Data Analysis for Music Sentiment Recommendation

Alpha Project Team Members

1) **Thiha Tun**
2) **Thandar Aung**
3) **Htet Htet Moe San**
4) **Myat Phoo**
5) **Thiri Whar Whar Lwin**

About Dataset		
1.	**Columns**	**Description**
2.	**Sentiment_Label**	**Classified sentiment (Happy, Sad, Relaxed, Motivated).**
3.	**Recommended_Song_ID**	**Unique identifier for the recommended song.**
4.	**Song_Name**	**Name of the recommended song.**
5.	**Artist**	**Music artist of the recommended song.**
6.	**Genre (အမျိုးအစား)**	**Genre classification of the song.**
7.	**Tempo (BPM):**	**Beats per minute (BPM) of the song.**
8.	**Mood:**	**Emotional tone of the song (e.g., Joyful, Melancholic, Soothing).**
9.	**Energy:**	**Level of energy in the song (Low, Medium, High).**
10.	**Danceability:**	**Suitability of the song for dancing (Low, Medium, High).**

(1) Objective:

The objective of this Music Sentiment Analysis study is to analyze musical attributes such as:

1. **Genre**
2. **Tempo**
3. **Mood**
4. **Energy**

5. **Danceability**

The goal is to find their correlation with **Sentiment Labels** (e.g., happiness, sadness, calmness, excitement).

Main Objectives:

1) Examine the Relationship Between Music Genre and Sentiment:
    a) For example: Pop music may be associated with "Happy" sentiments, while Hip-Hop could correlate with "Motivated" sentiments.
2) Understand the Role of Tempo:
    a) Higher tempos (120–160 BPM) are expected for "Happy" sentiments.
    b) Lower tempos (60–80 BPM) are expected for "Sad" sentiments.
3) Analyze the Impact of Energy and Danceability:
    a) "High Energy" is anticipated to correlate with "Happy" and "Motivated" sentiments.
4) Build a Music Recommendation Model Based on Sentiment Data:
    a) This will involve using algorithms, such as the Random Forest Algorithm, to predict sentiment primarily based on Tempo, Genre, and Mood.
5) Assess Data Quality and Consistency:
    a) The correlation between sentiment and other data points will be validated using statistical methods like the Chi-square Test and ANOVA Test.

Benefits

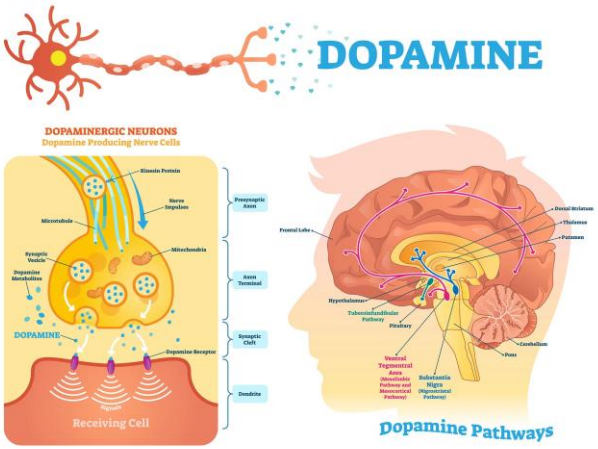
1. **This study will aid in the development of Automated Music Recommendation systems, allowing for the precise selection of songs that match a listener's mood.**
2. **Music creators can use this research as a guide when composing songs to evoke specific emotions.**

a) For example:

i) If the goal is to uplift spirits, High Tempo music (Funk, Hip-Hop) can be recommended.

ii) If the aim is to reduce stress, Low Tempo music (Ambient, Classical) can be chosen.

The Role of Brain Chemicals in Music-Induced Emotions



1) Dopamine

a) Dopamine is a neurotransmitter that controls "happiness, motivation, and addiction."

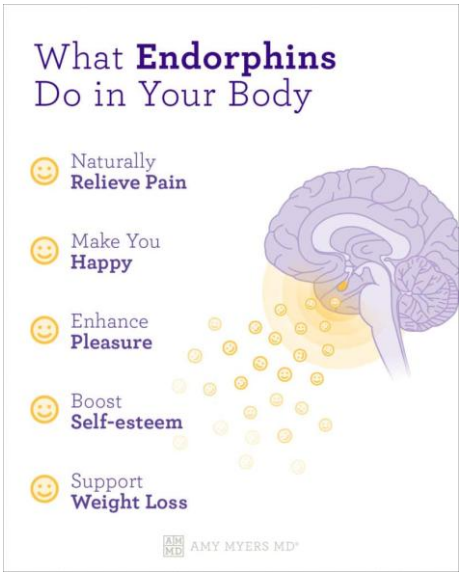
2) Connection to Music:

a) Fast-tempo songs (e.g., 120–160 BPM, Pop, Funk) stimulate dopamine production, leading to increased energy and excitement.

b) Listening to exciting music (e.g., Hip-Hop, EDM) increases dopamine in the brain, resulting in feelings of satisfaction.

3) Song Preference (Anticipation & Reward):

a) When you anticipate a chorus or a specific part of a song you like, dopamine is released, creating a "positive emotional response."



Endorphins – Natural Painkillers

1. Endorphins **reduce pain** and **induce feelings of euphoria**, similar to the effects of exercise.
2. Connection to Music:

   a) High-energy rhythms ("Energetic," "Powerful") stimulate the release of endorphins, boosting endurance and morale.

   Example: Workout playlists or drum-heavy tracks.

Serotonin – The Mood Stabilizer

1. Serotonin **regulates mood, relaxation, and overall well-being**.
2. Connection to Music:

a) Soothing melodies ("Calm," "Emotional") can increase serotonin levels, helping to reduce stress and anxiety.

Example: Slow-tempo, instrumental music, or nature sounds often promote relaxation.

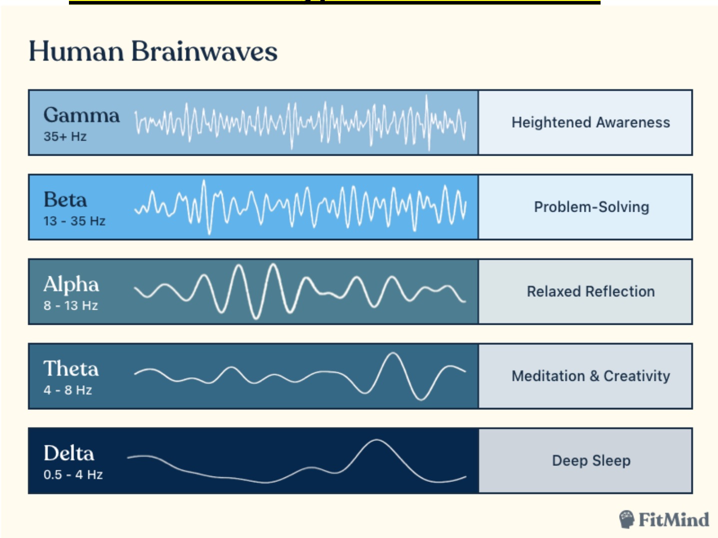
Oxytocin – The Bonding Hormone

1. Oxytocin **enhances social bonding and trust**.
2. Connection to Music:

a) Group singing, harmonies, or emotionally intimate lyrics ("Melancholic," "Soothing") can increase oxytocin levels, promoting social connection and trust.

Example: Choral music or love ballads may foster emotional closeness.

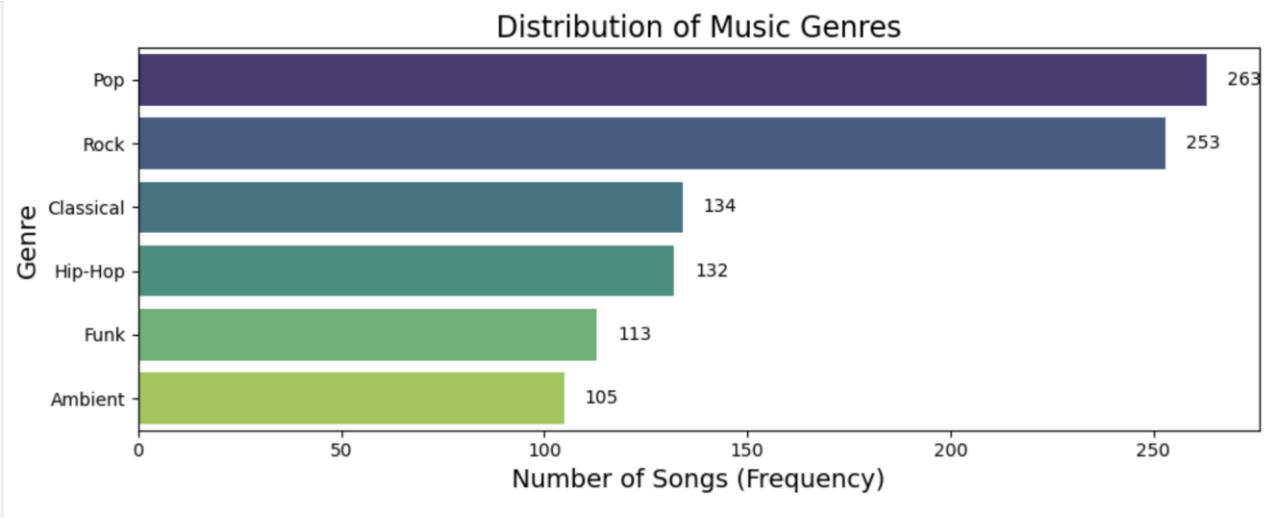
Brain Waves: Types and Functions



Type of Human Brain Waves	Functions
1) Gamma Waves (30 – 100+ Hz)	High-level cognition Memory recall Awareness or Consciousness Peak concentration
2) Beta Waves (13 – 30 Hz)	Active thinking Concentration or Focus Problem-solving Alertness or Vigilance
3) Alpha Waves (8 – 13 Hz)	Calmness / Relaxation Alertness Relaxed focus / Gentle attention Learning Coordination
2) Theta Waves (4 – 8 Hz)	Light sleep Relaxation Meditation Creativity Insight
5) Delta Waves (0.5 – 4 Hz)	Deep sleep Unconsciousness Healing or Therapy Regeneration or Restoration

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

(1) Song Frequencies by Music Genre



Number of Songs by Music Genre

Total Songs: 1000 tracks

1) Pop music has the highest number of songs (263 tracks).
    i) Rock: 253 tracks
    ii) Classical: 134 tracks
    iii) Hip-Hop: 132 tracks
    iv) Funk (rhythmic, danceable, energetic music): 113 tracks
    v) Ambient (calming music): 105 tracks

"Statistical Foundations & Algorithmic Implementation of Music Sentiment Analysis"

When using normalize='index', the cross-tabulation calculates the **conditional probability** of each **sentiment category (s)** for each individual **music genre**.

Algorithm / Formula

$$P(\text{Sentiment} = s \mid \text{Genre} = g) = \frac{\#\{\text{rows with Genre} = g \ \wedge \ \text{Sentiment} = s\}}{\sum_{s'} \#\{\text{rows with Genre} = g \ \wedge \ \text{Sentiment} = s'\}}$$

In other words:

1. For each genre (g), count the number of songs in each sentiment category (s).
2. Divide these counts by the total number of songs within that specific genre (g).
3. The result is the probability distribution of sentiments for each music genre.

Example:

For 100 Pop songs:

1. 60 songs → Happy
2. 25 songs → Sad
3. 15 songs → Exciting

Distribution:

1. P(happy|Pop) = 0.6
2. P(sad|Pop) = 0.25
3. P(exciting|Pop) = 0.15

This method helps us understand "which music genre is more likely to evoke specific types of emotions." (This is a fundamental concept of Conditional Probability, useful in Data Analysis.)

What this table shows is:

1. The probability of each sentiment category (s)
2. for each music genre (g)
3. calculated as a percentage *within* that genre.

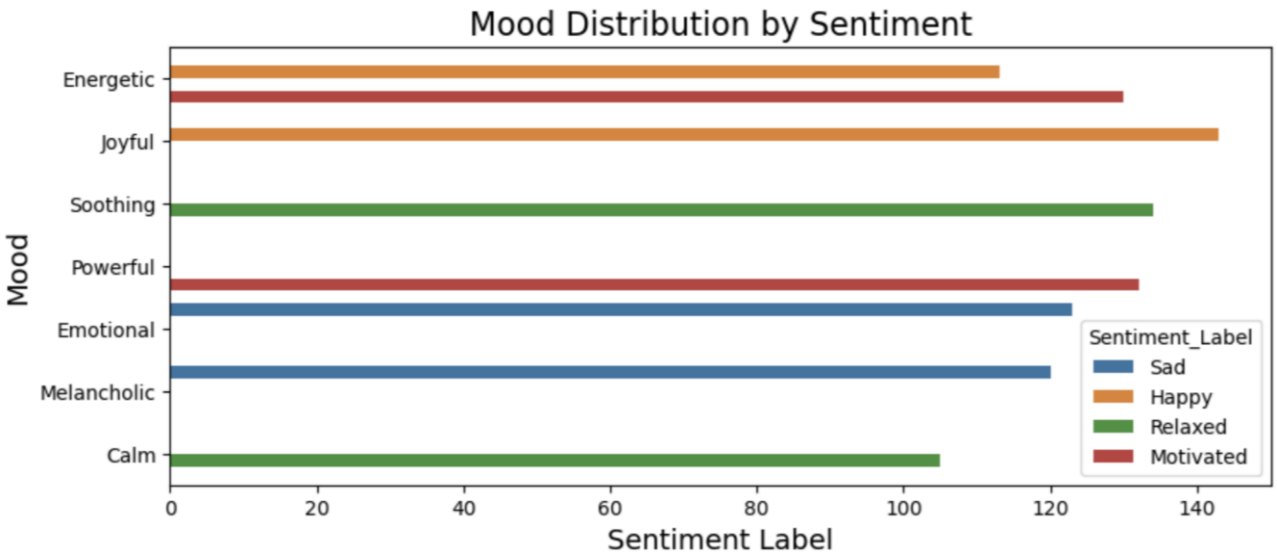
For example, 30% of all Rock music is exciting, 50% is calm, and so on.

This is calculated using the Conditional Probability Formula.

(It's similar to using pd.crosstab(..., normalize='index') in Pandas when doing Data Science!)

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

(2) Mood Distribution by Sentiment Category



Mood Distribution by Sentiment

Key Points:

1. The "Joyful" mood is the most frequently observed sentiment.
2. The "Happy" sentiment is most strongly associated with the "Joyful" mood.
3. The "Relaxed" sentiment is most strongly associated with the "Soothing" mood.
4. The "Sad" sentiment is least frequently observed with the "Melancholic" mood.

"Statistical Foundations & Algorithmic Implementation of Music Sentiment Analysis"

Count Formula

$$\text{Count}(m, s) = \sum_{i=1}^{N} \mathbf{1}\{\text{Mood}_i = m \wedge \text{SentimentLabel}_i = s\}$$

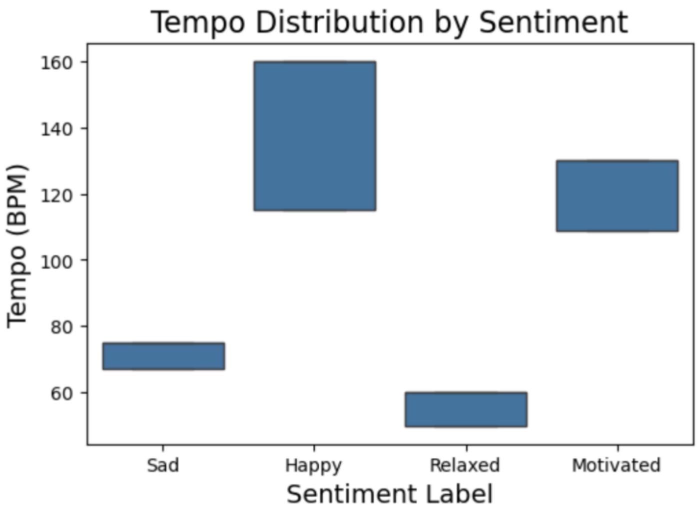
For each sentiment m and sentiment label s, the countplot function indicates the number of songs that fall into that combination (1 if true, 0 otherwise). Seaborn's countplot then takes these raw counts (using its default stat='count') and displays a bar for each sentiment on the y-axis. The bars are colored by the hue parameter for different sentiments and can be viewed side-by-side ("dodged")

Summary

Visualizing various moods by sentiment provides immediate insight into which moods are most strongly associated with positive, neutral, or negative songs. For example, if "Happy" songs predominantly fall into the positive category, or if "Melancholic" songs skew negative, this visualization makes it clear.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

(3) Tempo Distribution by Sentiment Category



Tempo (BPM) and Sentiment Boxplot

Key Points:

1. The "Happy" sentiment has the highest Tempo (Median: ~140 BPM).
2. The "Relaxed" sentiment has the lowest Tempo (Median: ~60 BPM).
3. The "Sad" sentiment also shows a low Tempo range (60-80 BPM).

Other Observations:

1. There are no outliers present.
2. "Happy" has the largest Interquartile Range (IQR), while "Relaxed" has the smallest IQR.

"Statistical Foundations & Algorithmic Implementation of Music Sentiment Analysis"

1. Mathematical Method of Seaborn (and Matplotlib) Boxplot and its Significance for Tempo-Sentiment Comparison

1) Boxplot Structure

a) Defining the box with Quartiles (Q1, Q3) and IQR (Interquartile Range).

b) Setting whisker boundaries.

c) Highlighting outliers specifically.

2) Utility for Tempo-Sentiment Analysis

a) Clearly visualizes tempo differences across sentiments.

b) Allows for quick analysis of tempo distribution for each group.

c) Helps identify the presence of extremely fast/slow tempos (outliers).

2. Algorithm / Formula

1. Sort the data for a given sentiment category in ascending order.

a) "This ensures that quartile calculations are accurately performed on ordered values."

2. Compute the three quartiles:

a) Q2 (Median) is the 50th percentile value.

b) Q1 is the 25th percentile value.

c) Q3 is the 75th percentile value.

3.*Calculate *the interquartile range (IQR)

$$\mathrm{IQR} = Q_3 - Q_1$$

The IQR (Interquartile Range) measures the spread of the middle 50% of the data.

4.How Whisker Boundaries are Calculated in Seaborn (using default whis=1.5)

In Seaborn's boxplots, the whiskers are typically determined using a factor of 1.5 times the Interquartile Range (IQR). Here's how it works:

1. Lower Whisker: Q1−(1.5×IQR)
2. Upper Whisker: Q3+(1.5×IQR)

Any data points that fall outside these whisker boundaries are considered outliers and are usually plotted individually as points or symbols. This method helps to visually identify values that are significantly different from the majority of the data.

$$\textbf{Lower bound} = \max\left(\min(\text{data}),\ Q_1 - 1.5\,\mathrm{IQR}\right)$$

$$\textbf{Upper bound} = \min\left(\max(\text{data}),\ Q_3 + 1.5\,\mathrm{IQR}\right)$$

5. How to Draw Boxplots and Whiskers

Here's a breakdown of how boxplots and their whiskers are drawn:

1. From Bottom to Top:

   a) Draw a box from Q1 (25th Percentile) up to Q3 (75th Percentile).

2. The Middle Line:

   a) Add a line at Q2 (Median/50th Percentile) within the box.

3. The Whiskers:

   a) Extend a whisker downwards from Q1 to the lowest data value (that falls within the calculated Lower Bound).

   b) Extend a whisker upwards from Q3 to the highest data value (that falls within the calculated Upper Bound).

$$< Q_1 - 1.5\,\mathrm{IQR} \quad \text{or} \quad > Q_3 + 1.5\,\mathrm{IQR}$$

Outlier Points Beyond Whisker Boundaries

1) Outliers are typically shown as individual points ("fliers").
   a) A boxplot summarizes a distribution using five key numbers: minimum, Q_1, median, Q_3, and maximum/outliers.
2) When Comparing Tempo (BPM) and Sentiment Categories:
   a) You can observe if "Positive" songs have average tempos that are higher or lower than "Neutral" or "Negative" songs.
   b) You can see how uniformly the tempos are clustered within each category (indicated by the IQR width).
   c) You can identify if songs with extremely fast or extremely slow tempos are more prevalent in any particular sentiment category.

(The boxplot is an effective method for comparing central tendency, spread, and outliers across different data sets.)

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Analysis- By Song Frequency, Mood Distribution, and Tempo Distribution

Pop (100-130 BPM)

1. **Mood and Energy:**

   a) Elicits a wide range of emotions, from happiness and excitement to nostalgia and melancholy.

2. **Brainwaves:**

   a) Associated with Beta Waves (13–30 Hz), which are linked to alertness and motivation, making listeners feel more energized and positive.

3. **Neurochemical Effects:**

   a) Stimulates the brain by boosting Dopamine, which enhances mood and energy.

Rock (110-140 BPM)

1. **Mood and Energy:**

   a) Can uplift mood or provide emotional release.

1) Brainwaves

a) Beta Waves (13–30 Hz), associated with alertness and concentration, and sometimes Gamma Waves (30–100+ Hz), linked to high-level cognition, can increase energy and excitement.

2) Neurochemical Effects

a) The Amygdala (emotions), Prefrontal Cortex (decision-making), and Auditory Cortex (sound processing) are actively involved while listening to music.

b) Dopamine is boosted, especially during joyful musical moments, increasing happiness and motivation.

c) Oxytocin is often elevated during communal musical activities, such as concerts, fostering social bonding and trust.

d) Endorphins act as natural painkillers and mood elevators, helping to reduce stress and promote relaxation.

Classical (Common Tempos: 60-100 BPM)

1) Mood and Energy

a) Can induce relaxation, reduce stress, and elevate mood.

b) May improve focus and mental clarity.

2) Brainwaves

a) Alpha Waves (8–13 Hz): Associated with relaxation and calmness.

b) Theta Waves (4–8 Hz): Linked to deep relaxation and meditation.

c) Gamma Waves (30–100 Hz): Connected to enhanced cognitive function and memory processing.

3) Neurochemical Effects

a) Dopamine: Boosts happiness and motivation.

b) Serotonin: Promotes calmness and a sense of well-being.

c) Endorphins: Act as natural painkillers and mood elevators.

d) Oxytocin: Enhances social bonding and trust.

Hip-Hop (85-115 BPM)

1) Mood and Energy

a) Can elevate excitement and energy levels, providing motivation and emotional release.

b) Its dynamic rhythms and expressive lyrics resonate with listeners, fostering a sense of empowerment and connection.

2) Brainwaves

a) Beta Waves (13–30 Hz): Associated with active thinking and concentration. Hip-Hop's rhythm and lyrical content can stimulate these waves, enhancing focus.

b) Gamma Waves (30–100 Hz): Linked to higher cognitive functions. The complex lyrical themes often found in Hip-Hop can engage these waves, promoting problem-solving and creativity.

3) Neurochemical Effects

a) Dopamine: Boosts happiness and motivation, released during enjoyable musical experiences.

b) Serotonin: Promotes calmness and well-being.

c) Endorphins: Act as natural painkillers and mood elevators, helping to reduce stress and promote relaxation.

d) Oxytocin: Enhances social bonding and trust during shared musical experiences.

Funk (Typically Around 114 BPM)

1) Mood and Energy

a) The upbeat and rhythmic patterns of Funk music can **elevate mood and increase energy levels**, providing **motivation and joy**.

2) Brainwaves

a) Beta Waves (13–30 Hz): Associated with active thinking and concentration. Funk's rhythmic grooves can stimulate these waves, enhancing focus.

b) Alpha Waves (8–13 Hz): Linked to relaxation and calmness. Funk's melodic elements can promote these waves, reducing stress.

3) Neurochemical Effects

a) Dopamine: Boosts happiness and motivation, released during enjoyable musical experiences.

b) Serotonin: Promotes calmness and well-being.

c) Endorphins: Act as natural painkillers and mood elevators, reducing stress and fostering relaxation.

d) Oxytocin: Enhances social bonding and trust during shared musical experiences.

Ambient (Generally Between 45-65 BPM)

1) Mood and Energy

a) Ambient music can **reduce stress and anxiety**, promoting **calmness and well-being**.

2) Brainwaves

a) Alpha Waves (8-13 Hz): Associated with relaxation and calmness. The slow tempos and repetitive structures of ambient music can enhance these waves.

b) Theta Waves (4–8 Hz): Linked to deep relaxation and meditation. Ambient music can facilitate these waves, further reducing stress.

3) Neurochemical Effects

a) Dopamine: Promotes happiness and motivation, released during enjoyable musical experiences.

b) Serotonin: Provides calmness and a sense of well-being.

c) Endorphins: Act as natural painkillers and mood elevators, reducing stress and fostering relaxation.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Recommended Music Based on Analysis of Song Frequency, Mood Distribution, and Tempo Distribution

Recommended Music by Sentiment

1. Melancholic: Classical

    a) Its expressive melodies and harmonies can deeply resonate with contemplative feelings.

2. Joyful: Pop

    a) Its rhythmic and catchy tunes tend to stimulate happiness and uplift the mood.

3. Soothing: Ambient

    a) Its gentle, flowing sounds promote relaxation and tranquility.

4. Energetic: Rock and Funk

    a) The driving, lively rhythms can enhance vitality and motivation.

5. Emotional: Hip-Hop

    a) Its expressive lyrics and engaging beats offer a broad spectrum of emotional and personal narratives.

6. Powerful: Rock

    a) Its intense instrumentation and strong vocals can evoke feelings of strength and empowerment.

7. Calm: Ambient and Classical

    a) Both genres provide serene compositions that alleviate stress and induce a state of calm.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Recommended Songs Based on Analysis of Song Frequency, Mood Distribution, and Tempo Distribution

Here are the recommended **Sentiment Label** associations, based on the emotional impact and brain/chemical responses of each genre:

1) Pop → Happy, Motivated
2) Rock → Motivated, Sad
3) Classical → Relaxed, Happy
4) Hip-Hop → Motivated, Happy
5) Funk → Happy, Relaxed
6) Ambient → Relaxed, Sad

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

1. Energy Level Distribution

Sentiment	High Energy	Low Energy
Happy	1.0	0.0
Motivated	1.0	0.0
Relaxed	0.0	1.0
Sad	0.0	1.0

2. Danceability Distribution

Sentiment	High Danceability	Medium Danceability	Low Danceability
Happy	1.0	0.0	0.0
Motivated	0.0	0.598	0.0
Relaxed	0.0	0.0	1.0
Sad	0.0	0.506	0.0

Sentiment Table by Energy and Danceability

Energy:

1. "Happy" and "Motivated" sentiments are associated with "High Energy."
2. "Relaxed" and "Sad" sentiments are associated with "Low Energy."

Danceability:

3. The "Happy" sentiment is associated with "High Danceability."
4. The "Relaxed" sentiment is associated with "Low Danceability."
5. The "Sad" sentiment is associated with "Medium Danceability."

```
Top 10 Recommended Artists:
 Artist
Pharrell Williams    143
Debussy              134
Kanye West           132
Survivor             130
Coldplay             123
Adele                120
Bruno Mars           113
Marconi Union        105
Name: count, dtype: int64
```

Song Count Table by Artist and Song

1) Top Artists:

a) Pharrell Williams (143 songs) - Associated with "Happy"

b) Debussy (134 songs) - Associated with "Relaxed"

c) Kanye West (132 songs) - Associated with "Motivated"

d) Coldplay (123 songs) - Associated with "Sad"

2) Top Songs:

a) "Happy" (Pharrell Williams) - 143 occurrences

b) "Clair de Lune" (Debussy) - 134 occurrences

c) "Stronger" (Kanye West) - 132 occurrences

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Mood States Based on Energy Level and Danceability

Happy

1. **Energy:** High
2. **Danceability:** High

3. **Recommended Genres:** Pop (100–130 BPM), Funk (~114 BPM), Hip-Hop (85–115 BPM)
4. **Impact:** Boosts **dopamine** levels, invigorates the mind, sparks joy, and increases the desire for physical movement. For example, listening to exciting music while exercising.

Motivated

1. **Energy:** High
2. **Danceability:** Medium to High
3. **Recommended Genres:** Rock (110–140 BPM), Hip-Hop, Upbeat Pop
4. Impact: Activates the brain, enhancing focus and drive! Intense and exciting beats can produce this effect!

   a) Scientific Explanation: Beta (13-30Hz) waves are linked to alertness, while Gamma (>30Hz) waves are associated with peak concentration.

Relaxed

1. **Energy:** Low
2. **Danceability:** Low
3. **Recommended Genres: Ambient** (45–65 BPM), **Classical** (60–100 BPM)
4. Impact: Calms the mind and alleviates stress! For example, gentle music can bring a sense of peace similar to meditation.

   a) Scientific Explanation: Alpha (8-12Hz) waves are associated with calmness, while Theta (4-7Hz) waves are linked to deep relaxation.

Sad

1. **Energy:** Low
2. **Danceability:** Medium
3. **Recommended Genres:** Mellow Classical, Slow Hip-Hop, Ambient
4. Impact: Gentle melodies can lighten heavy hearts and bring emotional relief. For instance, it's like unwinding to soft music in the evening.

a) Many artists create such tunes aiming to provide catharsis and comfort to listeners' emotions.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Conclusion

1. **Music genres significantly influence our emotional states by altering brainwave patterns, energy levels, and neurotransmitter release.**
2. **Studies indicate that upbeat, high-energy genres like Pop and Funk boost Dopamine and Beta Wave (13–30 Hz) activity, making them ideal for happiness and motivation.**
3. **Conversely, lower-energy genres such as Ambient and Classical enhance Alpha Waves (8–13 Hz) and Theta Waves (4–8 Hz), promoting Serotonin release, leading to relaxation and introspection.**
4. **Mid-range genres like Rock and Hip-Hop combine both Beta Waves (13–30 Hz) and Gamma Waves (30–100+ Hz). They provide emotional release and drive, aligning with feelings of power and focus.**

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

Overall Impact

This reflects music's direct power to influence the brain and nervous system.

"These scientific findings clearly indicate that songs can:

1. **Regulate mood**
2. **Improve focus and memory**
3. **Alter brain chemistry"**

Music proves to be an incredibly important tool for humans.

For example, listening to music can relieve stress when you're feeling down, or choosing uplifting tunes before an exam can boost your spirits.

"Therefore, music can even be considered a natural medicine for human mental and physical well-being."

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<

References

https://pubmed.ncbi.nlm.nih.gov/35325516/

https://www.tmh.org/healthy-living/blogs/healthy-living/how-music-affects-your-mind-mood-and-body?utm_source=chatgpt.com

https://openai.com/

https://www.deepseek.com/

https://en.wikipedia.org/wiki/Main_Page

https://chat.qwen.ai/

https://www.kaggle.com/datasets/ziya07/ai-powered-music-recommendation-system