brain injuries and lost their ability to distinguish melodies but retained the ability to recognize the emotion conveyed by music. (Rice and Galbraith 2008)

The relationship between music and mood has long been a topic of interest in psychological research. It is widely accepted that a person's mood can influence their musical preferences, and that music can also have an impact on a person's mood. However, the concept of mood itself is more complex than simple emotions, as it is often more diffuse and longer-lasting.

There are two main models used to characterize mood: dimensional and categorical models. The dimensional model organizes moods into a simple and effective system based on two dimensions, which allows for easy comparison of different moods. On the other hand, categorical models use a rich set of distinct words to describe moods, but the number of words available may be limited compared to the full range of moods that can be perceived by humans.

For this particular study, the researcher chose to use Russell's circumplex model as a basis for analysis, due to its simplicity and effectiveness. The model represents mood along two dimensions: arousal and valence. Arousal refers to the level of excitement or energy associated with a particular mood, while valence represents the positivity or negativity of that mood. To represent these dimensions in music recommendations, the researcher used four variables: valence, energy, danceability, and tempo. Energy measures the intensity of the tracks, while valence measures the overall positivity of the tracks. Danceability refers to how suitable a track is for dancing, and tempo represents the speed of the track.

By using this model to analyze users' musical preferences, the researcher can gain a deeper understanding of how mood influences music choices, and how different musical features can affect mood. This information can be useful in developing more effective music recommendation systems, as well as in understanding the complex relationship between music and human emotion.

This exploratory study is designed to investigate how the user's mood changed over a course of four years starting from January 2019 to December 2022 using music. In order to validate the hypothesis, in this study the data from Spotify web API is used to scrape top 100 monthly songs charts along with their attributes which are defined as mood of a particular song.

The following are the four features and their definitions as defined and measured by Spotify:

1. Valence: A measure from 0.0 to 1.0 describing the musical positiveness conveyed by a track. Tracks with high valence sound more positive (e.g. happy, cheerful, euphoric), while tracks with low valence sound more negative (e.g. sad, depressed, angry).
2. Energy: A measure from 0.0 to 1.0 that represents a perceptual measure of intensity and activity. Typically, energetic tracks feel fast, loud, and noisy. For example, death metal has high energy, while a Bach prelude scores low on the scale. Perceptual features contributing to this attribute include dynamic range, perceived loudness, timbre, onset rate, and general entropy.
3. Danceability: Danceability describes how suitable a track is for dancing based on a combination of musical elements including tempo, rhythm stability, beat strength, and overall regularity. A value of 0.0 is least danceable and 1.0 is most danceable.
4. Tempo: The overall estimated tempo of a track in beats per minute (BPM). In musical terminology, the tempo is the speed or pace of a given piece and derives directly from the average beat duration. The beat of the song we listen to can even influence our heart rate, and when people sing together, their breathing often becomes synchronized, producing positive emotions.

These four components of mood help in identifying the users of Spotify, indicating how users preferences changed over the course of COVID’19. The first cases of novel coronavirus (nCoV) were first detected in China in December 2019, with the virus spreading rapidly to other countries across the world. This led WHO to declare a Public Health Emergency of International Concern on 30 January 2020, and to characterize the outbreak as a pandemic on 11 March 2020. (World Health Organization 2020)

In order to explore the patterns four major events are used for analysis of mood.

1. When COVID’19 virus was declared as pandemic and gradually the world went on complete lock down by the end of March 2020.

2. When vaccines were approved by the end of July 2020 and people were jabbed with them as a protective measure against the virus.
3. Delta variant of COVID when third peak was observed globally
4. Omicron variant which was entirely different and severe as compared to the previous variant of COVID.

These four landmarks were important and played a critical role in solving the uncertainty at times, later changing the course to increase uncertainty at times.

2. Methodology

2.1. Data Collection

The first part of this study was to gather data from a valid source. There were two sources of data needed for such an analysis. The first is the Top 100 most streamed songs, on a weekly basis globally, which Spotify makes available on spotifycharts.com. I chose the last week of each month to provide an actual picture of top songs. Instead of selecting data and manually downloading the csv files, I used a python script to scrape data for me using Spotipy library to extract the features. This data collection process was time consuming and required a lot of debugging during the process. By accessing Spotify's developer API, users can search for music based on different criteria such as artist, album, or genre. They can also create, edit, and share playlists with other users. This has made it easier for people to discover new artists and songs that they may not have otherwise been exposed to.

One of the key benefits of Spotify's platform is its ability to track and identify each song uploaded to its platform using advanced technology. This allows for the collection of valuable data such as valence, energy, danceability, and tempo, which can be used to analyze music trends and moods. In order to access this data, the author of the passage signed up on Spotify's developer's website and collected the necessary information on features such as valence, energy, danceability, and tempo, and matched it against the corresponding songs and their week of appearance on the charts. While the data collection process was time-consuming, it provided the necessary foundation for the analysis of music trends and moods. Overall, the use of Spotify's developer API has allowed for a deeper understanding of music consumption patterns and has opened up new possibilities for music analysis.

Top 100 songs were chosen from January 2019 to December 2022, providing more than 4,000 songs along with their features to see the casual relationship. In order to measure the mood of how positive and negative the users were, the average monthly valence is plotted against time, to observe the pattern during each event identified.

2.2. Data Wrangling

Data wrangling was a crucial step in data analysis that involved the conversion of raw, unstructured data into a usable and organized format using excel. This process involves several steps such as data collection, cleaning, transformation, and integration to ensure that the data is accurate and complete. The primary objective of data wrangling is to make the data suitable for analysis. In this context, before conducting any data analysis, it is necessary to ensure that the data collected is reliable and complete using the scraping script.

In order to ensure the accuracy and reliability of the data, data sanity and verification were performed during the data wrangling process. To achieve this, several songs were individually checked for their features on the Spotify console. This helped in identifying any discrepancies or errors in the data that needed to be cleaned. By cleaning and verifying the data, it was ensured that the data was prepared for analysis.

At this stage during the data cleaning process, data was reorganized into columns and different ids and links in the data were removed for quick processing of the csv files. This allowed for easy manipulation of data, making it more accessible for analysis. By removing irrelevant information, to make data more concise and efficient for analysis. Overall, the data wrangling process is a crucial step in the data analysis process that ensures the accuracy and reliability of the data, making it suitable for analysis.

2.3. Data Processing

After completing the data wrangling and cleaning process, an initial data exploration was conducted to gain insights into how the mood of the users was reflected through the songs. This process aimed to identify any noticeable trends in the data, which could be used to draw meaningful conclusions about the listeners' behavior during specific periods of time. One noticeable trend that emerged during the data exploration was that the mood of the users seemed to shift during each; lockdown period, when the first vaccine was approved, and during the emergence of the delta and omicron variants. These events likely had a significant impact on the mood of the listeners, which was reflected in the songs they were listening to.

To consolidate the various features of the data and build a narrative around the listeners' behavior, the average of each month was calculated. This provided a measure to look at the overall pattern and trends in the data during a certain period of time. By calculating the average of each month, it was possible to gain a more comprehensive understanding of how the mood of the users was evolving over time and how different events or situations were influencing their musical preferences. Using this approach allowed for a more nuanced understanding of the data, which could be used to identify key insights into the listeners' behavior. By understanding the

overall pattern of the data, it became possible to draw conclusions about the underlying factors that were driving the listeners' preferences and how these factors changed over time.

Data exploration process was a critical step in understanding the relationship between the mood of the users and the songs they were listening to. By identifying trends and patterns in the data, it was possible to gain insights into the underlying factors that were driving the listeners' preferences and how these factors changed over time. The use of an average calculation for each month provided a useful measure to consolidate the data and build a narrative around the listeners' behavior.

2.4. Data Visualization

After data analysis, a storyboard and moodboard (Appendix A) were created to spell out the narrative between the intricate interplay of COVID'19 and the mood of Spotify users.

For the presentation of the findings in an easy-to-understand format, a website was created using HTML, CSS, Javascript d3 library, and Flourish. The website aimed to provide a holistic view of the data gathered, allowing users to gain insights into the mood of the users and how it changed over time. To select the most appropriate visualization for the website, the line chart was used as the baseline due to its effectiveness for explanation. Line charts allow users to compare trends over time, making it easier for them to understand how the mood of the users was evolving, making it easier for users to grasp information, even if they are not familiar with data visualization techniques. An interaction was added to understand the trends and patterns; as users can click on the elements of mood to observe the differences.

2.4.1. Mood Composition

In the analysis, two important features were identified - valence and energy - which provided the most insightful findings about the users. These features were used to gain insights into the mood of the users, and how it changed over time. By analyzing these features, it was possible to identify the underlying factors that were driving the listeners' preferences, such as the emergence of new variants or the approval of vaccines. The four major significant events which were identified are the following:

1. When COVID'19 was declared as pandemic and lockdown started
2. Introduced of first vaccine and its adoption
3. Delta variant of COVID'19
4. Spread of Omicron variant which was not protected by vaccine shots

Against each event the pattern of four mood elements was observed and patterns were identified.

2.4.2. Popularity Scale

The popularity index measure provided a way to quantify the overall popularity of an artist on the streaming platform. This measure is calculated by summing up the popularity of all the songs by an artist and ranking them from 0 to 100. This allows for a more objective way of comparing the popularity of different artists and understanding which artists are most popular among the listeners. By using this measure, the researchers were able to gain insights into which artists were trending during different periods and how their popularity changed over time.

For instance, if the popularity index of a particular artist increased significantly during a certain period, it might indicate that their music was resonating with the listeners and that they were gaining popularity. On the other hand, if the popularity index of an artist decreased during a certain period, it might indicate that their music was not as popular among the listeners as it was before. It can be most influenced right after a track has been released. The more early data points the algorithm is able to collect, the higher its initial popularity will be, and the release will suddenly start accelerating by itself. Any effort invested into the early stages of a release results in a much broader reach of listeners and ultimately more streams throughout an extended period of time. The first week of a release is critical for its success Therefore, the popularity index measure provided valuable insights into the users' behavior and helped to identify trends in the music industry.

3. Discussion

Listening to music has been found to activate the same reward centers in the brain that are activated by food, drugs, and other pleasurable stimuli. This release of endorphins can boost our mood, reduce stress levels, and promote feelings of happiness and well-being. In addition to releasing endorphins, music can also have therapeutic effects on the mind and body. For example, it has been used in music therapy to help people with various mental health conditions, such as depression, anxiety, and PTSD. Music therapy involves using music to address specific goals, such as improving mood, reducing stress, or promoting relaxation. Music therapy can be particularly effective for individuals who have difficulty expressing their emotions verbally.

It is evident that music can have physiological effects on the body, such as reducing heart rate and blood pressure. This can lead to a decrease in stress levels, which can have a positive impact on both physical and mental health. Additionally, music can improve sleep quality, which is important for overall well-being. Whether listening to upbeat music to boost our mood or using music therapy to address specific mental health concerns, incorporating music into our daily lives can be a valuable tool for promoting overall wellness.

In this way, music has become an important tool for people during lockdowns, helping the users to stay motivated and positive in the face of adversity. The trend of using positive, low energy,

and soothing tracks is a testament to the power of music to uplift our mood and keep us motivated, even during challenging times. We breaking the discussion into four parts will help to explore further.

3.1. Declared as Pandemic and Lockdown

On March 11, 2020, COVID-19 was officially designated a pandemic by the World Health Organization. “The novel coronavirus had fanned out across the globe, and the world had lost its ability to contain it. Countries reacted to the emerging disease with a mix of denial, incredulity and fear. COVID-19 went on to be responsible for the first pandemic ever caused by a coronavirus. More than three years in, there have been 759 million cases and almost 7 million deaths worldwide.” (Daniel 2023)

The analysis of the top 100 songs data revealed an interesting trend in the valence of the songs. Valence is a measure of the musical positivity of a song and can range from negative to positive on a scale of 0 to 1. During the time period being analyzed, there was a steady increase in the valence of the top 100 songs, from 0.49 to 0.53. This suggests that users were increasingly listening to positive songs that uplift their mood during the uncertain and stressful times of the pandemic.

The top 5 songs during this period further support this trend, as they were high on positivity, energy, and danceability. The tempo of the songs matched with the danceability, which might have helped the users to keep themselves motivated and uplifted during the difficult times. It is noteworthy that people often listen to music to manage their mood, whether it's to feel better when they are feeling low or to stay motivated when they need to perform a task. The high valence, energy, and danceability of the top songs during this period might suggest that users were using music to improve their mood and maintain their motivation in the face of adversity.

Moreover, the popularity of the songs and the artists who performed them also contributed to the insights gained from the analysis. The popularity index allowed for a deeper understanding of the listeners' behavior and preferences in terms of the artists they preferred to listen to. This measure helped to reveal which artists were most popular among the listeners and how their popularity was reflected in the streaming data.

Table 1 - Top 5 Songs in March 2020

Song	Artist	Valence	Energy	Danceability	Tempo
Blinding Lights	The Weeknd	0.334	0.73	0.514	171.005
The Box	Roddy Ricch	0.642	0.586	0.896	116.971
Dance Monkey	Tones And I	0.541	0.593	0.826	98.083

Don't Start Now	Dua Lipa	0.679	0.793	0.793	123.95
Roses - Imanbek Remix	SAINt JHN	0.898	0.724	0.777	121.975

3.2. COVID'19 Vaccines

The pandemic had a significant impact on global health and well-being, as well as on the socio-economic and political landscape of countries around the world during the initial months. In order to mitigate the spread of the virus, many countries implemented measures such as lockdowns, social distancing, and mask mandates. However, vaccines have emerged as a crucial tool in the fight against the pandemic.

The efficacy of vaccines in preventing COVID-19 infection, hospitalization, and death was well-documented. In addition, vaccines were available to the public at no cost, making them accessible to a wide range of individuals regardless of socio-economic status. The importance of vaccination in reducing the potential global death toll due to COVID-19 cannot be overstated, with an estimated 19.8 million deaths averted as a result of vaccination, according to excess mortality estimates of the pandemic's impact. (Valliammai 2022) The success of vaccines in reducing the spread and severity of COVID-19 has had a significant impact on the mood of users. The availability of vaccines has reduced the sense of uncertainty and fear among individuals, providing a sense of security and hope for the future. Additionally, the implementation of vaccines has enabled countries to ease lockdown measures and resume economic and social activities, leading to an overall improvement in the mood of the population.

Vaccines played a crucial role in the global response to the pandemic. The availability and efficacy of vaccines have had a significant impact on the mood of users, reducing fear and uncertainty and providing a sense of security and hope for the future. The success of vaccines in reducing the spread and severity of COVID-19 highlights the importance of continued investment in vaccine research and development, as well as the need for equitable distribution of vaccines to ensure their availability to all individuals, regardless of their socio-economic status.

After vaccines were introduced in August 2020, people started to go back to normal life. Yet less they knew of what might be coming in later months. While adapting to a new normal with masks and sanitizers: an increase in the positivity and willingness to go back to life was evident. An analysis of the top 100 songs during a particular time period revealed a wave of increase, as reflected in Appendix B, where the positivity of the songs increased from 0.52 to 0.53. This indicates a general trend of increasing positivity in the songs during that period. However, when looking specifically at the top 5 songs during this period, a mix of valence in terms of positivity and energy was observed.

This mix of valence reflected the shifting social landscape during the time period in question. With outdoor spaces gradually opening up for parties and social gatherings, individuals may have been feeling more positive and energetic. However, it is important to note that social distancing measures were still in place, which may have influenced the mix of valence observed in the top 5 songs. In particular, Cardi B and BTS seemed to be back in action during this time period, as they both made it to the top songs in August 2020, as seen in the table. Their inclusion in the top songs during this time period may be reflective of their ability to connect with audiences in a positive and energetic way, while still adhering to social distancing guidelines.

Overall, the mix of valence observed in the top 5 songs during this time period highlights the complex interplay between social factors and musical preferences. As individuals navigate a rapidly changing social landscape, their musical tastes may shift in response, reflecting both positive and negative emotions. Understanding these nuances is important for musicians and researchers alike, as it can inform the creation and analysis of music that resonates with audiences on a deeper level.

Table 2 - Top 5 Songs in August 2020

Song	Artist	Valence	Energy	Danceability	Tempo
WAP (feat. Megan Thee Stallion)	Cardi B	0.357	0.454	0.935	133.073
Dynamite	BTS	0.737	0.765	0.746	114.044
Hawaii	Maluma	0.558	0.727	0.783	180.067
Savage Love (Laxed - Siren Beat)	Jawsh 685	0.761	0.481	0.767	150.076
Laugh Now Cry Later (feat. Lil Durk)	Drake	0.522	0.518	0.761	133.976

3.3. Delta Variant

Delta variant was first identified in India in late 2020 near the end the year it soon spread throughout the world, becoming what was the predominant version of the coronavirus. (Katella 2023). By May 2021, after a steady decline in COVID-19 cases and hospitalizations, the arrival of Delta coincided with a rapid reversal of that trend. Delta was believed to be more than twice as contagious as previous variants, and studies have shown it to be more likely than the original virus to put infected people in the hospital. “People who were not vaccinated were most at risk, and the highest spread of cases and severe outcomes happened in places with low vaccination rates.” (Kathella 2022)

The mood of users is an important factor to consider when analyzing public sentiment towards a particular issue or event. In the case mentioned, it was observed that initially, there was a gradual

increase in positivity among users regarding the issue being discussed. However, this positivity was short-lived as soon as the vulnerability of those who were not vaccinated became apparent and they were at risk of losing their lives. This caused a sense of uncertainty and fear among users, leading to a decline in the overall positivity of their mood.

Furthermore, when analyzing the top 5 songs, it was observed that a specific track, "Tode Di Ti" by Rauw Alejandro, had a mixed emotional response from users. The track was high on energy and danceability, which generally tend to be associated with positive emotions. However, despite the upbeat nature of the song, the emotional response among users was more complex, and the positivity of the track seemed to have shifted.

This indicates that emotions are not always straightforward and can be influenced by a variety of factors, including external events and personal experiences. Understanding the nuances of user emotions and sentiment is crucial for businesses and organizations to tailor their messaging and communication strategies accordingly. By analyzing and interpreting the mood of users, organizations can gain valuable insights into how their target audience is feeling and make informed decisions to better connect with them.

Table 3 - Top 5 Songs in May 2021

Song	Artist	Valence	Energy	Danceability	Tempo
good 4 u	Olivia Rodrigo	0.688	0.664	0.563	166.928
Todo De Ti	Rauw Alejandro	0.336	0.719	0.78	127.962
Yonaguni	Bad Bunny	0.44	0.648	0.644	179.951
MONTERO (Call Me By Your Name)	Lil Nas X	0.758	0.508	0.61	178.818
Kiss Me More (feat. SZA)	Doja Cat	0.781	0.705	0.764	110.97

3.4. Omicron Variant

The original Omicron strain was first identified in Botswana and South Africa in late November 2021, and cases quickly began to surface and multiply in other countries. By December 2021 right before the holiday season, Omicron was causing daily case numbers in the U.S. to skyrocket to over a million. (Katella 2023) This variant was not protected in the booster dose of the vaccine against the protection of COVID'19. While breakthrough infections in vaccinated people were expected, getting vaccinated and staying up to date with your vaccine and the latest booster shot is the best protection against Omicron.

During this time a rollercoaster of mood was observed. In terms of valence, it varied from 0.57 to 0.50 then increased to 0.55 and dropped to 0.51. It was due to the certainty yet people were

celebrating Christmas and new years. A similar pattern was observed in the energy and danceability of the songs. The top 5 songs depict a similar picture of mood as mentioned in the table below with top 2 songs being the Christmas celebration songs.

Table 3 - Top 5 Songs in December 2021					
Song	**Artist**	**Valence**	**Energy**	**Danceability**	**Tempo**
All I Want for Christmas Is You	Mariah Carey	0.35	0.627	0.336	150.273
Last Christmas	Wham!	0.947	0.478	0.735	107.682
STAY (with Justin Bieber)	The Kid LAROI	0.478	0.764	0.591	169.928
abcdefu	GAYLE	0.415	0.54	0.695	121.932
Rockin' Around The Christmas Tree	Brenda Lee	0.898	0.472	0.589	67.196

After evaluating the data of Spotify users for the major events of COVID'19 from February 2020 to December 2022, it indicated that high valence, low energy and soothing music with lower tempo had an impact on mood and perceptions of the users. In times of certainty users were using music as a coping mechanism to stay motivated and keep their mood lifted.

3.5. Spotify Popularity Index

Spotify also measures the popularity of the artist during a certain time. It is a 0-to-100 score that ranks how popular an artist is relative to other artists on Spotify. Importantly, having a high rank will improve a track's discoverability within the platform. When you release a song, the first days will be crucial to determine its popularity and future success. Sadly, the Spotify popularity index is not visible on the artist page like the monthly listeners and followers are or in the Spotify for artists dashboard, or on the desktop or mobile app. It's only available within the Spotify Developer API, and from there, you can find it through other external tools.
As an artist's numbers grow, they get placed in more editorial playlists and their reach on algorithmic playlists and recommendations is increased. The Index can be used to monitor and influence the progress of new releases. Each track has its own Spotify Popularity Index, calculated influencing the artist's overall index. Yet, it is majorly determined by recent stream count, other factors like save rate, the number of playlists, skip rate, and share rate can indirectly bump up or push down a song's popularity index. It helps in understanding the algorithm and how it affects the popularity index, by providing the knowledge about users' power to influence the market and share our music in more effective ways.

In my visualization I have taken the popularity index during pandemic to identify which artist influenced the users most and made it to their playlists. Using the tool tip the users can spot their favorite artist's popularity during January 2020 to December 2022. Clearly it was evidence that

Taylor Swift is one of the major additions to the users playlists. It suggests that she had more visibility, which means more streams, follows and saves on Spotify into discovery playlists, which then will get her into the personalized playlists of the most engaged fans.

4. Conclusion

After evaluating the four different major milestones of the pandemic along with the mood of Spotify users it could easily be said that music has been an important tool for Spotify users during the COVID-19 pandemic. It was helping them to cope with the various mood changes they may have experienced during the pandemic which reinforced the toll that a lack of social contacts can take on mental health. As it was directly affecting the physiological aspects of stress, helping to calm the body and promote relaxation, while also having a psychological effect on stress, improving worry, anxiety, and restlessness. By exploring the relationship between music and worldly affairs, we can gauge the mood of users through the music they listen to, whether positive or negative songs, or more danceable and high beat music based on the beat of a track to stay motivated. Ultimately what kept Spotify's users going through this time was positive, happy and noisy music to keep their moods uplifted and motivated.

To address this gap in the research, it may be useful to conduct a more in-depth analysis of the lyrics of songs that are commonly associated with motivation, such as those often used in workout playlists or motivational speeches. By examining the language and patterns within these lyrics, researchers can gain a better understanding of what makes certain songs more effective at motivating listeners than others. Furthermore, a machine learning algorithm could be used to extract common words and phrases from motivational songs and create new songs that are optimized for valence, energy, danceability, and tempo. By taking into account these factors, researchers could create new music that is specifically designed to uplift listeners and help them achieve their goals.

The limitations of this research were that only top 100 songs were used globally so there is no geographical distribution of the songs. As Spotify operates in more than 60 countries and each country may have different song choices based on their language understanding and community they belong to. Against each song the values are calculated by Spotify based on their meters to quantify the tracks on a normalized scale which is not a standardized measure. In addition to this, average was used to generalize the findings, which may have been used to equalize the emotions in a way.

5. References

Daniel, Ari. 2023. “COVID was declared a pandemic on 3/11/20. Photos and quotes capture the moment : Goats and Soda.” NPR. https://www.npr.org/sections/goatsandsoda/2023/03/10/1162169741/on-3-11-20-who-declared-a-pandemic-these-quotes-and-photos-recall-that-historic-.

FDA. 2020. “FDA Takes Key Action in Fight Against COVID-19 By Issuing Emergency Use Authorization for First COVID-19 Vaccine.” https://www.fda.gov/news-events/press-announcements/fda-takes-key-action-fight-against-covid-19-issuing-emergency-use-authorization-first-covid-19.

Ferguson, Yuna L., and Kennon L. Sheldon. 2013. “Trying to be happier really can work: Two experimental studies.” *The Journal of Positive Psychology* 8 (1): 23-33.

Katella, Kathy. 2021. “Our Pandemic Year—A COVID-19 Timeline > News.” Yale Medicine. https://www.yalemedicine.org/news/covid-timeline.

Katella, Kathy. 2023. “Omicron, Delta, Alpha, and More: What To Know About the Coronavirus Variants.” Yale Medicine. https://www.yalemedicine.org/news/covid-19-variants-of-concern-omicron.

Kathella, Kathy. 2022. “5 Things To Know About the Delta Variant > News.” Yale Medicine. https://www.yalemedicine.org/news/5-things-to-know-delta-variant-covid.

Khadpe, Jay. 2019. “Music is the Shorthand of Emotion – The Vocal CORD.” The Vocal CORD. https://cordemblog.com/2019/01/17/music-is-the-shorthand-of-emotion/.

Lee, C., Eduardo B. Andrado, and S. Palmer. 2013. “Interpersonal Relationships and Preferences for Mood-Congruency in Aesthetic Experiences.” Semantic Scholar.

https://www.semanticscholar.org/paper/Interpersonal-Relationships-and-Preferences-for-in-Lee-Andrade/ca111d00b9ba52bd127c8b684ffe146bb5359a2b#citing-papers.

Rice, Damien, and Matt Galbraith. 2008. “Music and emotion: Perceptual determinants, immediacy, and isolation after brain damage.” Cognition. https://psycnet.apa.org/record/1998-12962-002.

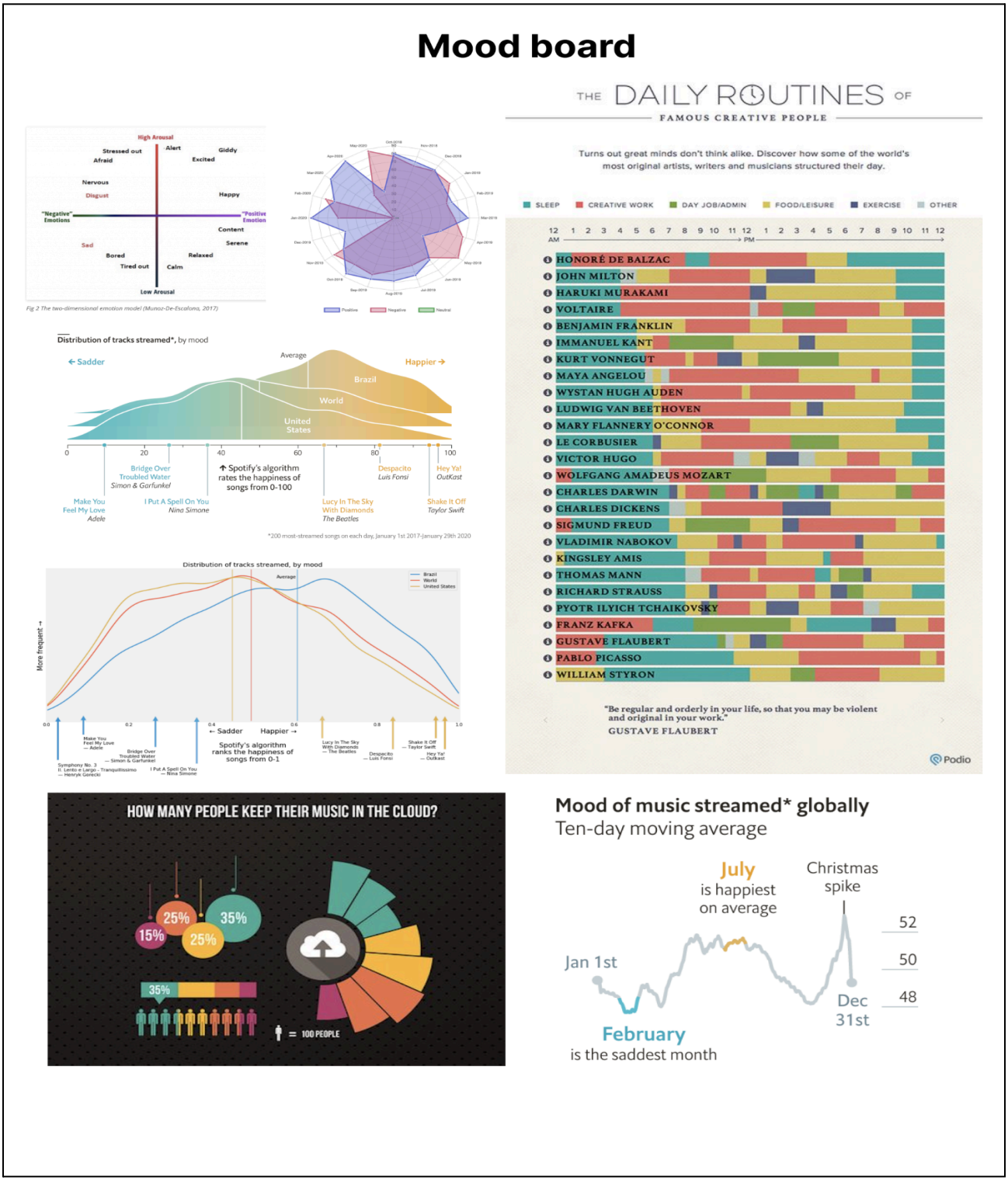
Stratton, Valerie N., and Annette H. Zalanowski. 1989. “The Effects of Music and Paintings on Mood.” https://doi.org/10.1093/jmt/26.1.30.

Valliammai, Akila M. 2022. “Covid-19 vaccines prevented nearly 20 million deaths in a year, study estimates.” STAT News. https://www.statnews.com/2022/06/23/covid19-vaccines-prevention-global-deaths/.

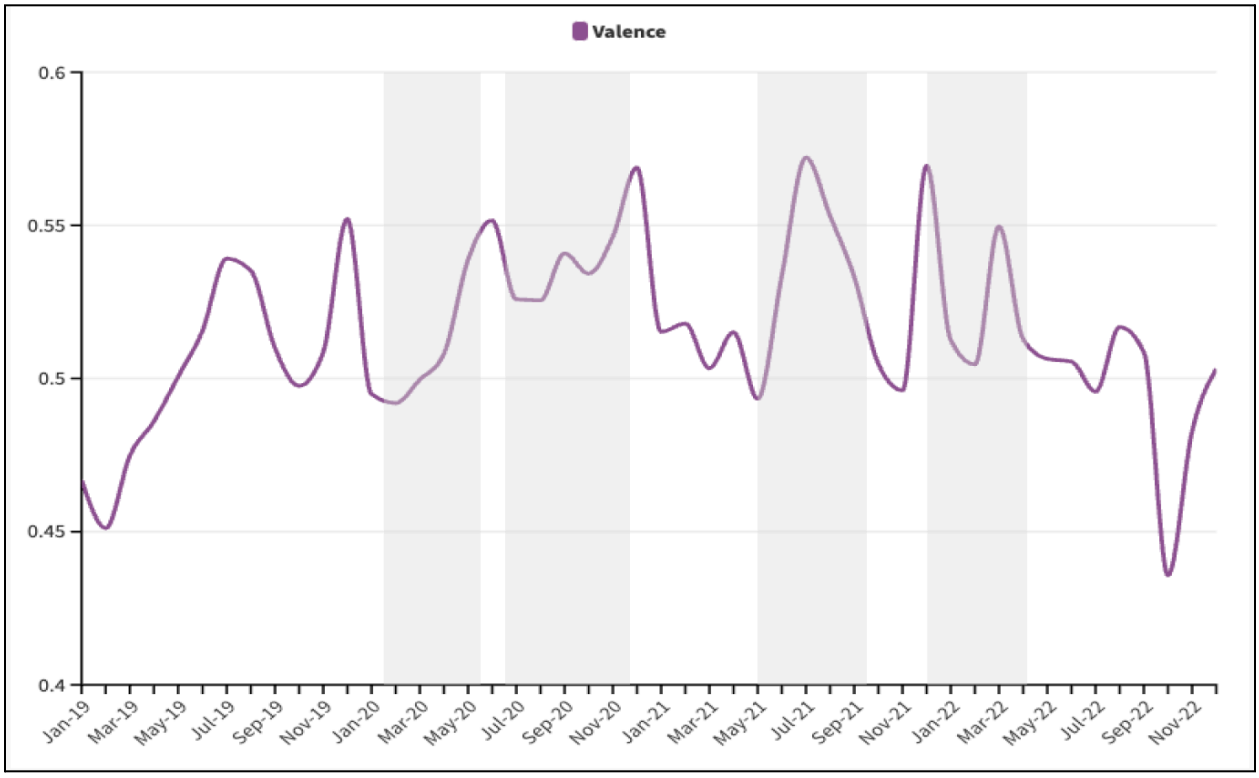
World Health Organization. 2020. “Coronavirus disease (COVID-19) pandemic.” https://www.who.int/europe/emergencies/situations/covid-19.

6. Appendix

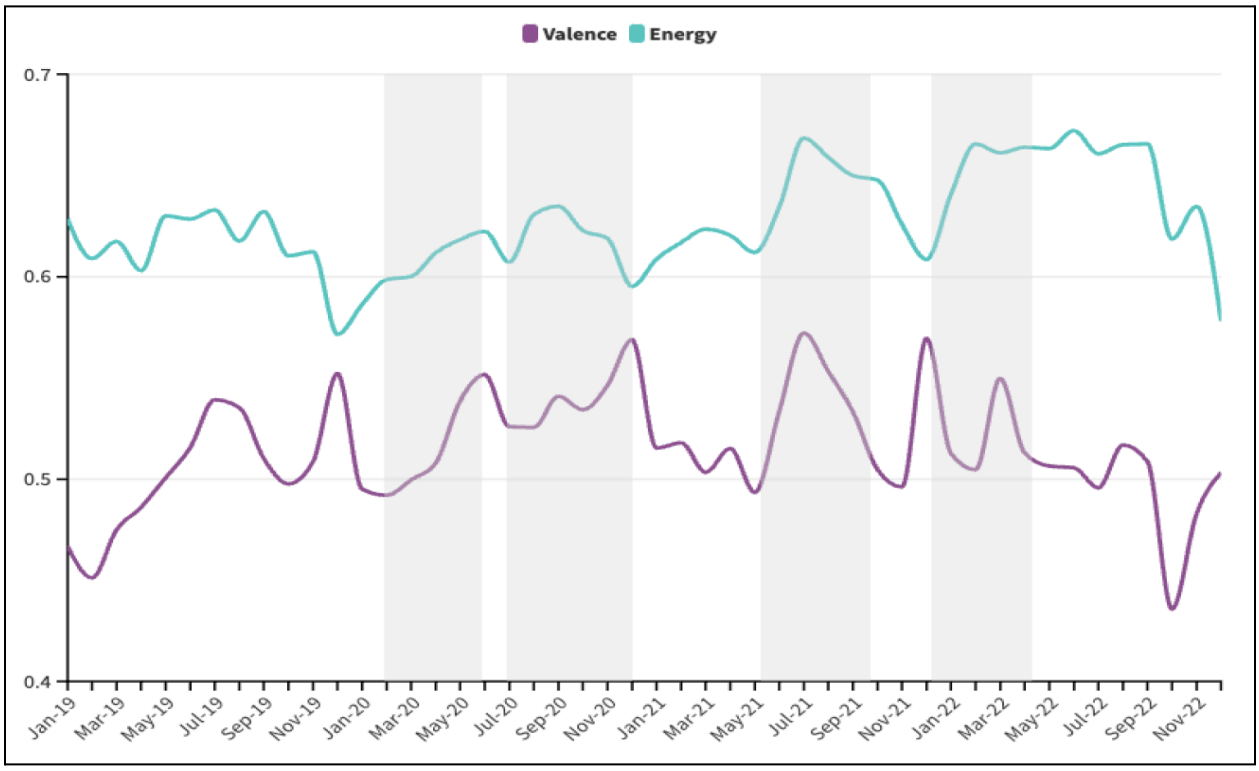
A - Moodboard



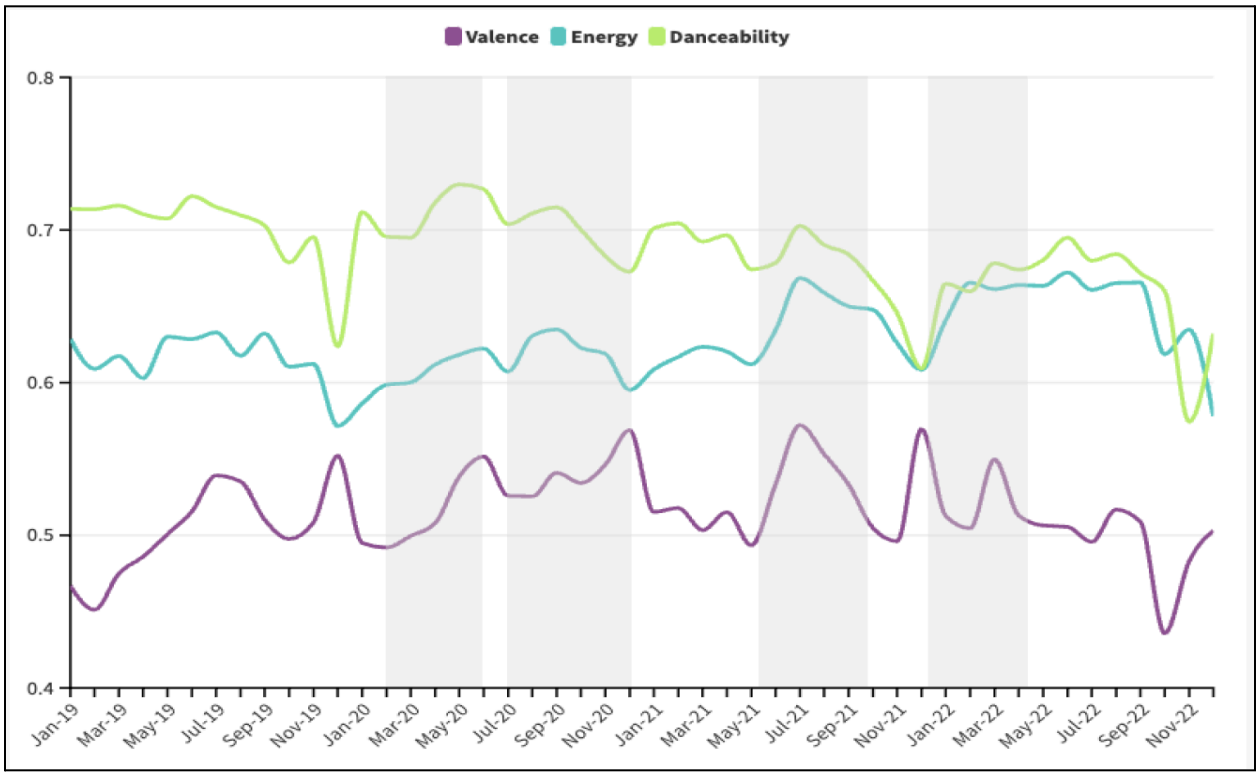
B - Valence



C - Valence and Energy



D - Valence, Energy and Danceability



E - Valence, Energy, Danceability and Tempo