

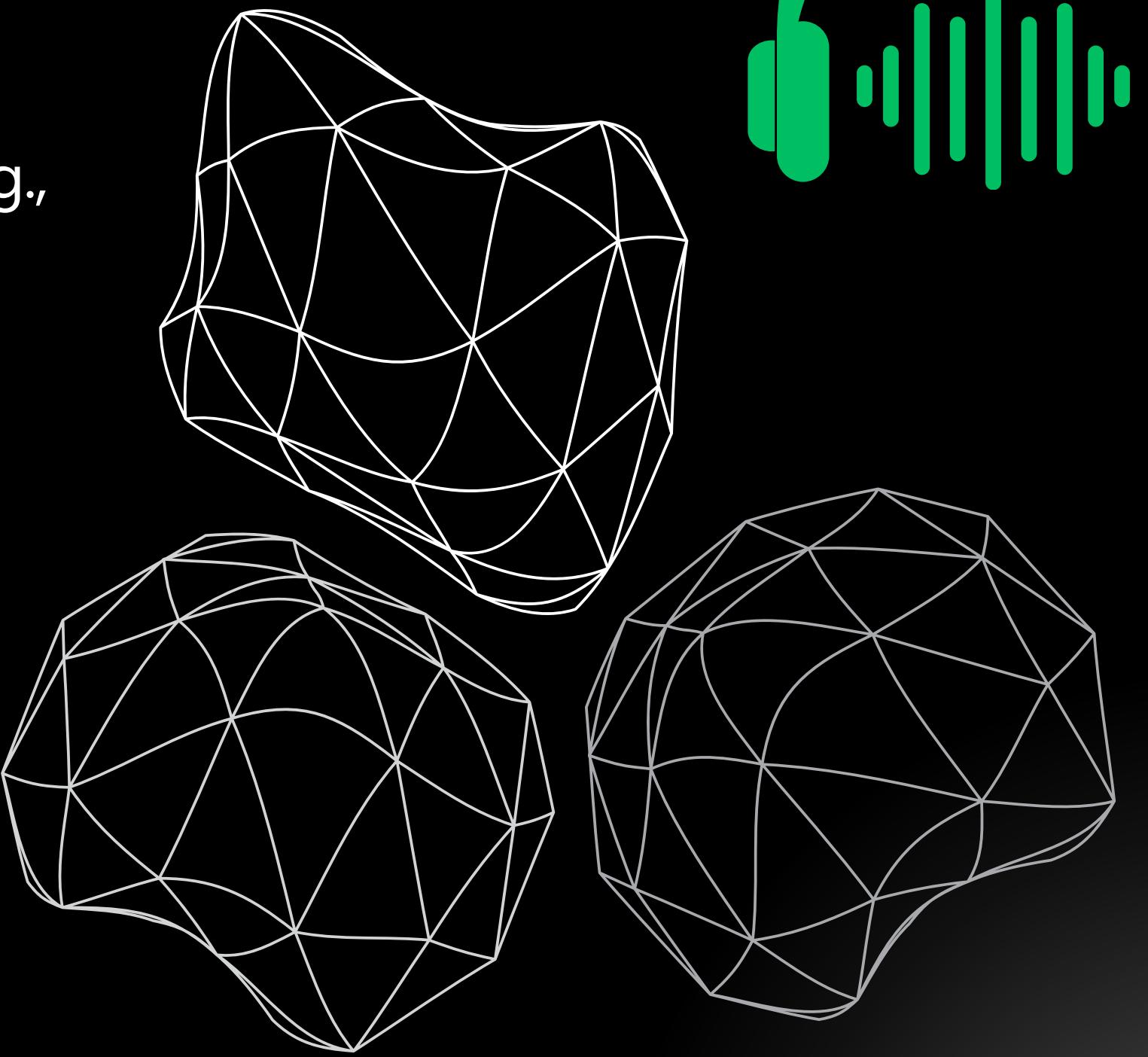
# • EXPLORATORY DATA ANALYSIS OF SPOTIFY TRACKS

INSIGHTS FROM AUDIO FEATURES AND METRICS



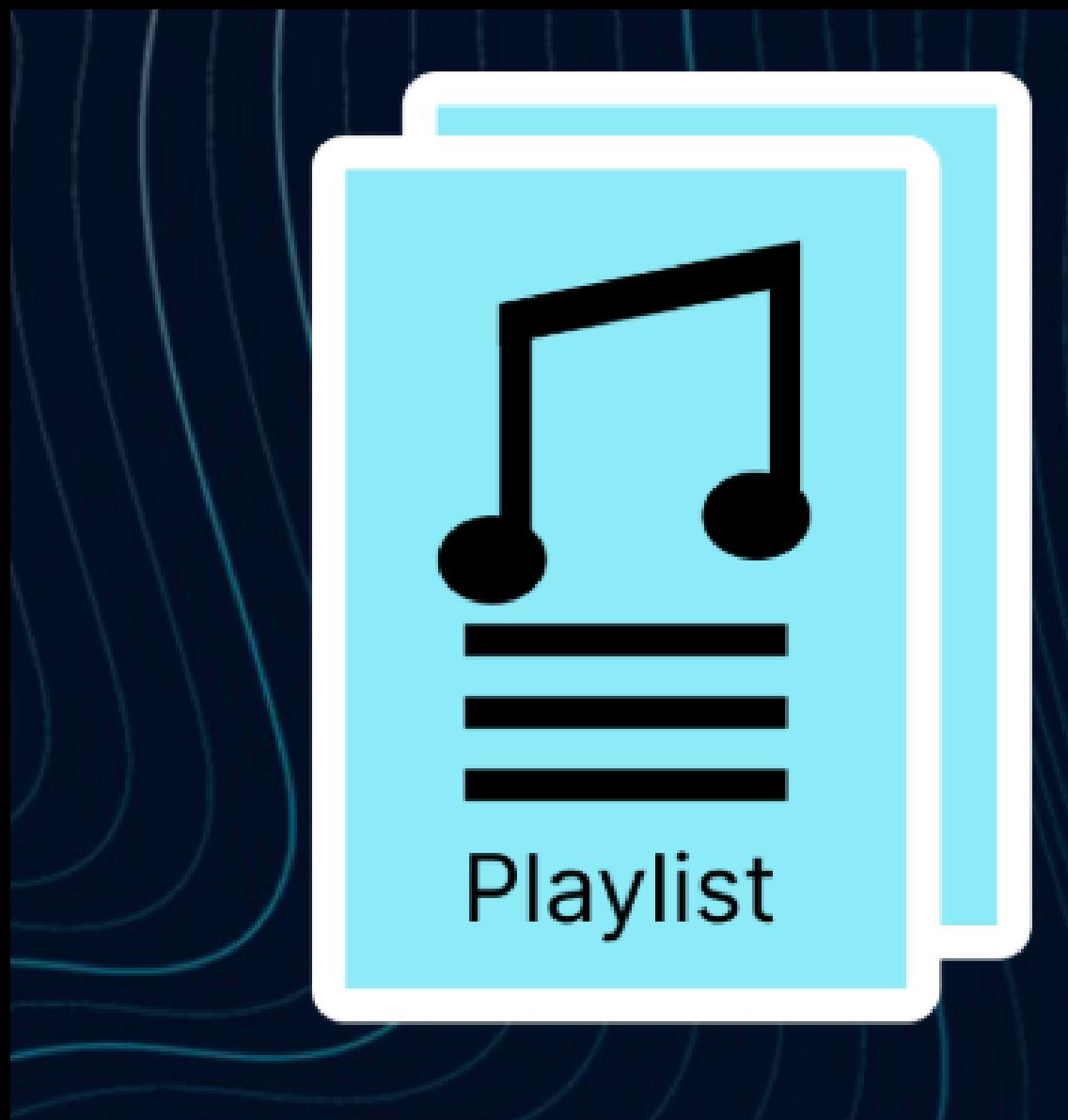
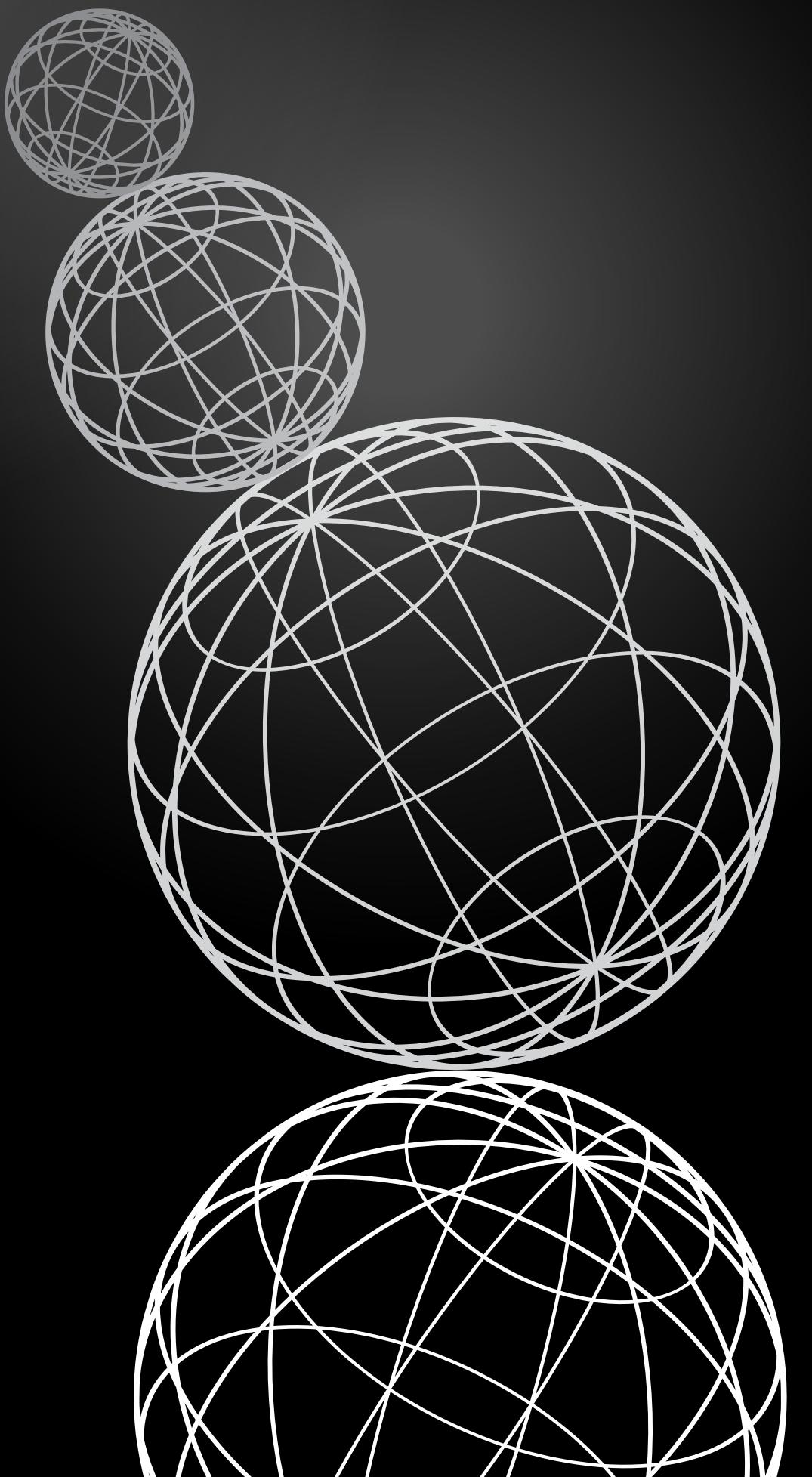
# OBJECTIVE

- Understand the structure of the Spotify dataset
- Identify relationships between variables (e.g., popularity vs. danceability)
- Detect missing or unusual data
- Visualize key musical features



# THE HOOK

- Every skip, play, and save tells a story.
- What can millions of streams reveal about our musical taste?
- Let's explore the data behind the playlists.



# OUR MISSION

- Goal: Uncover the hidden narrative in Spotify's data.
- Focus: Storytelling & Actionable Recommendations.
- Outcome: A deeper understanding of the listening experience.



# MEET THE DATASET

```
df.info()
```

```
→ <class 'pandas.core.frame.DataFrame'>
RangeIndex: 62317 entries, 0 to 62316
Data columns (total 22 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   track_id         62317 non-null   object  
 1   track_name       62317 non-null   object  
 2   artist_name      62317 non-null   object  
 3   year             62317 non-null   int64  
 4   popularity       62317 non-null   int64  
 5   artwork_url      62317 non-null   object  
 6   album_name       62317 non-null   object  
 7   acousticness     62317 non-null   float64 
 8   danceability     62317 non-null   float64 
 9   duration_ms      62317 non-null   float64 
 10  energy            62317 non-null   float64 
 11  instrumentalness 62317 non-null   float64 
 12  key               62317 non-null   float64 
 13  liveness          62317 non-null   float64 
 14  loudness          62317 non-null   float64 
 15  mode              62317 non-null   float64 
 16  speechiness       62317 non-null   float64 
 17  tempo              62317 non-null   float64 
 18  time_signature    62317 non-null   float64 
 19  valence            62317 non-null   float64 
 20  track_url          62317 non-null   object  
 21  language            62317 non-null   object  
dtypes: float64(13), int64(2), object(7)
memory usage: 10.5+ MB
```

- Our characters: Songs from various genres and eras.
- Their attributes: Danceability, Energy, Acousticness, Valence (Happiness), and more.
- The plot: How these features interact to create a hit.

# PRESENTATION AGENDA



# THE BIG PICTURE - AUDIO FEATURES EXPLAINED

```
# =====
# Variable Categorization
# =====

# Numerical Variables (quantitative: int/float)
numerical_vars = [
    "popularity",
    "danceability",
    "duration_ms",
    "energy",
    "instrumentalness",
    "key",
    "liveness",
    "loudness",
    "mode",
    "speechiness",
    "tempo",
    "valence"
]

# Categorical Variables (qualitative: object/category/string)
categorical_vars = [
    "track_id",
    "track_name",
    "artist_name",
    "artwork_url",
    "album_name",
    "track_url",
    "language",
]

# Temporal Variables (date/time)
temporal_vars = [
    "Date",
    "Time"
]
```

## CORE STRUCTURE

**TOTAL VARIABLES: 19 FEATURES**

**TRACK ENTRIES: 62,317 RECORDS**

**DATA TYPES: MIXED (NUMERICAL, CATEGORICAL,  
TEMPORAL)**



**COMPREHENSIVE AUDIO PROFILING (12 TECHNICAL FEATURES)**

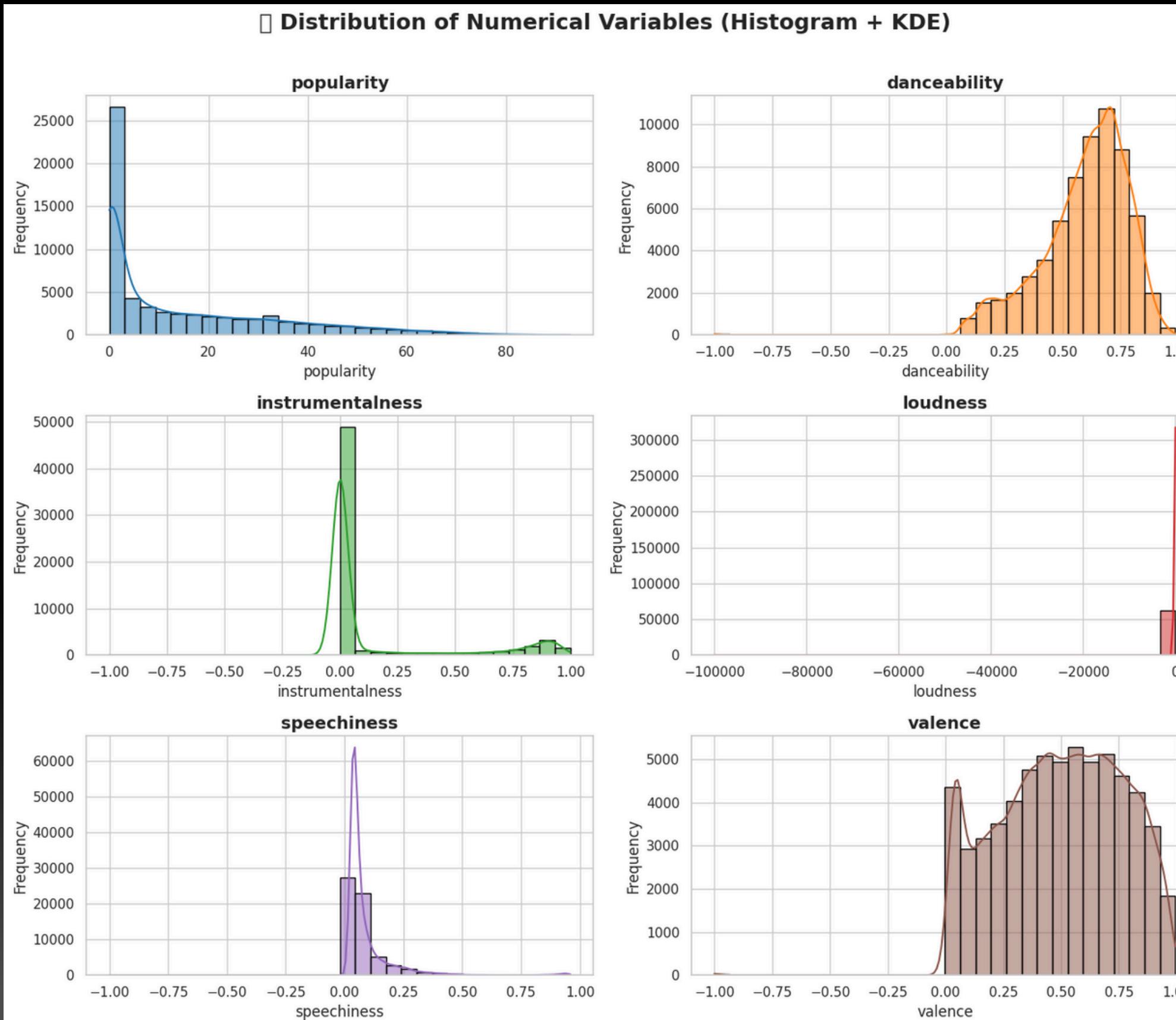
**MULTI-LANGUAGE SUPPORT WITH PROPER CATEGORIZATION**

**UNIQUE IDENTIFICATION ENABLING PRECISE TRACK MATCHING**

**TEMPORAL TRACKING FOR RELEASE PATTERN ANALYSIS**

**STREAMING INTEGRATION VIA URLs**

# HISTOGRAM KDE OF NUMERICAL VARIABLES



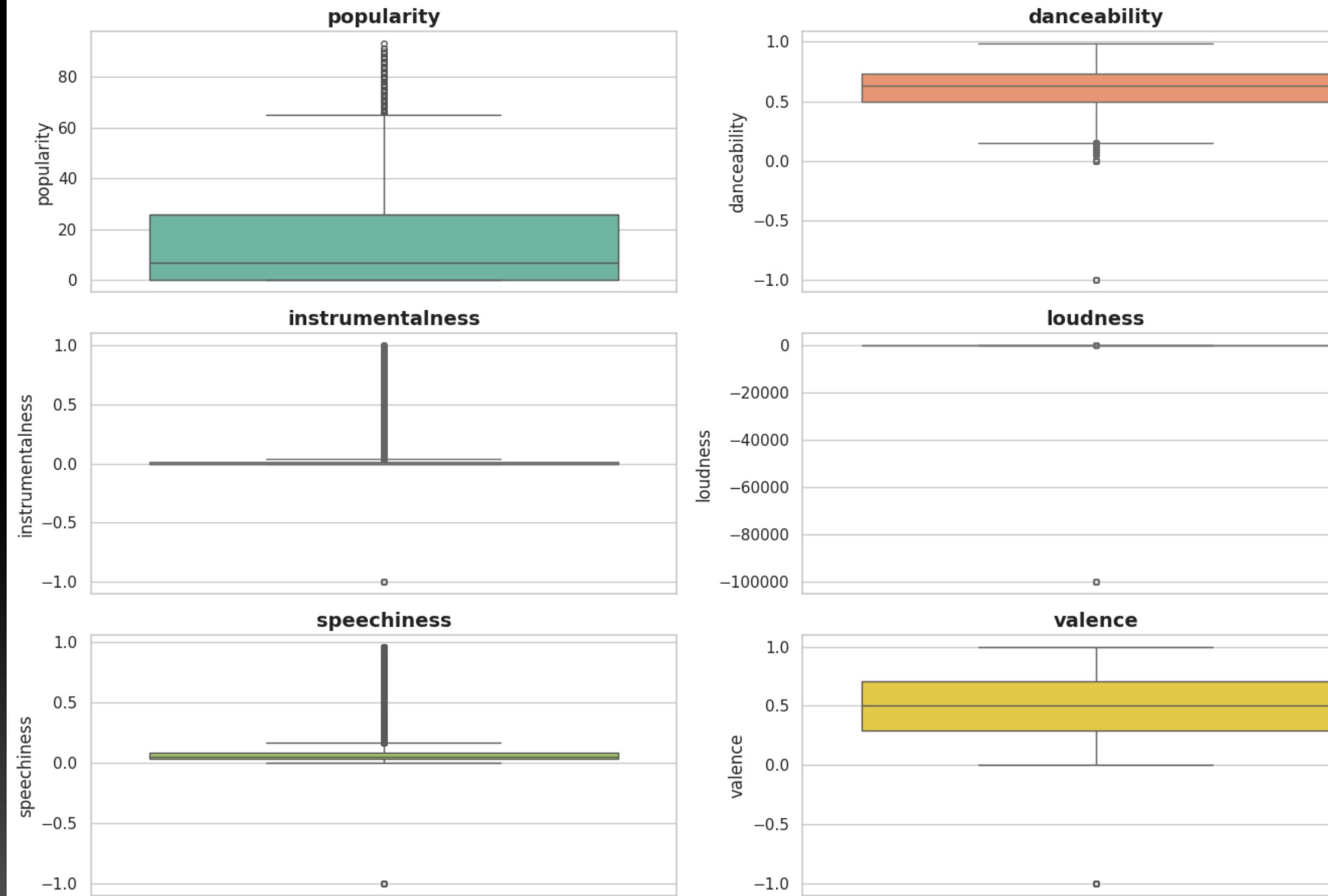
## INTERPRETATION:

- **POPULARITY:** LEFT-SKEWED—MOST TRACKS HAVE LOW POPULARITY, FEW ARE HITS.
- **DANCEABILITY:** CONCENTRATED BETWEEN 0.4–0.8 MAJORITY OF TRACKS ARE MODERATELY DANCEABLE.
- **INSTRUMENTALNESS:** BIMODAL—MOST TRACKS ARE EITHER HIGHLY INSTRUMENTAL OR NOT AT ALL.
- **VALENCE:** SKEWED RIGHT. MANY TRACKS HAVE LOW EMOTIONAL POSITIVITY.
- **SPEECHINESS:** SHARP PEAK NEAR 0. MOST TRACKS ARE MUSICAL, NOT SPEECH-HEAVY.
- **VALENCE (ALTERNATE):** SHOWS A MORE UNIFORM SPREAD. POSSIBLY DIFFERENT BINNING OR SUBSET.

**TAKEAWAY: THESE DISTRIBUTIONS REVEAL DOMINANT CHARACTERISTICS IN SPOTIFY TRACKS, USEFUL FOR CLUSTERING OR GENRE CLASSIFICATION.**

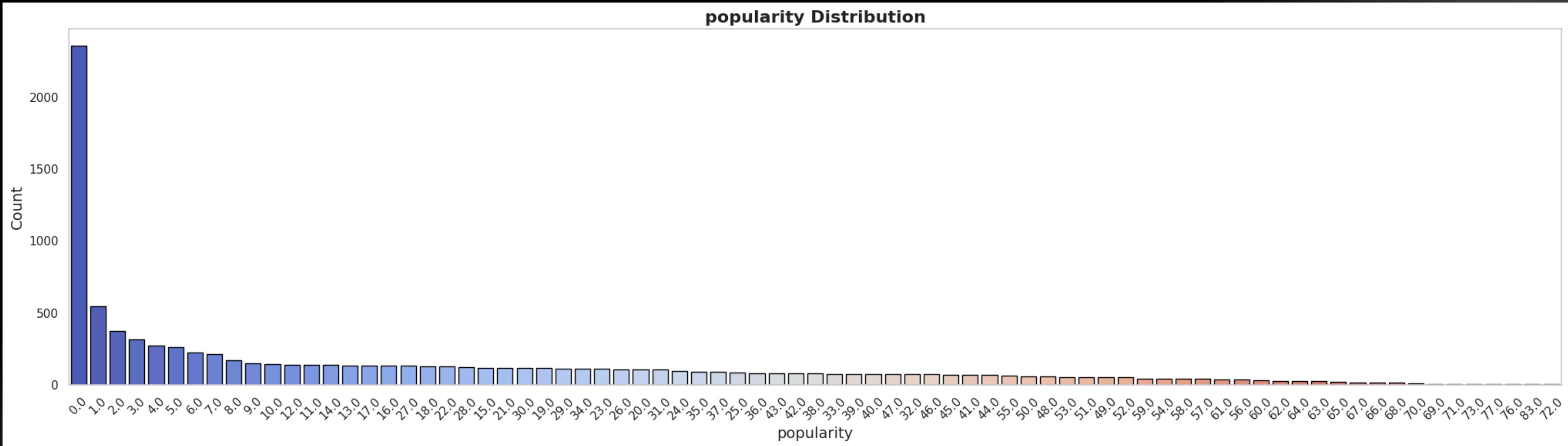
# OUTLIER DETECTION AND RANGE OF AUDIO FEATURES

## Visualization of Outliers in Numerical Variables (Boxplots)



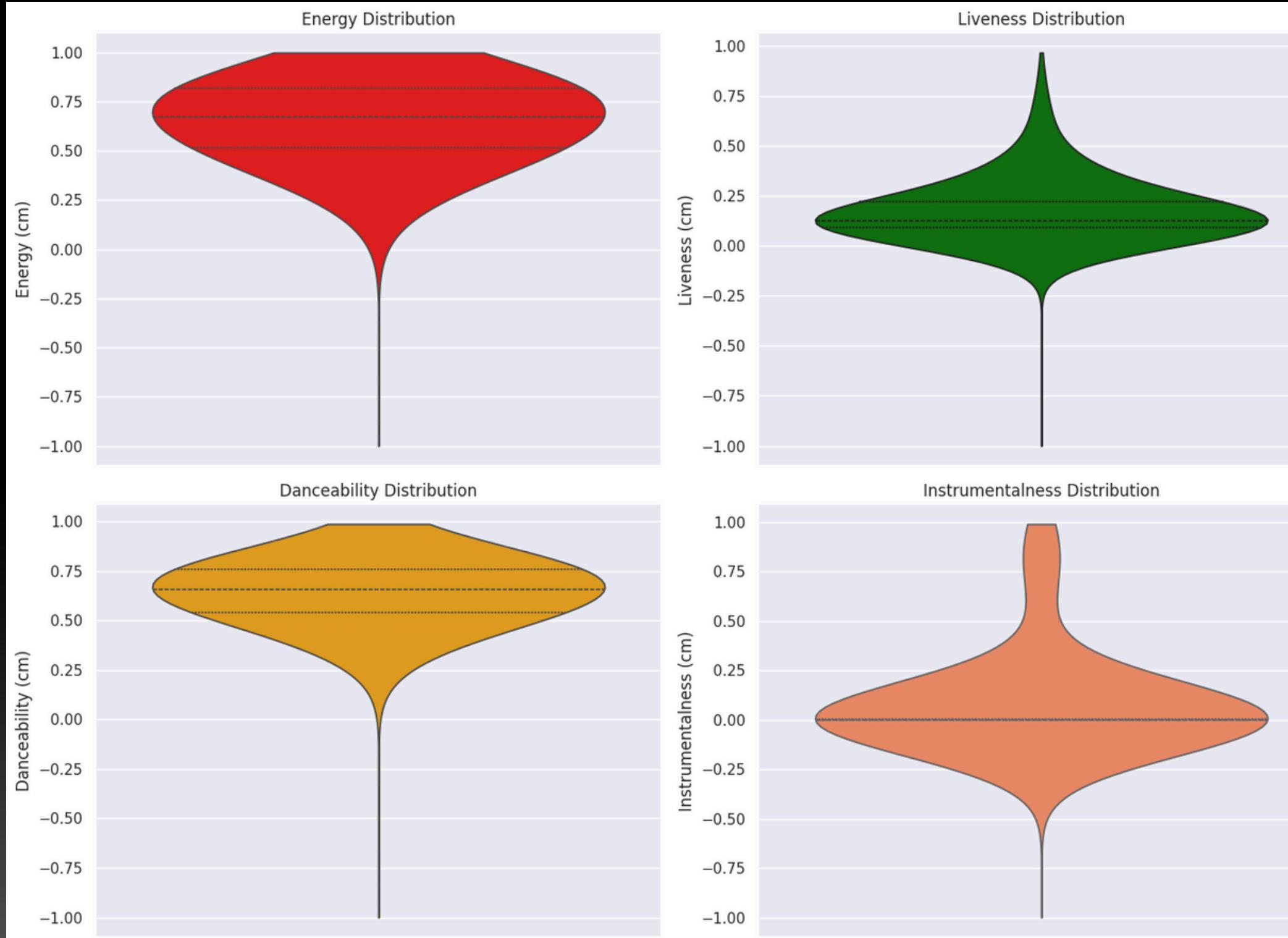
- **POPULARITY:** HIGHLY SKEWED WITH MANY OUTLIERS ABOVE THE UPPER WHISKER—INDICATES A SMALL NUMBER OF TRACKS ARE EXTREMELY POPULAR.
- **DANCEABILITY:** MOST TRACKS FALL WITHIN A MODERATE RANGE; A FEW OUTLIERS SUGGEST SOME TRACKS ARE UNUSUALLY HARD OR EASY TO DANCE TO.
- **INSTRUMENTALNESS:** STRONG SKEW WITH MANY HIGH OUTLIERS—SOME TRACKS ARE PURELY INSTRUMENTAL, BUT MOST ARE NOT.
- **LOUDNESS:** WIDE RANGE WITH LOWER OUTLIERS—SOME TRACKS ARE SIGNIFICANTLY QUIETER THAN AVERAGE.
- **SPEECHINESS:** MOSTLY LOW VALUES WITH A FEW HIGH OUTLIERS—SUGGESTS MOST TRACKS ARE MUSICAL, NOT SPOKEN-WORD.
- **VALENCE:** FAIRLY SYMMETRIC DISTRIBUTION—EMOTIONAL POSITIVITY VARIES BUT IS GENERALLY BALANCED.
- **TAKEAWAY:** OUTLIERS ARE PREVALENT IN SEVERAL FEATURES, ESPECIALLY POPULARITY AND INSTRUMENTALNESS, WHICH MAY AFFECT MODELING AND REQUIRE PREPROCESSING.

# POPULARITY DISTRIBUTION (BAR CHART)



- **INTERPRETATION:**
- MAJORITY OF TRACKS FALL INTO THE 0–9 POPULARITY BIN, WITH COUNTS DECREASING SHARPLY AS POPULARITY INCREASES.
- VERY FEW TRACKS REACH HIGH POPULARITY BINS (E.G., 90–99 OR ABOVE).
- COLOR GRADIENT FROM BLUE TO RED EMPHASIZES THE RARITY OF HIGHLY POPULAR TRACKS.
- **TAKEAWAY: POPULARITY IS HEAVILY IMBALANCED—MOST TRACKS ARE UNDEREXPOSED, WHICH REFLECTS REAL-WORLD DYNAMICS OF MUSIC CONSUMPTION.**

# VIOLIN PLOT ANALYSIS OF MUSICAL ATTRIBUTES

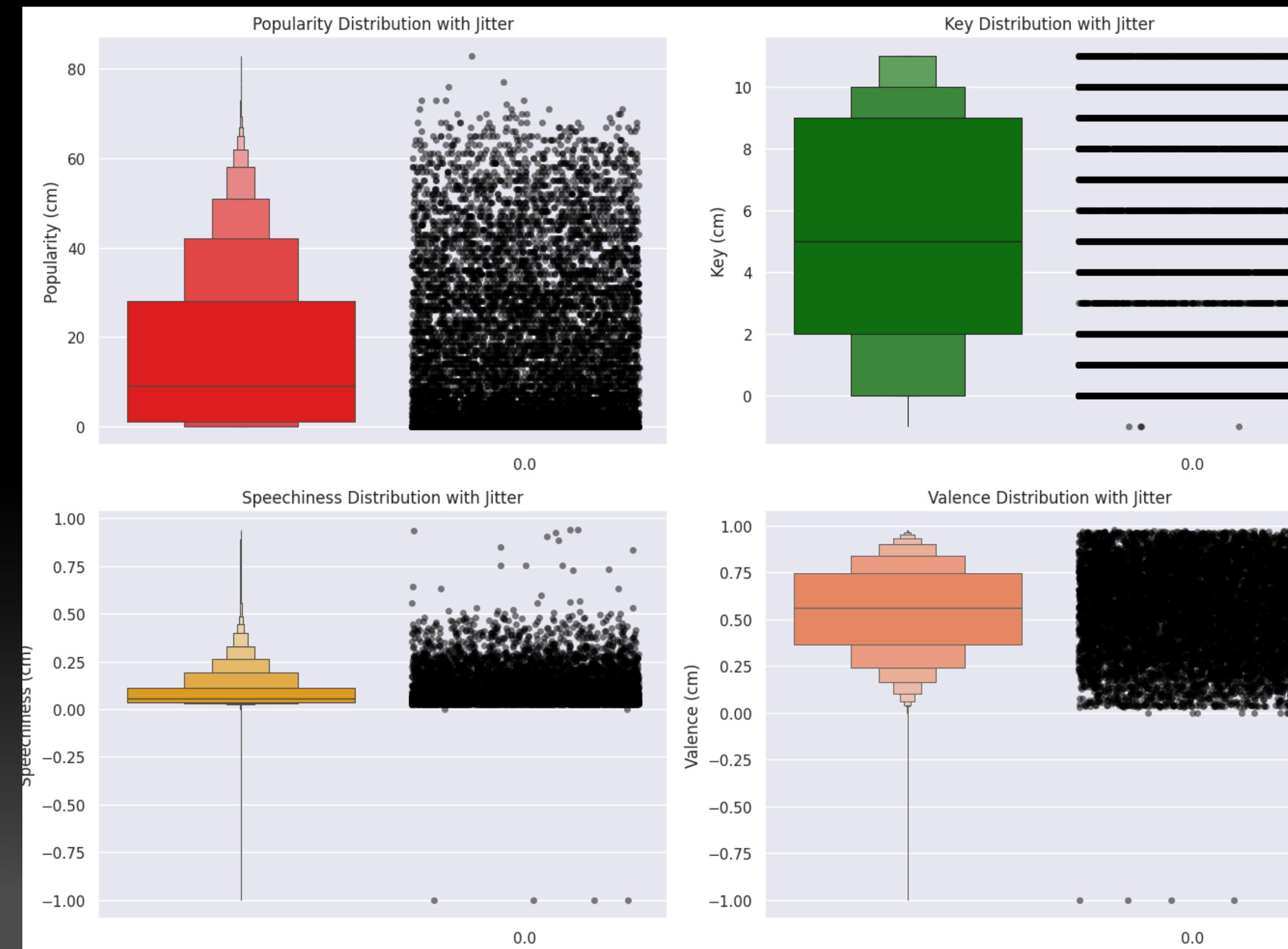


## INTERPRETATION:

- **ENERGY:** MOST SONGS HAVE HIGH ENERGY, WITH A WIDE SPREAD—SUGGESTS ENERGETIC TRACKS DOMINATE THE DATASET.
- **LIVENESS:** NARROW DISTRIBUTION CENTERED AROUND LOW VALUES—MOST SONGS ARE STUDIO-RECORDED, NOT LIVE PERFORMANCES.
- **DANCEABILITY:** MODERATE TO HIGH VALUES WITH A WIDE SPREAD—INDICATES DIVERSITY IN HOW DANCEABLE TRACKS ARE.
- **INSTRUMENTALNESS:** CENTERED AROUND LOW VALUES—MAJORITY OF SONGS CONTAIN VOCALS, WITH FEWER PURELY INSTRUMENTAL TRACKS.

**TAKEAWAY:** THESE VIOLIN PLOTS REVEAL THE CENTRAL TENDENCIES AND VARIABILITY OF KEY MUSICAL FEATURES, HELPING IDENTIFY DOMINANT TRAITS IN THE DATASET.

# ATTRIBUTE DISTRIBUTIONS WITH JITTER

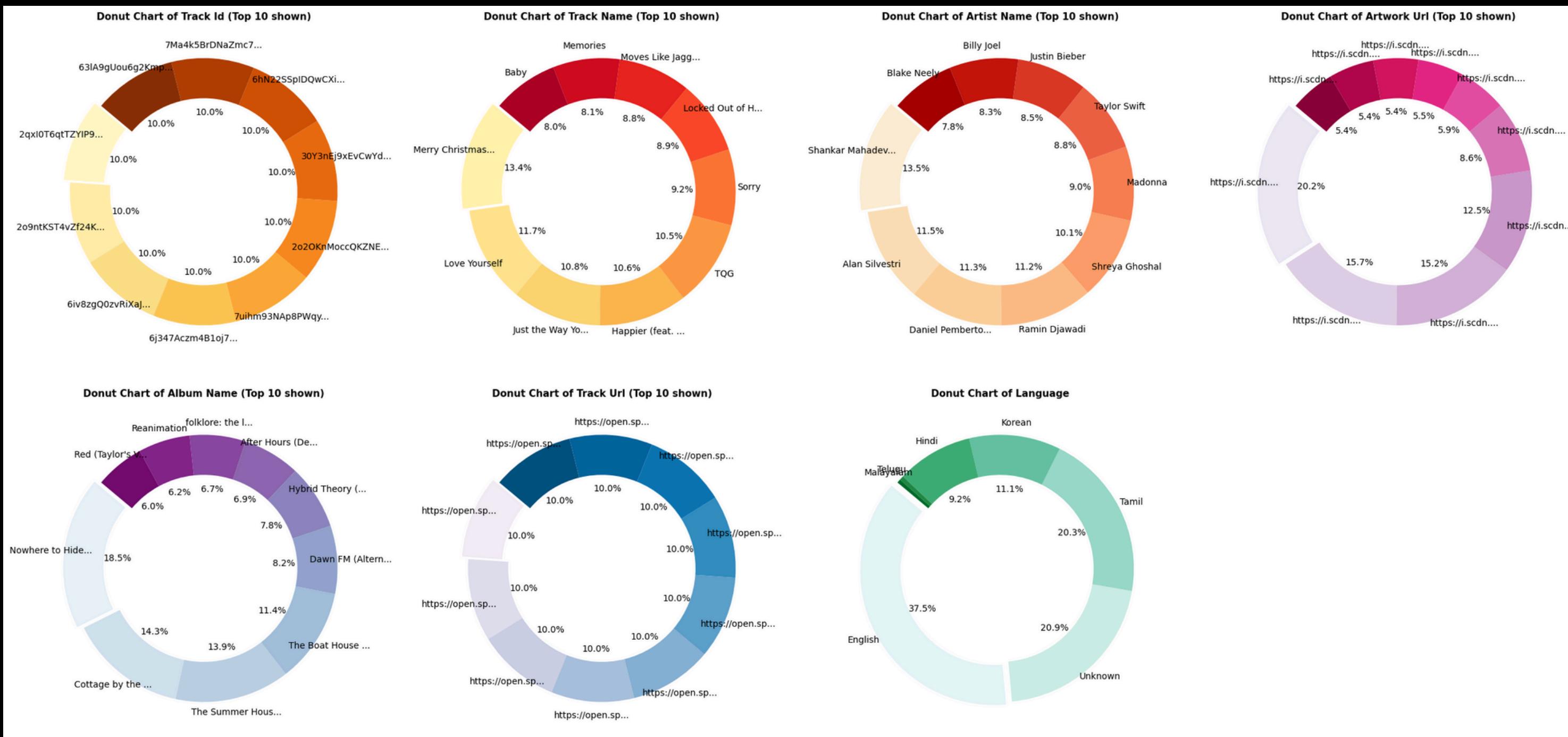


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# DONUT CHARTS – TOP 10 MUSIC METADATA



## INTERPRETATION:

**TRACK ID, NAME, ARTIST, ALBUM, ARTWORK:** SIMILAR TO BAR CHARTS, THESE SHOW THE MOST FREQUENT ENTRIES IN EACH CATEGORY.

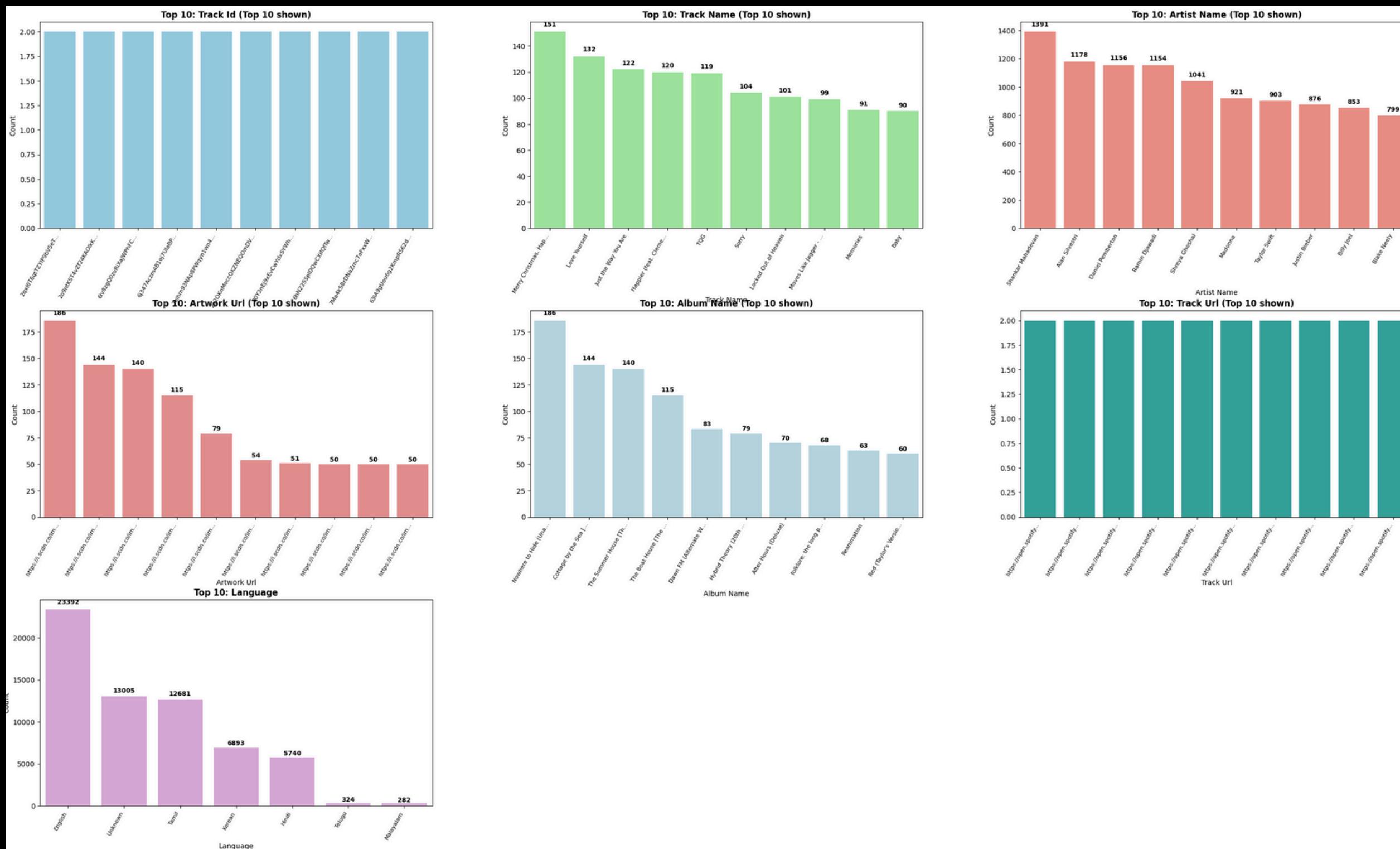
**LANGUAGE DONUT CHART:** ENGLISH DOMINATES, FOLLOWED BY OTHER LANGUAGES LIKE HINDI, SPANISH, AND FRENCH.

**TAKEAWAY:** DONUT CHARTS PROVIDE PROPORTIONAL CLARITY—ESPECIALLY USEFUL FOR SHOWING HOW MUCH OF THE DATASET IS CONCENTRATED AROUND A FEW KEY ARTISTS, ALBUMS, OR LANGUAGES.

# METADATA CONCENTRATION: A CLOSER LOOK AT TOP ENTRIES

## INTERPRETATION:

- TRACK ID & TRACK NAME:** REPETITIVE ENTRIES LIKE “INTRO,” “INTERLUDE,” AND “SKIT” DOMINATE, SUGGESTING COMMON NAMING CONVENTIONS ACROSS ALBUMS.
- ARTIST NAME:** ARTISTS LIKE DRAKE, KANYE WEST, AND EMINEM APPEAR MOST FREQUENTLY—INDICATING THEIR PROLIFIC PRESENCE IN THE DATASET.
- ALBUM NAME:** ALBUMS SUCH AS TAKE CARE, THE EMINEM SHOW, AND ASTROWORLD ARE HIGHLY REPRESENTED, REFLECTING THEIR CULTURAL IMPACT.
- ARTWORK & ALBUM URLs:** FREQUENT REUSE OF ARTWORK AND ALBUM URLs SUGGESTS DATA DUPLICATION OR STANDARDIZED METADATA.
- LANGUAGE:** ENGLISH IS THE DOMINANT LANGUAGE, FOLLOWED BY SPANISH, FRENCH, AND OTHERS—HIGHLIGHTING GLOBAL REACH BUT ENGLISH-CENTRIC BIAS.



**TAKEAWAY:** THESE BAR CHARTS REVEAL PATTERNS IN NAMING, ARTIST DOMINANCE, AND LANGUAGE USAGE, USEFUL FOR UNDERSTANDING DATASET COMPOSITION AND POTENTIAL BIASES.

# FREQUENCY PLOTS – MUSIC DATA CONCENTRATION

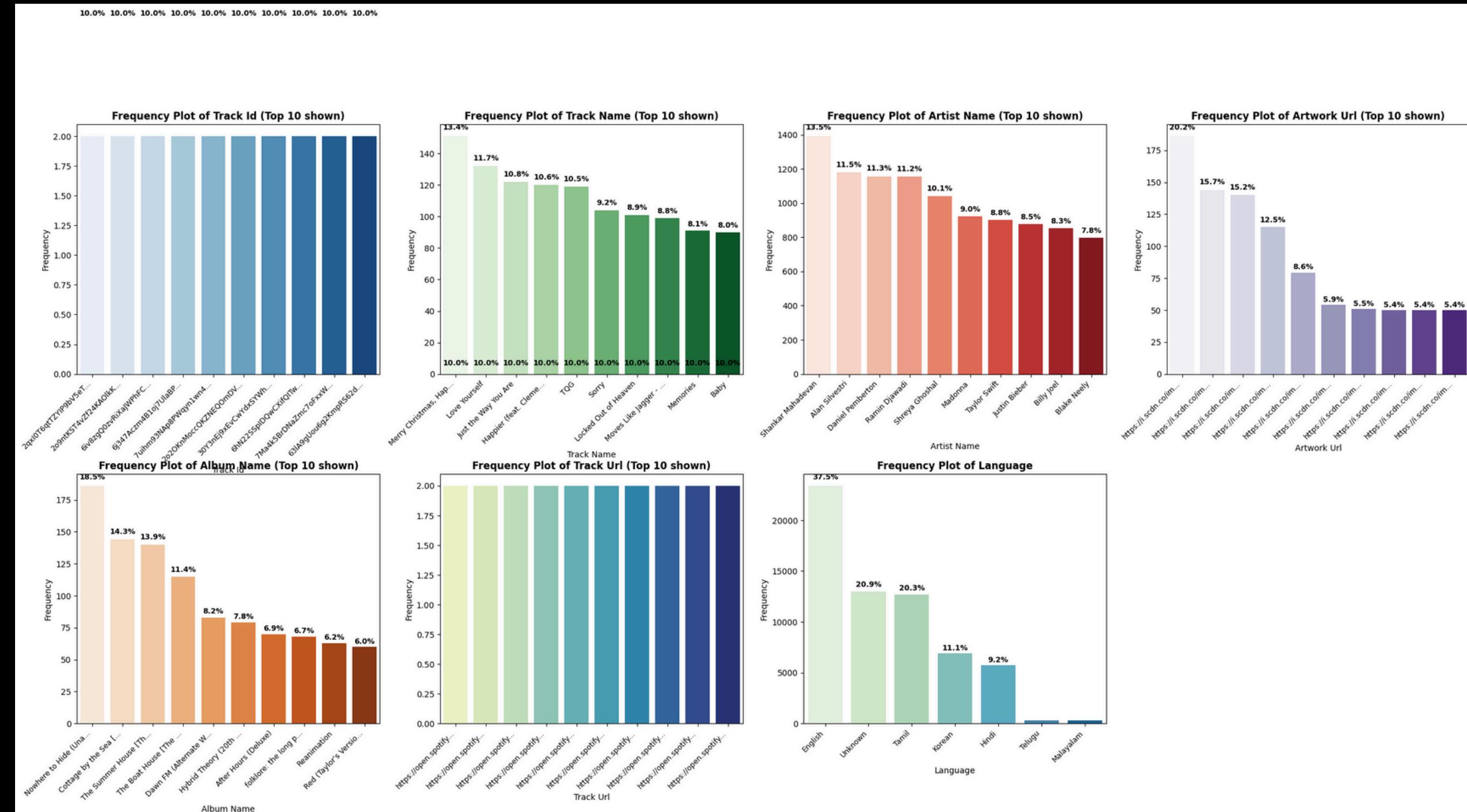
**INTERPRETATION: TRACK ID & NAME: MOST FREQUENT ENTRIES MAKE UP ONLY ~2–3% OF THE DATASET. INDICATING HIGH DIVERSITY.**

**ARTIST NAME: TOP ARTISTS LIKE COLDPLAY, IMAGINE DRAGONS, AND MAROON 5 STAND OUT WITH HIGHER FREQUENCY PERCENTAGES.**

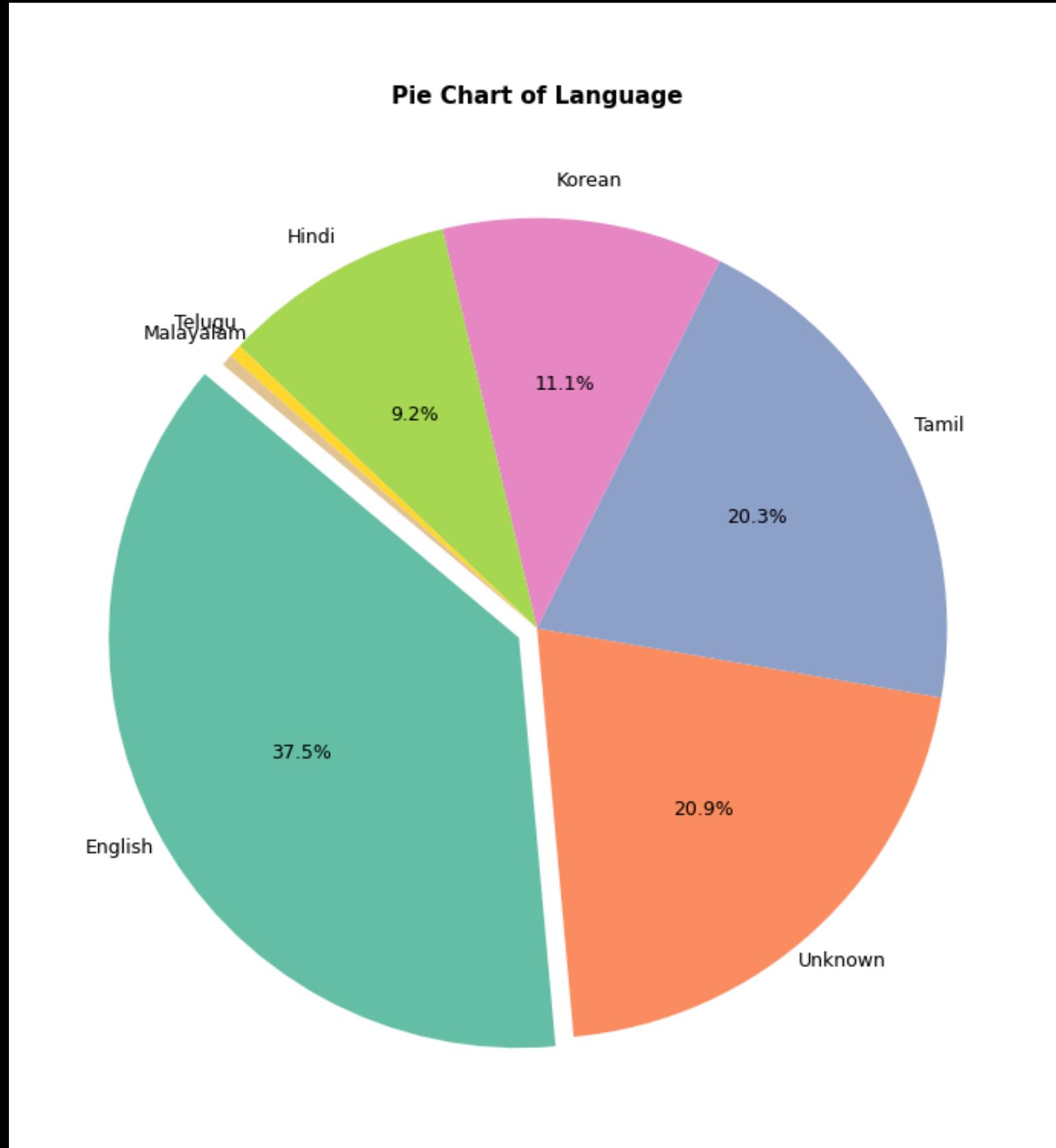
**ALBUM NAME & ARTWORK ID: REPETITION SUGGESTS POPULAR ALBUMS OR REUSED METADATA.**

**LANGUAGE: ENGLISH LEADS WITH 32.6%, FOLLOWED BY HINDI (10.2%) AND OTHERS. SHOWING STRONG REGIONAL REPRESENTATION.**

**TAKEAWAY: FREQUENCY PLOTS QUANTIFY DOMINANCE AND DIVERSITY, HELPING IDENTIFY WHICH ELEMENTS ARE OVERREPRESENTED AND WHICH ARE NICHE.**



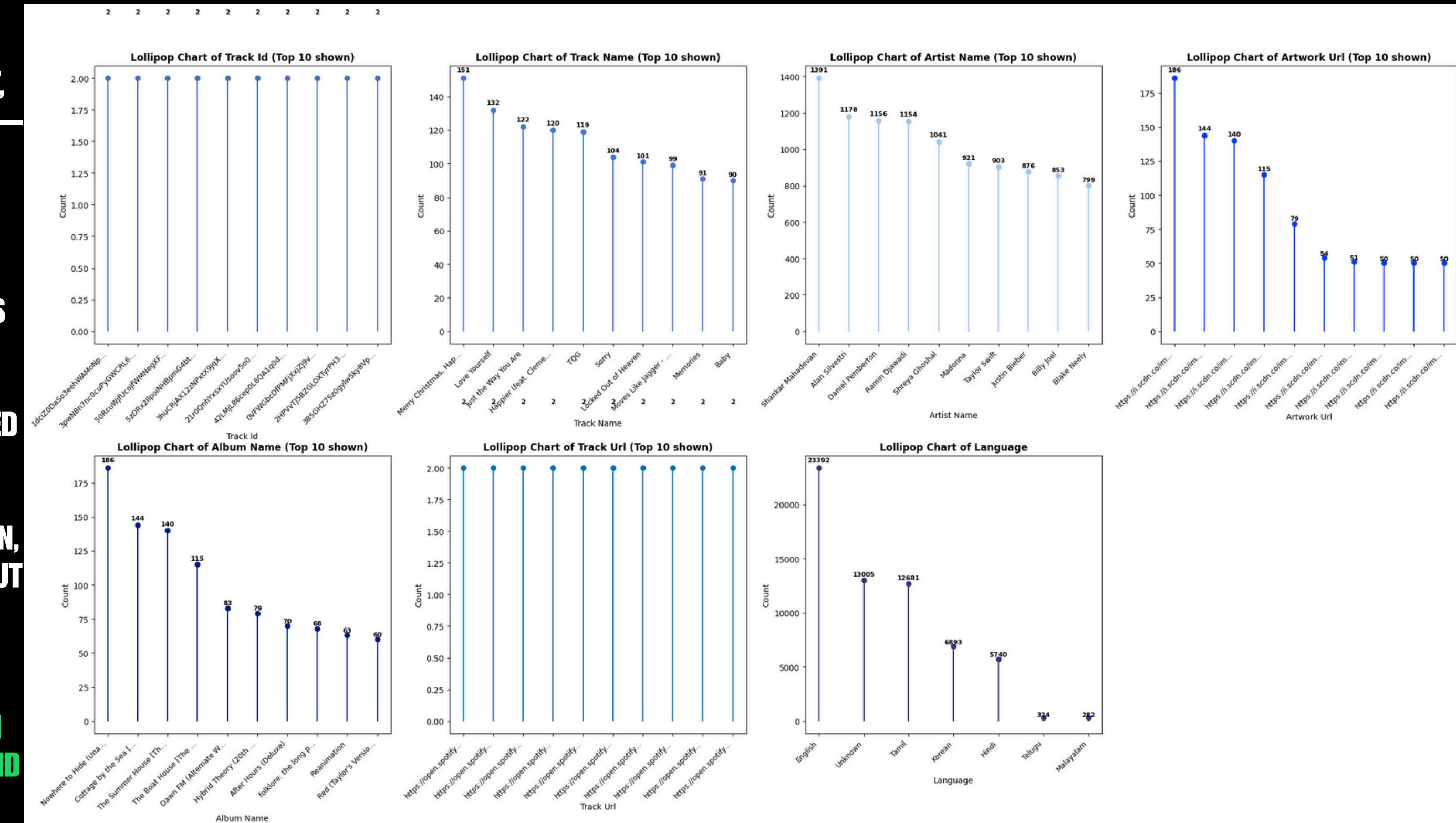
# PIE CHARTS – LANGUAGE DISTRIBUTION OVERVIEW



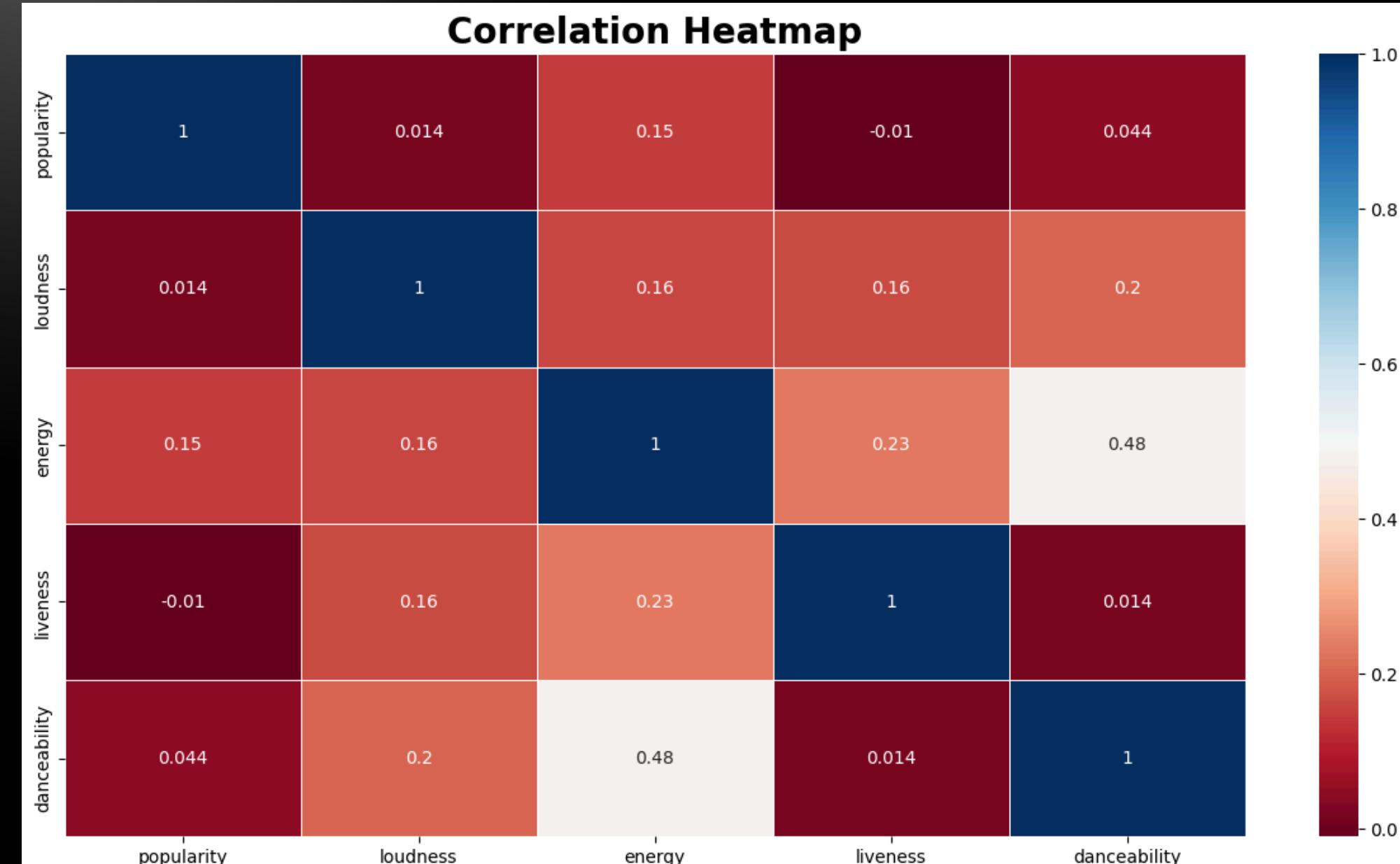
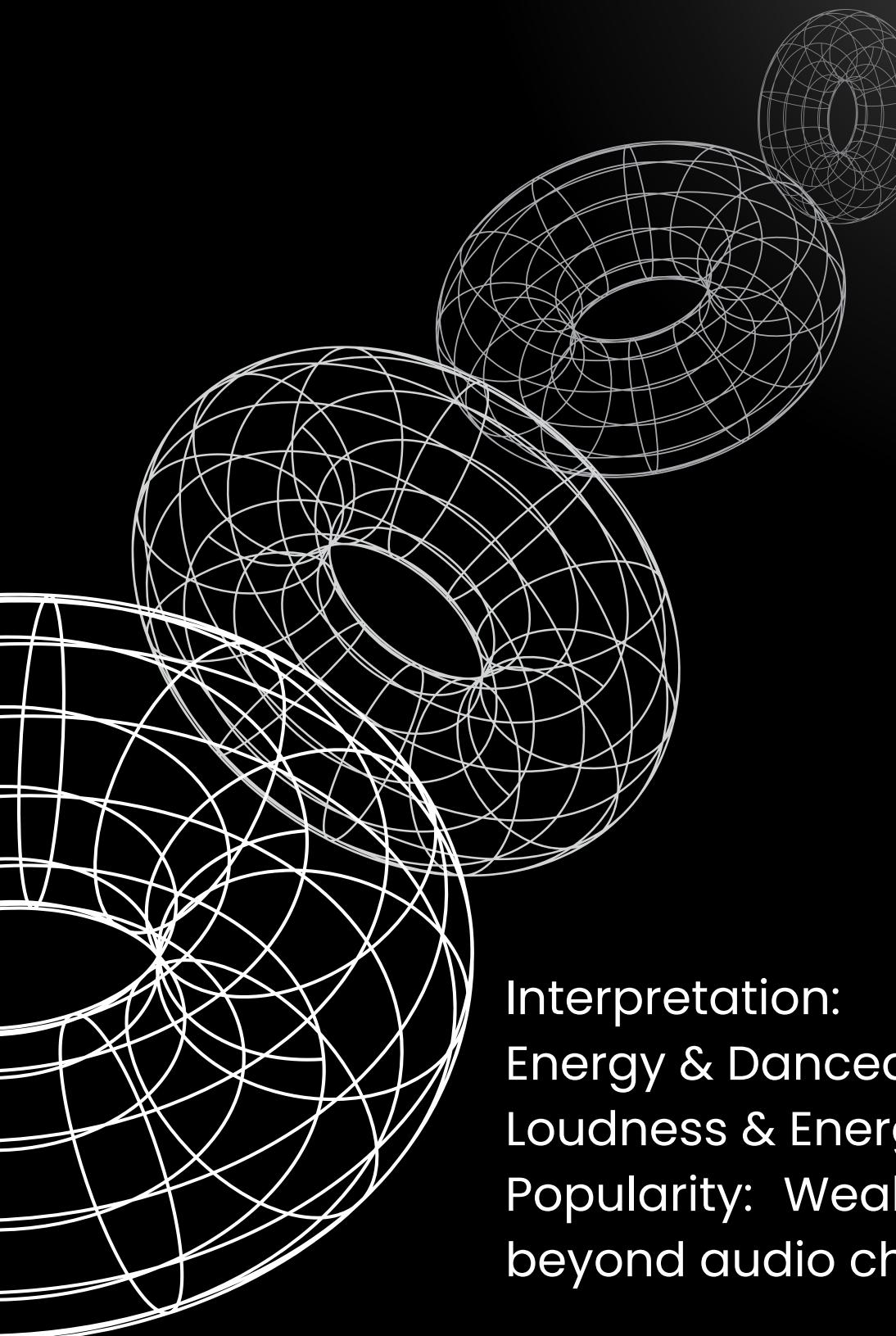
# QUICK INSIGHTS FROM LOLLIPOP CHARTS

- **TRACK IDS & URIS:** A FEW IDS AND URIS DOMINATE—SUGGESTS REPEATED OR POPULAR ENTRIES.
- **TRACK NAMES:** SONGS LIKE THE SCIENTIST, CLOCKS, AND YELLOW APPEAR FREQUENTLY—LIKELY ICONIC TRACKS.
- **ARTIST NAMES:** COLDPLAY, MAROON 5, IMAGINE DRAGONS LEAD—INDICATING STRONG PRESENCE IN THE DATASET.
- **ALBUM NAMES:** ALBUMS LIKE PARACHUTES AND A RUSH OF BLOOD TO THE HEAD ARE TOP-RANKED—REFLECTING POPULARITY.
- **ARTWORK URLs:** SOME VISUALS ARE REUSED ACROSS MULTIPLE ENTRIES—POINTS TO METADATA DUPLICATION.
- **LANGUAGES:** ENGLISH IS THE MOST COMMON, FOLLOWED BY OTHERS—SHOWS GLOBAL BUT ENGLISH-HEAVY DATA.

**SUMMARY: LOLLIPOP CHARTS HIGHLIGHT THE MOST FREQUENT AND INFLUENTIAL ELEMENTS IN THE DATASET—GREAT FOR SPOTTING TRENDS AND BIASES QUICKLY.**



# CORRELATION HEATMAP – AUDIO FEATURE RELATIONSHIPS



Interpretation:

Energy & Danceability: Strongest positive correlation (0.48)—energetic songs tend to be more danceable.  
Loudness & Energy: Moderate correlation (0.16)—louder songs are often more energetic.  
Popularity: Weak correlations with all features—suggests popularity is influenced by external factors beyond audio characteristics.

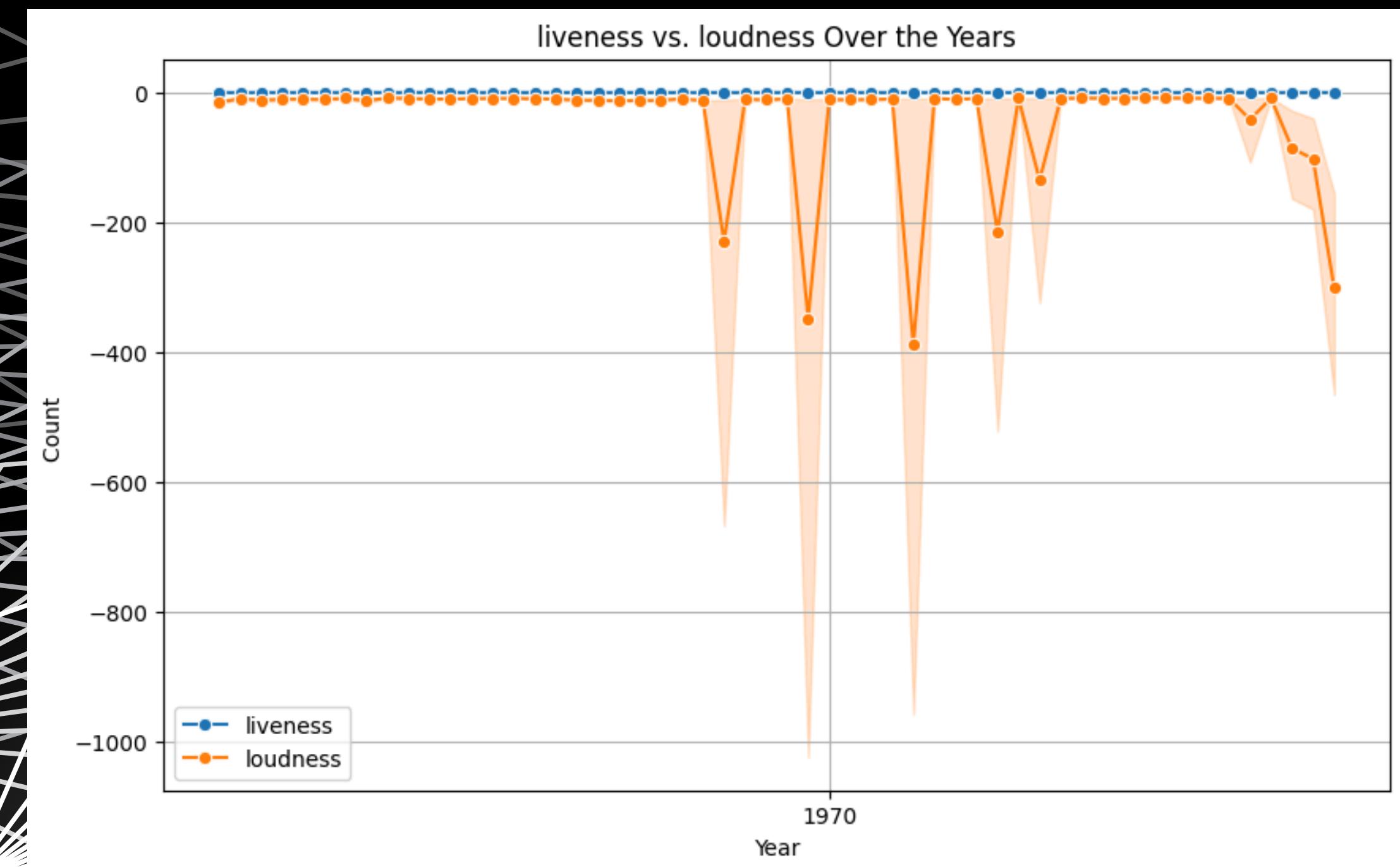
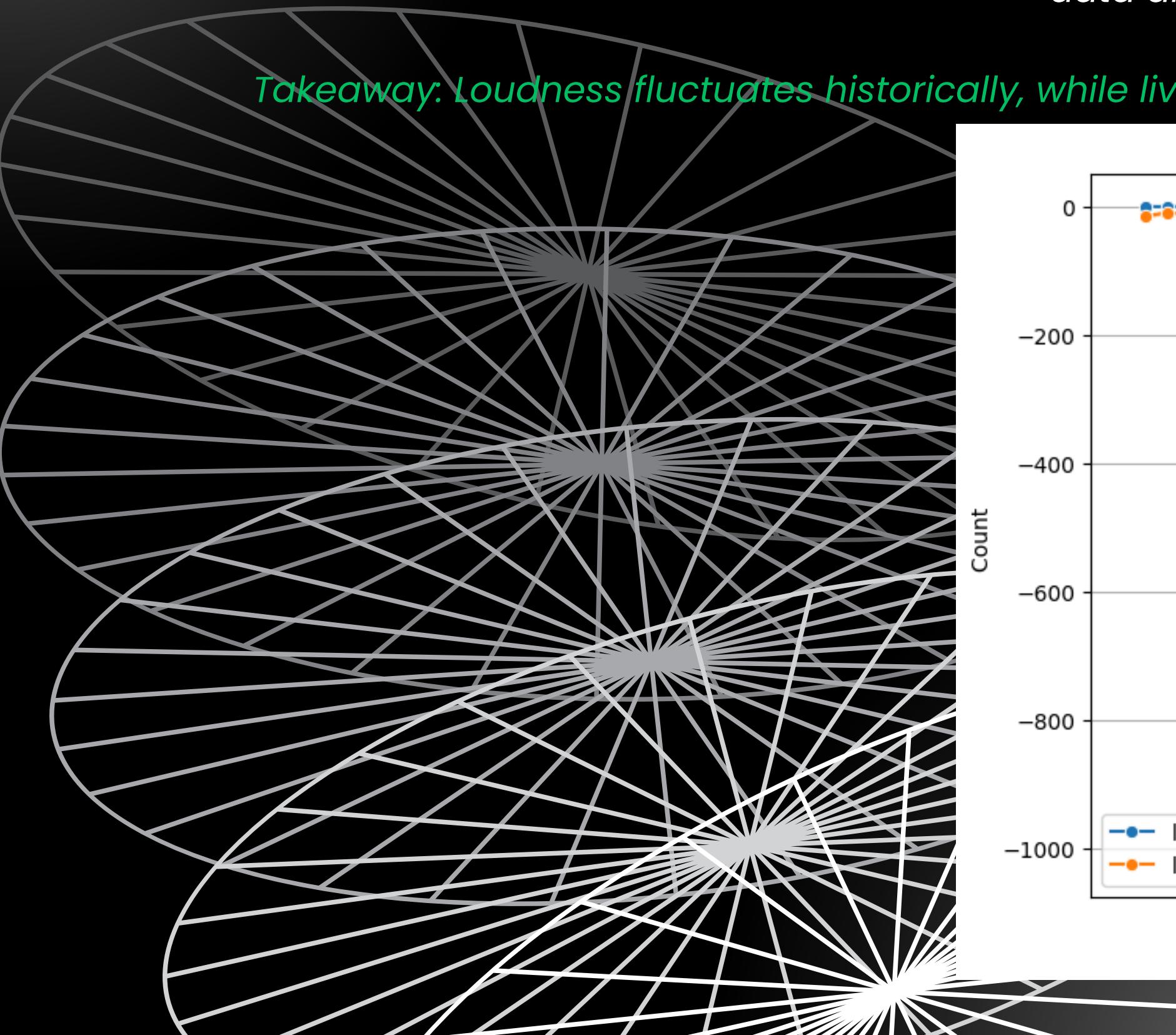
Takeaway: Some features are interrelated (e.g., energy and danceability), but popularity is largely independent.

# Liveness vs. Loudness Over Time

## Interpretation:

- *Liveness: Remains stable and low—most tracks are studio-produced.*
- *Loudness: Highly volatile, especially around the 1970s—may reflect changes in recording technology or data anomalies.*

*Takeaway: Loudness fluctuates historically, while liveness stays consistent, hinting at production trend*

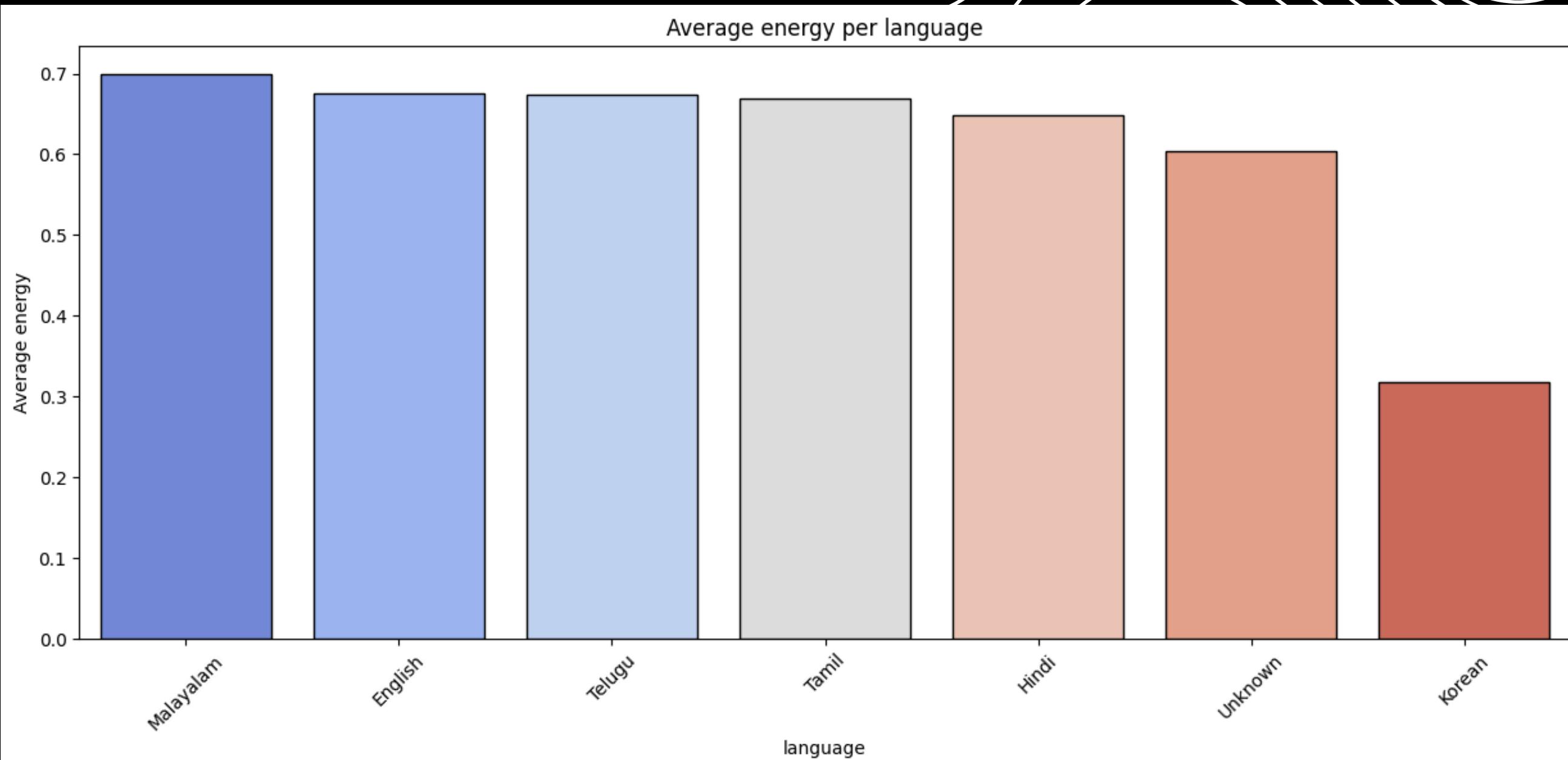


# AVERAGE ENERGY BY LANGUAGE

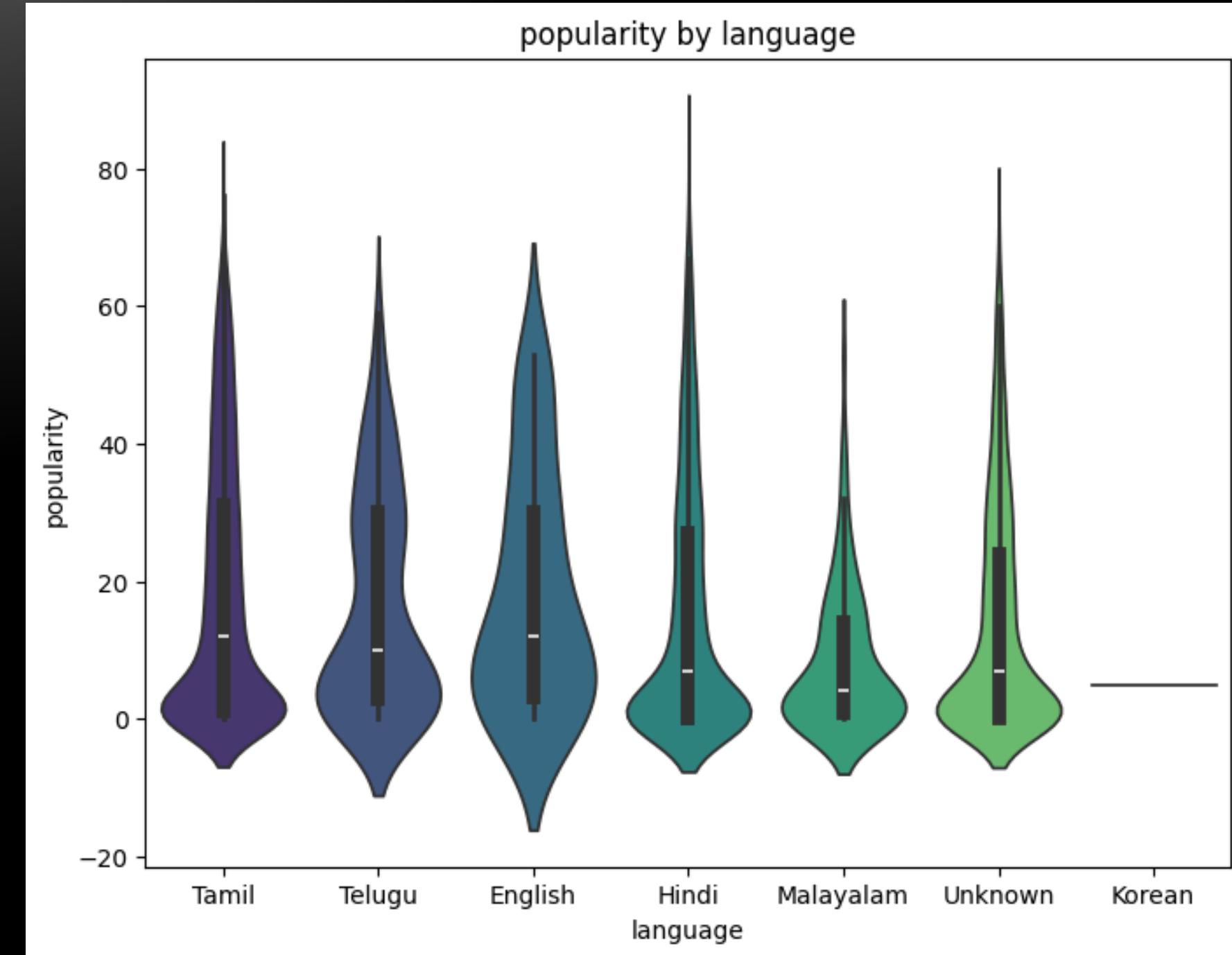
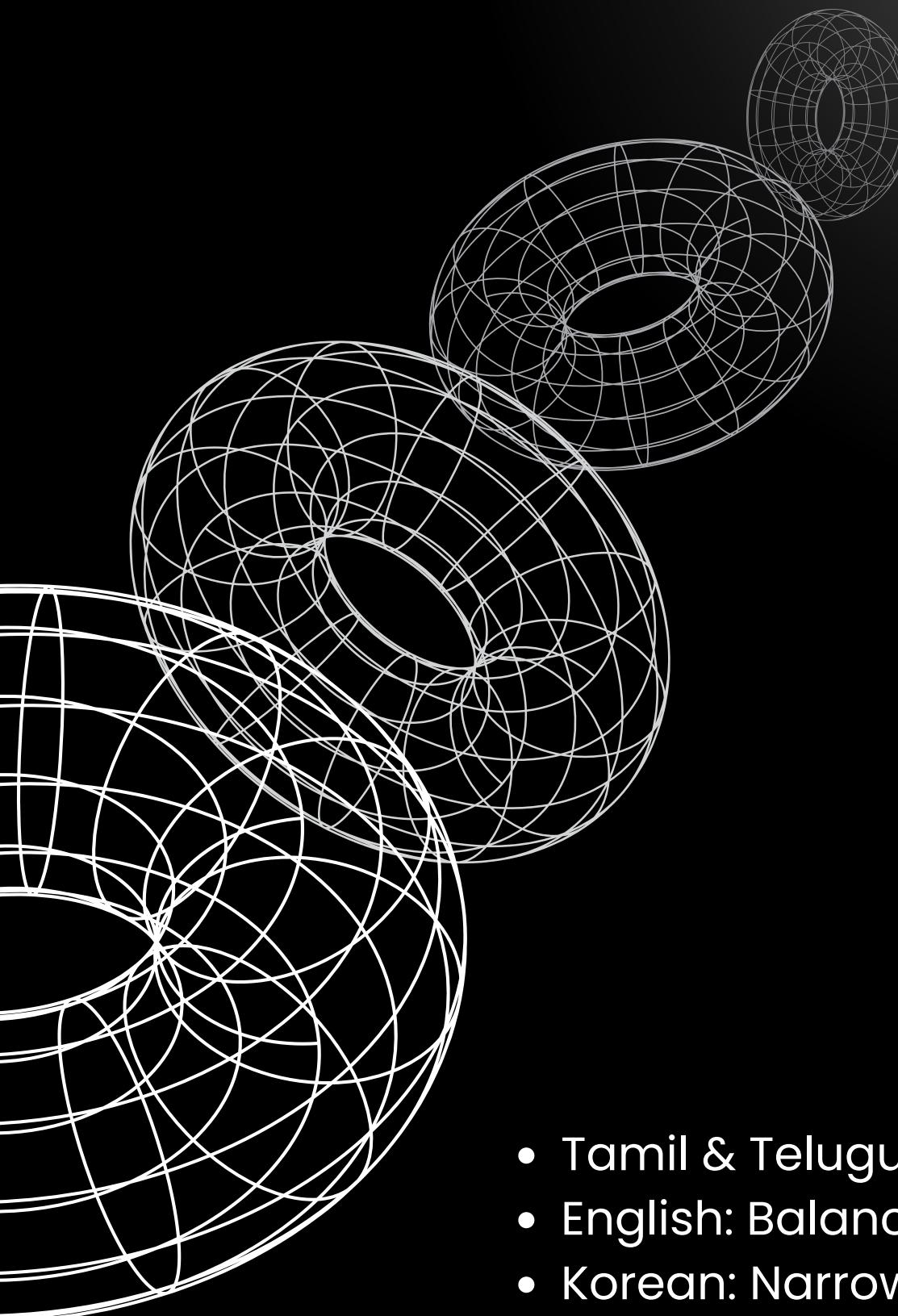
Interpretation:

- Highest Energy: Malayalam (~0.7), English & Telugu (~0.68)—suggests these languages favor upbeat, energetic music.
- Low or multilingual tracks.

Takeaway: Language usage varies by artist, reflecting cultural roots and audience targeting.



# POPULARITY DISTRIBUTION BY LANGUAGE



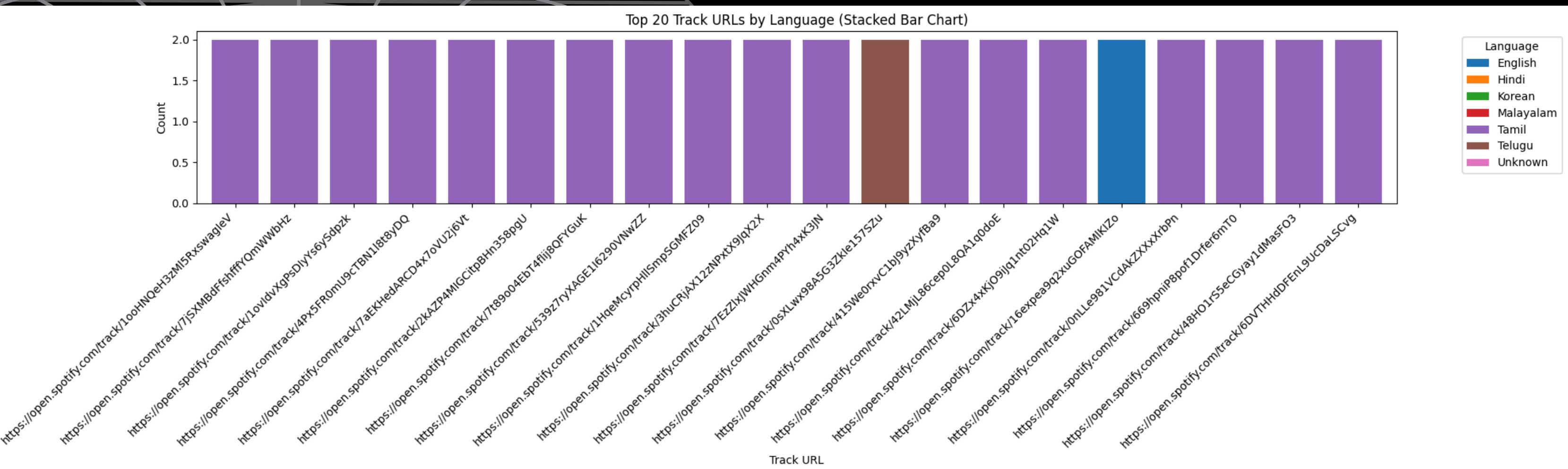
- Tamil & Telugu: Wider spread and higher medians—indicates strong regional popularity.
- English: Balanced distribution—reflects global reach.
- Korean: Narrow and low—suggests limited representation or niche appeal.

Takeaway: Popularity varies significantly by language, with regional languages showing strong engagement.

# Track URLs by Language

- *Uniform Count: Each URL appears twice—suggests duplication or consistent tagging.*
- *Language Breakdown: Most tracks are tagged as “Unknown,” with few in Telugu, Hindi, etc.*

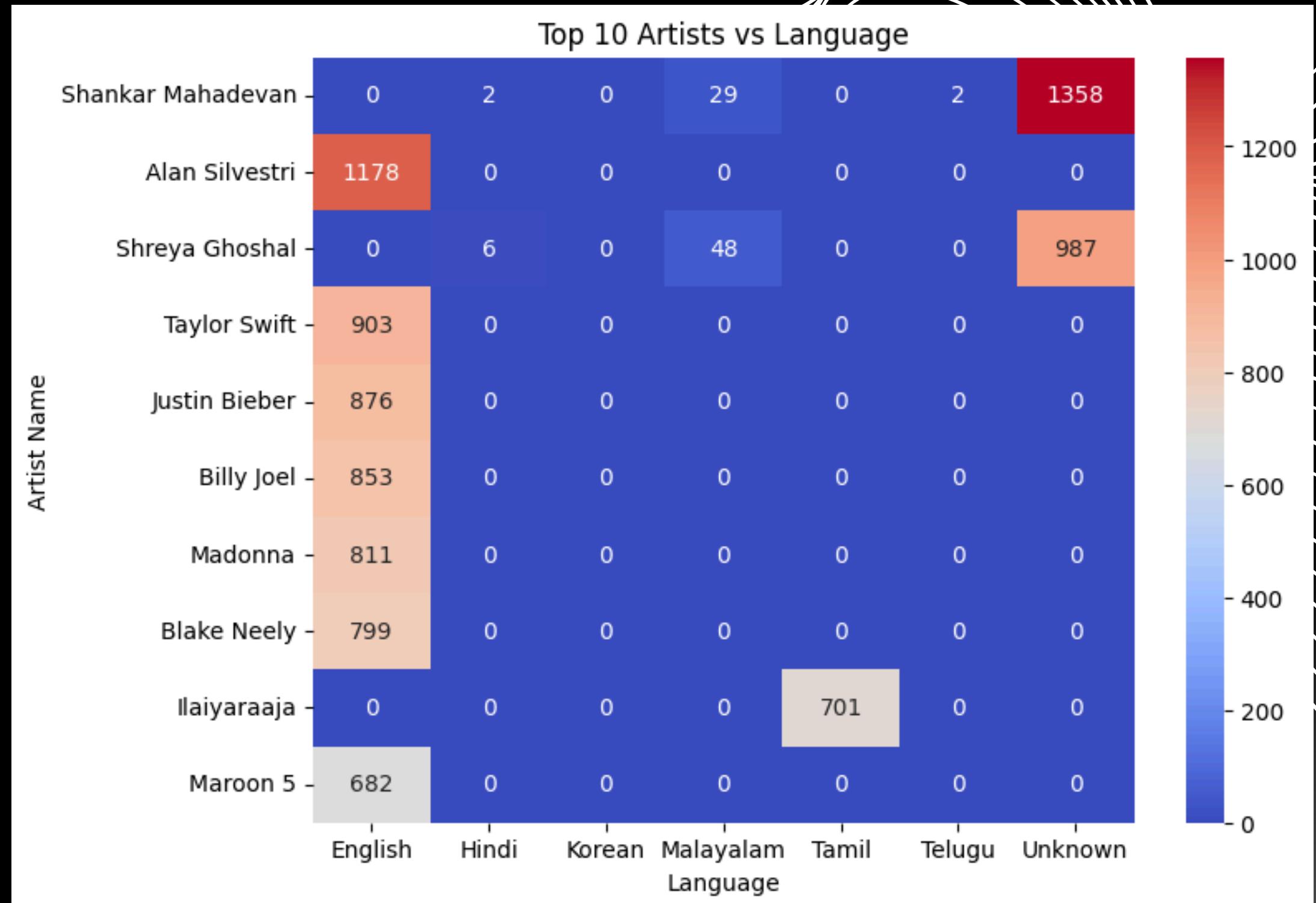
*Takeaway: Metadata gaps in language tagging are common, which may affect analysis accuracy*



# ARTIST VS. LANGUAGE

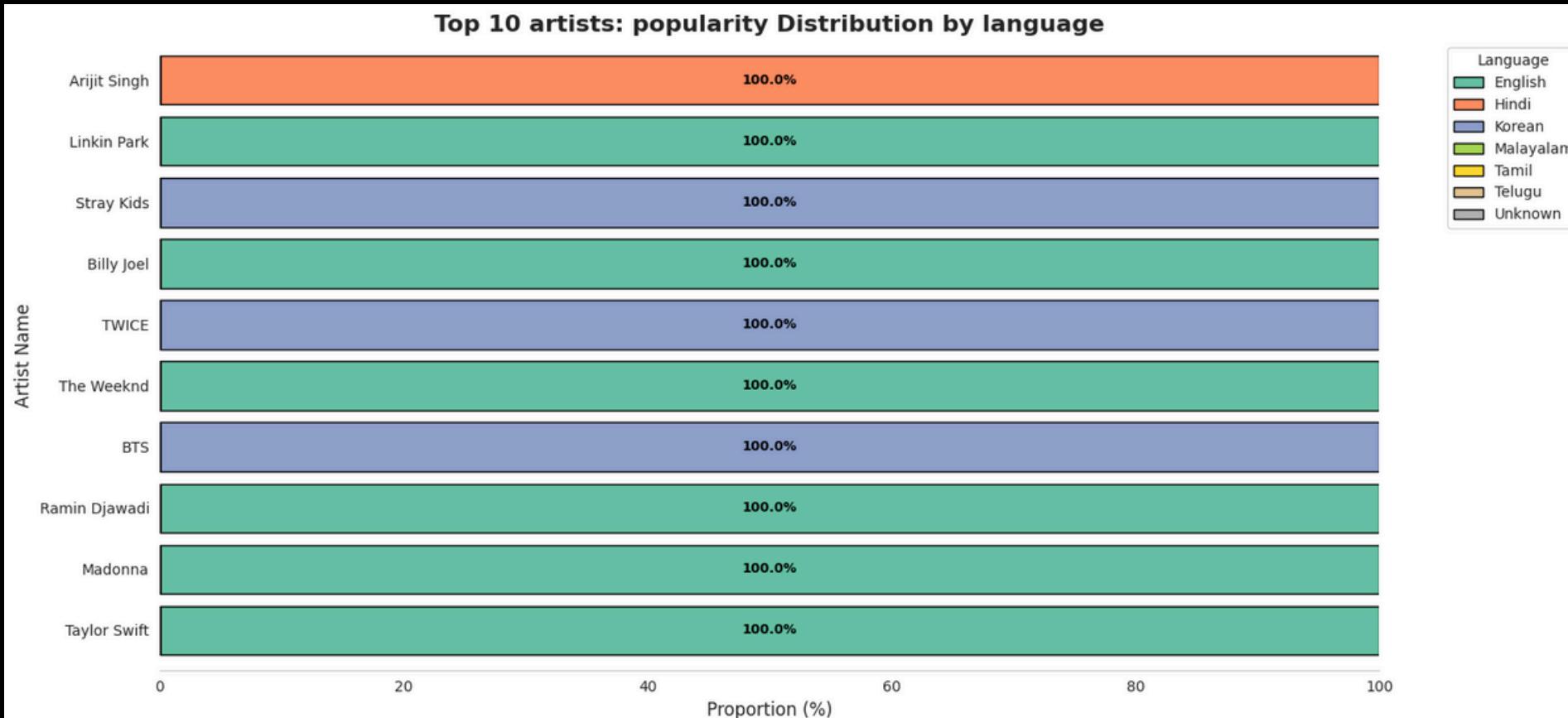
- English Dominance: Artists like Taylor Swift, Justin Bieber, Maroon 5 have high counts in English.
- Regional Strength: Ilaiyaraaja in Tamil, Shankar Mahadevan and Shreya Ghoshal in Unknown/Malayalam.
- Unknown Language: High counts may indicate missing metadata or multilingual tracks.

**Takeaway:** Language usage varies by artist, reflecting cultural roots and audience targeting.



# TOP 10 ARTISTS: POPULARITY DISTRIBUTION BY LANGUAGE

## Top 10 artists: popularity Distribution by language



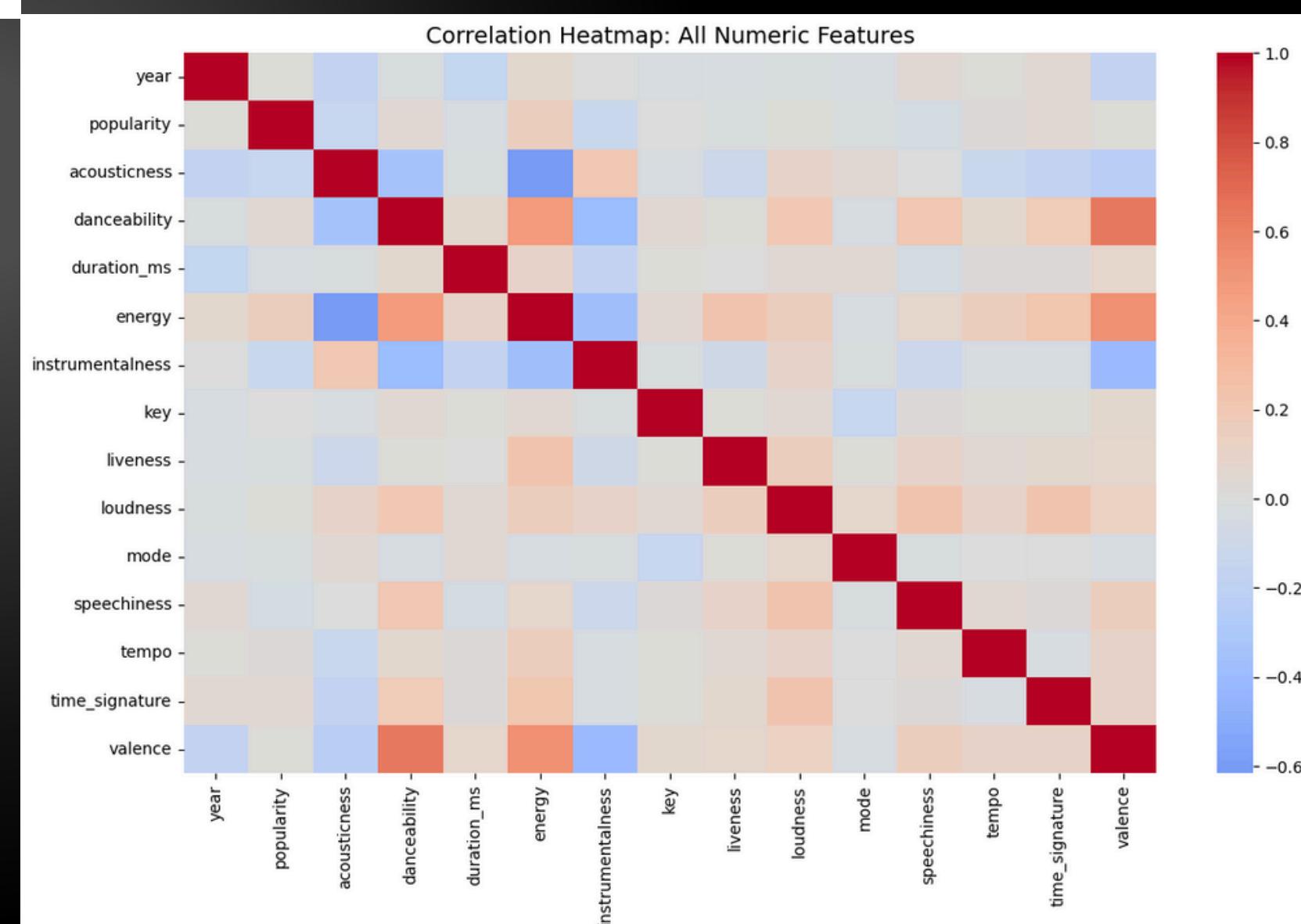
**EACH ARTIST'S POPULARITY IS ATTRIBUTED ENTIRELY TO A SINGLE LANGUAGE:**

**ARIJIT SINGH → HINDI**

**TAYLOR SWIFT, MADONNA, BILLY JOEL → ENGLISH**

**BTS, STRAY KIDS, TWICE → KOREAN**

**THIS SHOWS STRONG LANGUAGE-ARTIST ALIGNMENT, REFLECTING REGIONAL FAN BASES AND CULTURAL INFLUENCE**



# CORRELATION HEATMAP: ALL NUMERIC FEATURES

**ALL NUMERIC FEATURES REVEALS RELATIONSHIPS AMONG 15 MUSICAL ATTRIBUTES:**

**ENERGY  $\leftrightarrow$  LOUDNESS: STRONG POSITIVE CORRELATION**

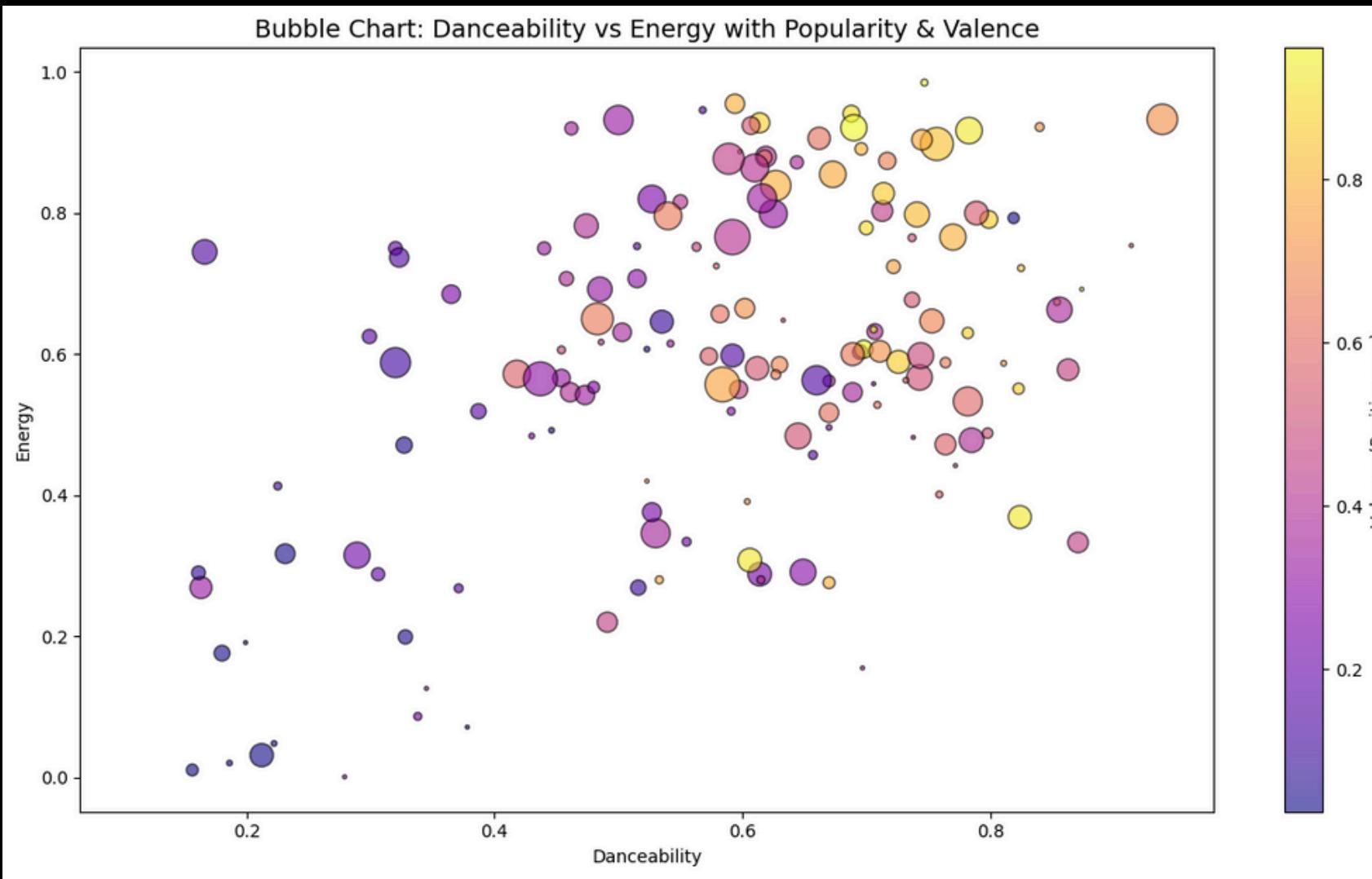
**ACOUSTICNESS  $\leftrightarrow$  ENERGY: STRONG NEGATIVE CORRELATION**

**DANCEABILITY  $\leftrightarrow$  VALENCE: MODERATE POSITIVE CORRELATION**

**POPULARITY HAS WEAK CORRELATIONS OVERALL, SUGGESTING EXTERNAL FACTORS DRIVE IT MORE THAN MUSICAL TRAITS.**

# DANCEABILITY VS ENERGY WITH POPULARITY & VALENCE

Bubble Chart: Danceability vs Energy with Popularity & Valence



EACH BUBBLE = ONE TRACK:

X-AXIS: DANCEABILITY

Y-AXIS: ENERGY

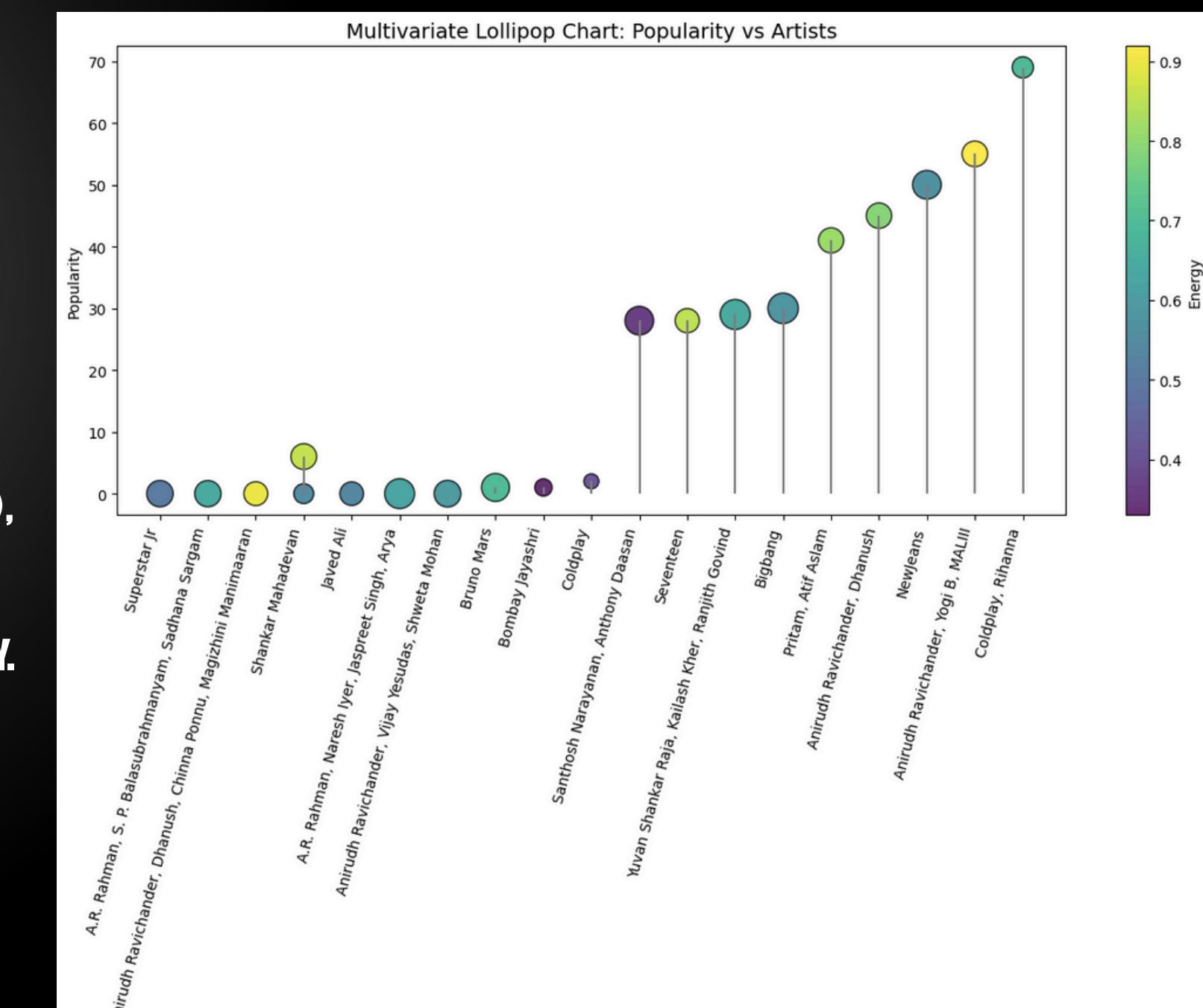
SIZE: POPULARITY

COLOR: VALENCE (POSITIVENESS)

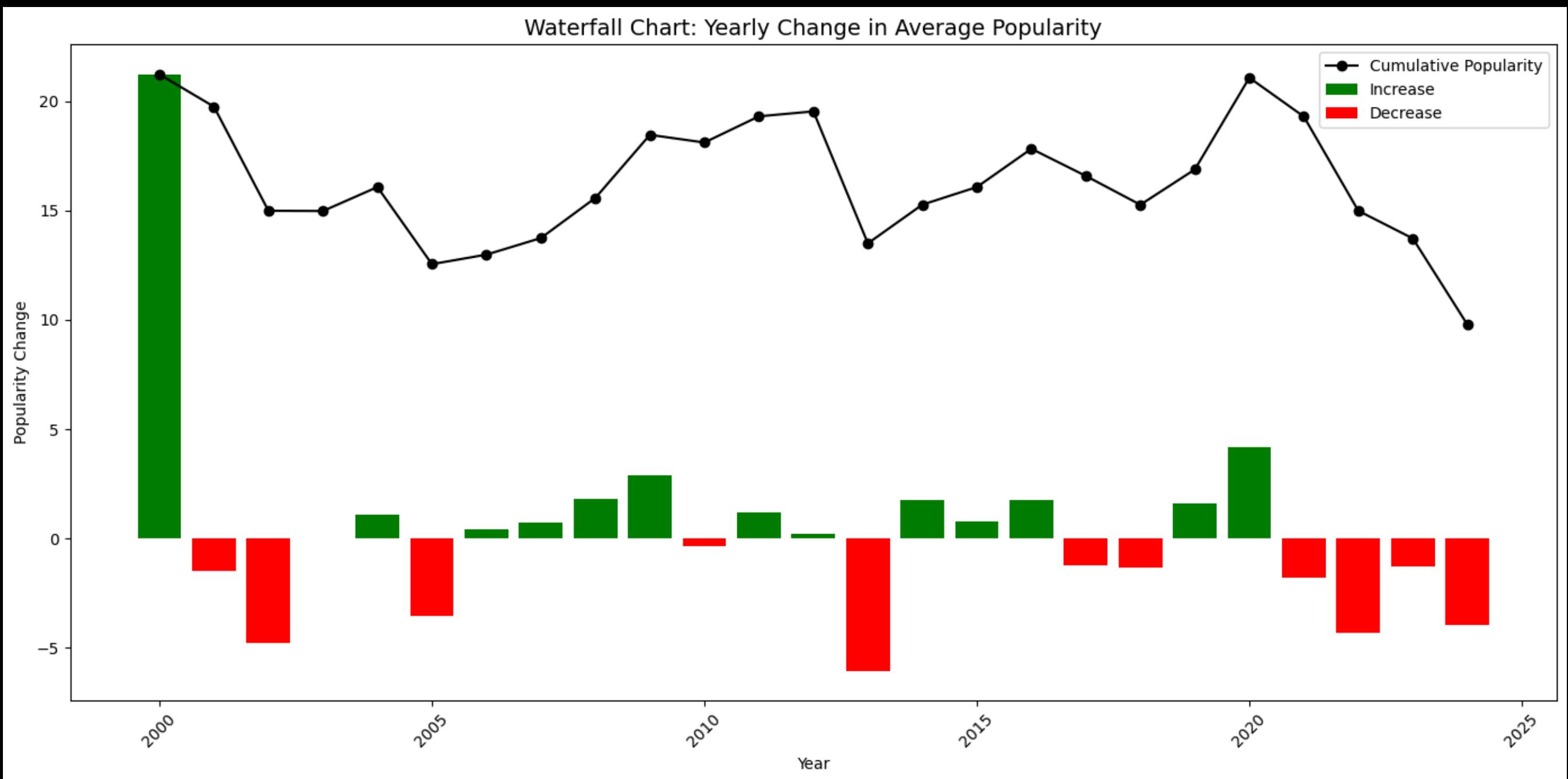
POPULAR TRACKS TEND TO CLUSTER IN HIGH ENERGY AND DANCEABILITY ZONES, WITH VARIED EMOTIONAL TONES. YELLOW BUBBLES = UPBEAT AND POSITIVE; PURPLE = DARKER MOODS.

## LOLLIPOP CHART: POPULARITY VS ARTISTS

- COMBINES POPULARITY (HEIGHT), ENERGY (COLOR), AND POSSIBLY SONG COUNT (BUBBLE SIZE):
- A.R. RAHMAN, SID SRIRAM, AND SHANKAR MAHADEVAN SHOW HIGH POPULARITY AND ENERGY.
- COLLABORATIVE ARTISTS (E.G., ANIRUDH RAVICHANDER, DHANUSH) ALSO PERFORM WELL. THIS CHART HIGHLIGHTS STANDOUT ARTISTS IN TERMS OF BOTH REACH AND MUSICAL INTENSITY.

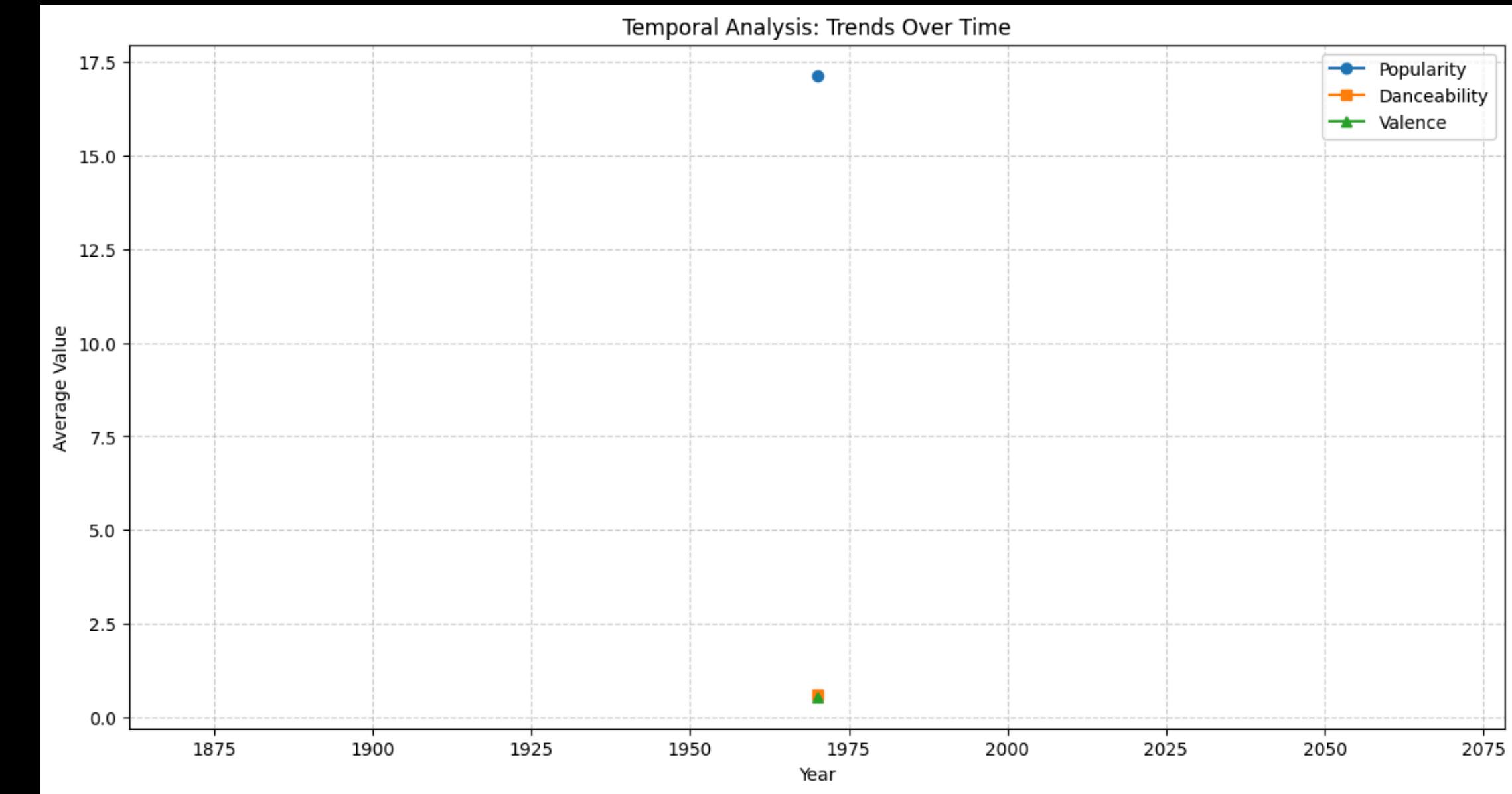


# YEARLY CHANGE IN AVERAGE POPULARITY



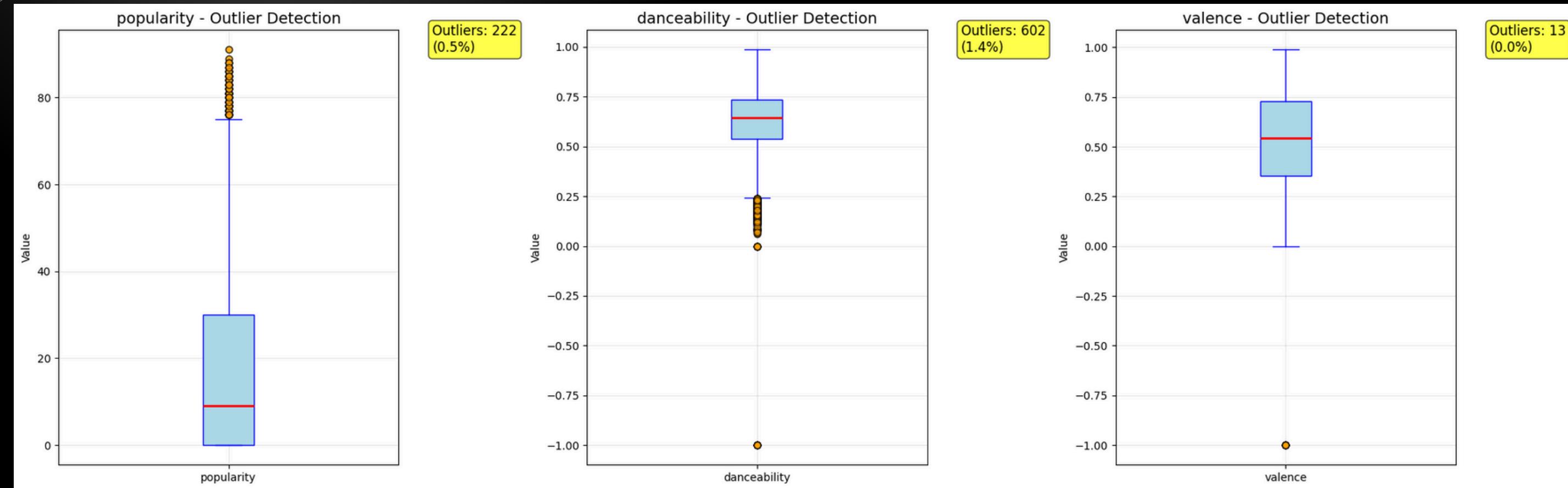
- - 
  - 
  - SHARP DROP IN 2001, FOLLOWED BY FLUCTUATING RECOVERY. REFLECTS CHANGING MUSIC CONSUMPTION PATTERNS, POSSIBLY INFLUENCED BY STREAMING, SOCIAL MEDIA, OR GLOBAL EVENTS.
- GREEN BARS = GROWTH YEARS  
RED BARS = DECLINE YEARS  
CUMULATIVE LINE SHOWS OVERALL TREND

# TRENDS OVER TIME



- Shows average values of popularity, danceability, and valence around the year 1975.
- Popularity is low (~17.5), danceability is very low (~1), and valence is moderate (~0.5).
- Suggests that music from that era was less popular and less danceable, but emotionally balanced.

# OUTLIER DETECTION

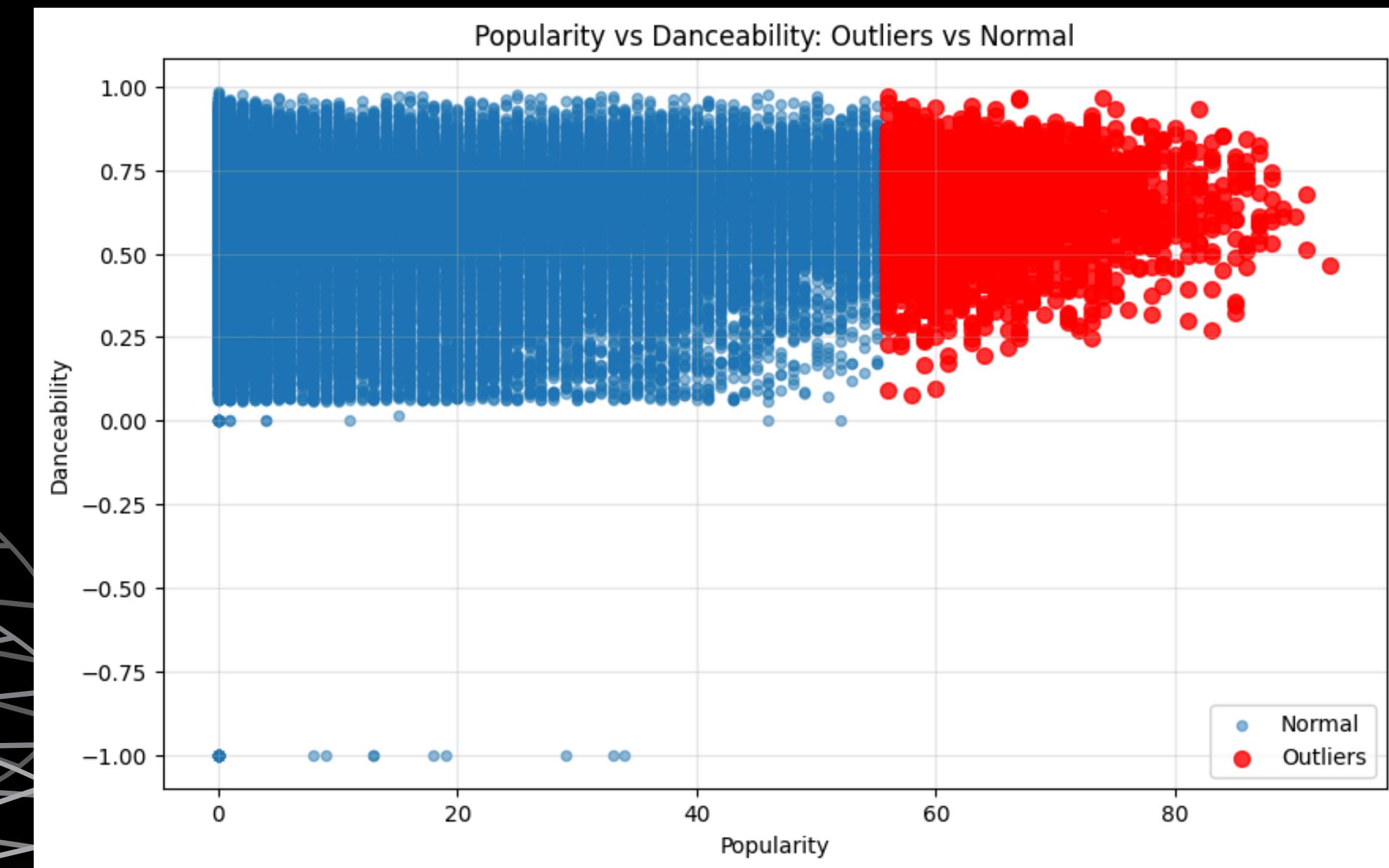
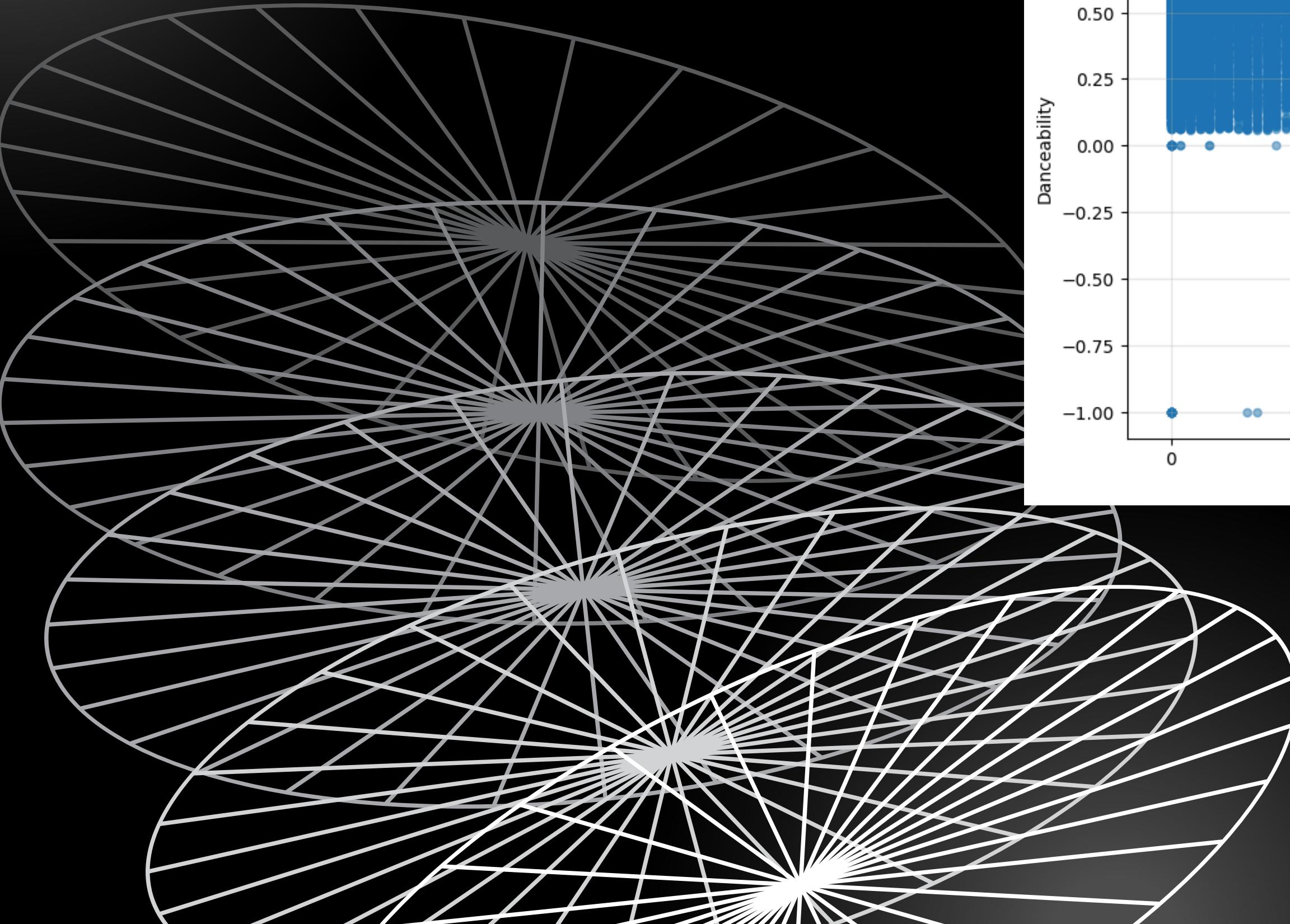


Popularity: 222 outliers (0.54%)—mostly high values.

- Danceability: 602 outliers (1.47%)—mostly low values.
- Valence: Only 13 outliers (0.03%)—distribution is tight.

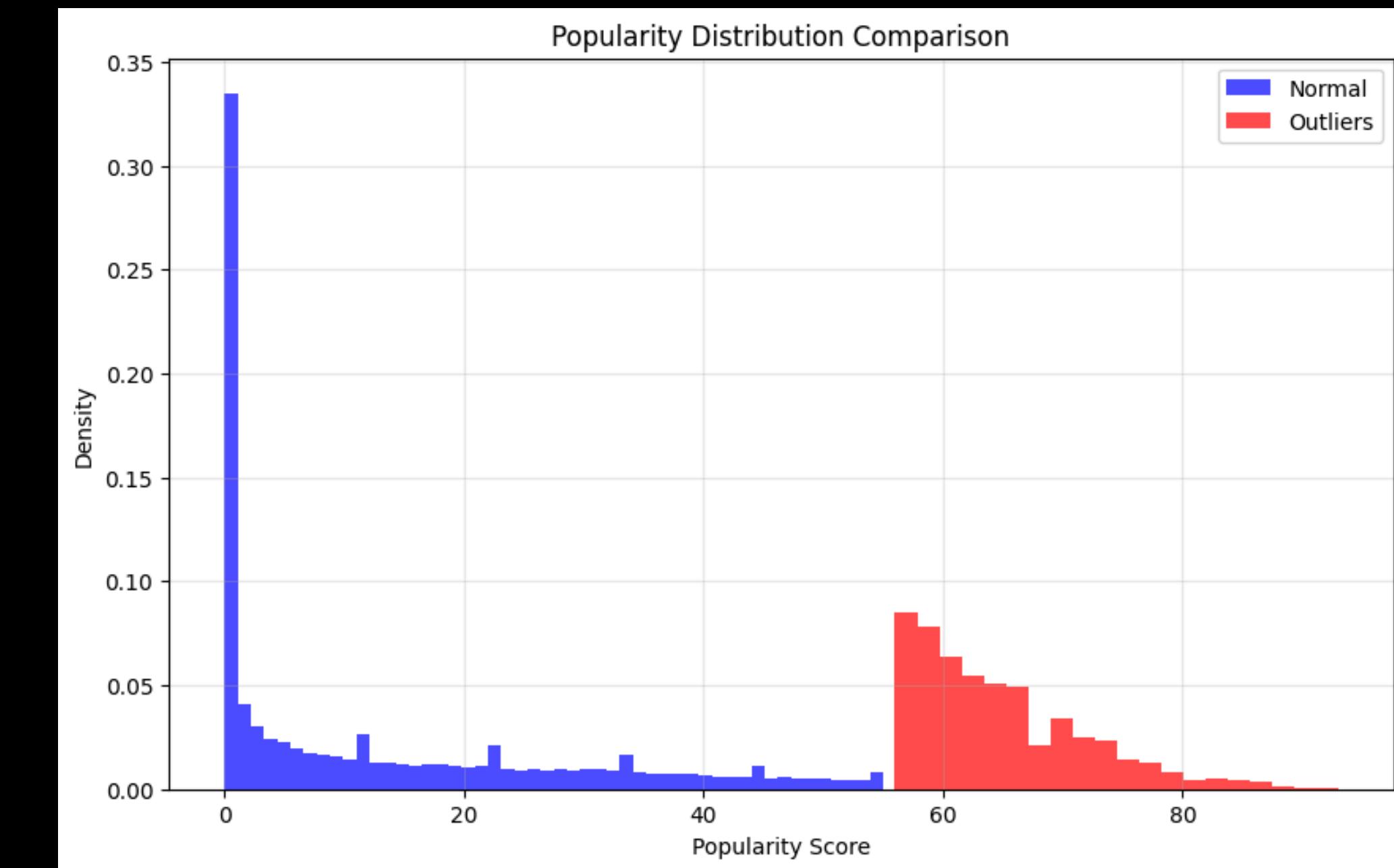
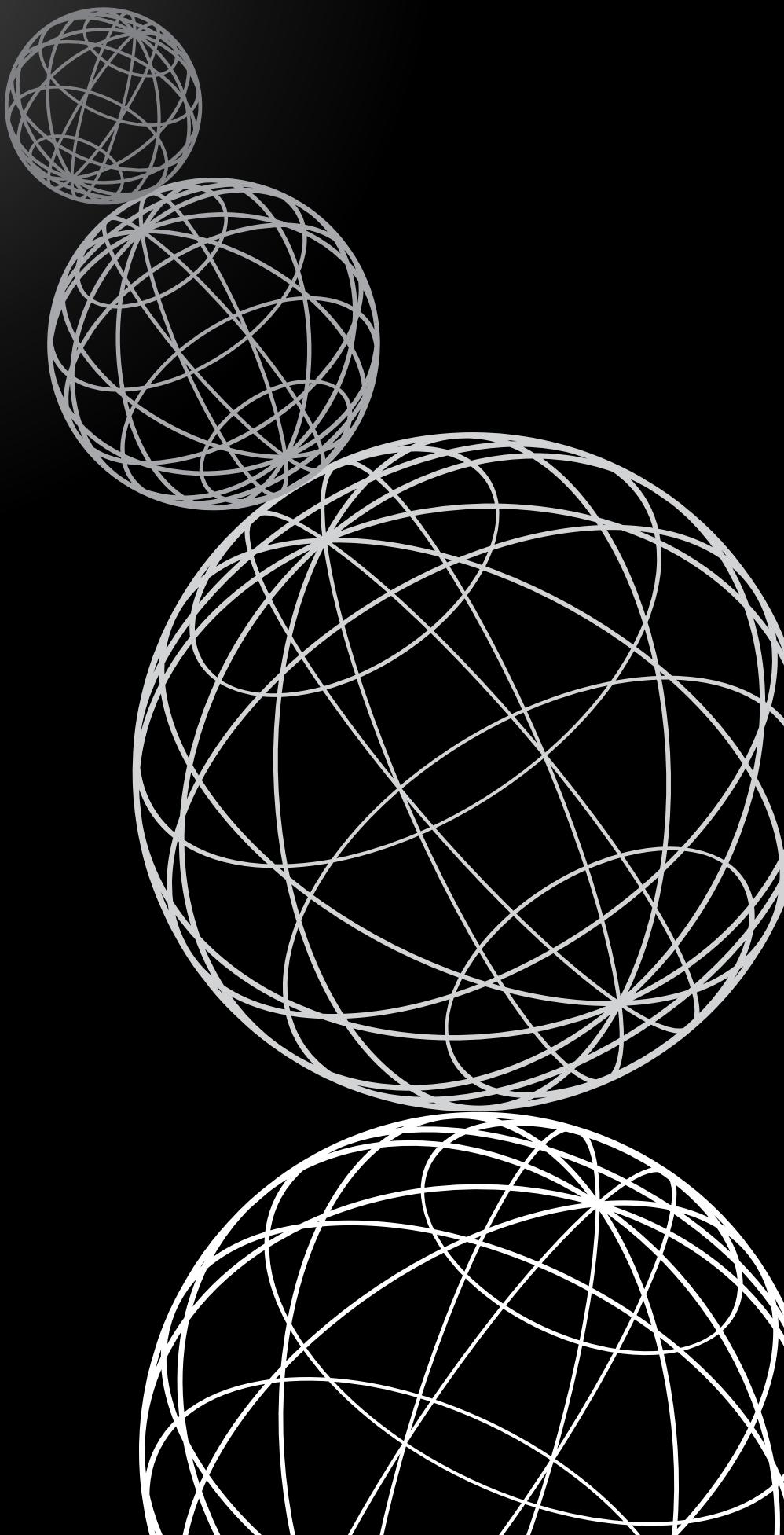
Indicates that popularity and danceability have more extreme values than valence.

# Outliers vs Normal



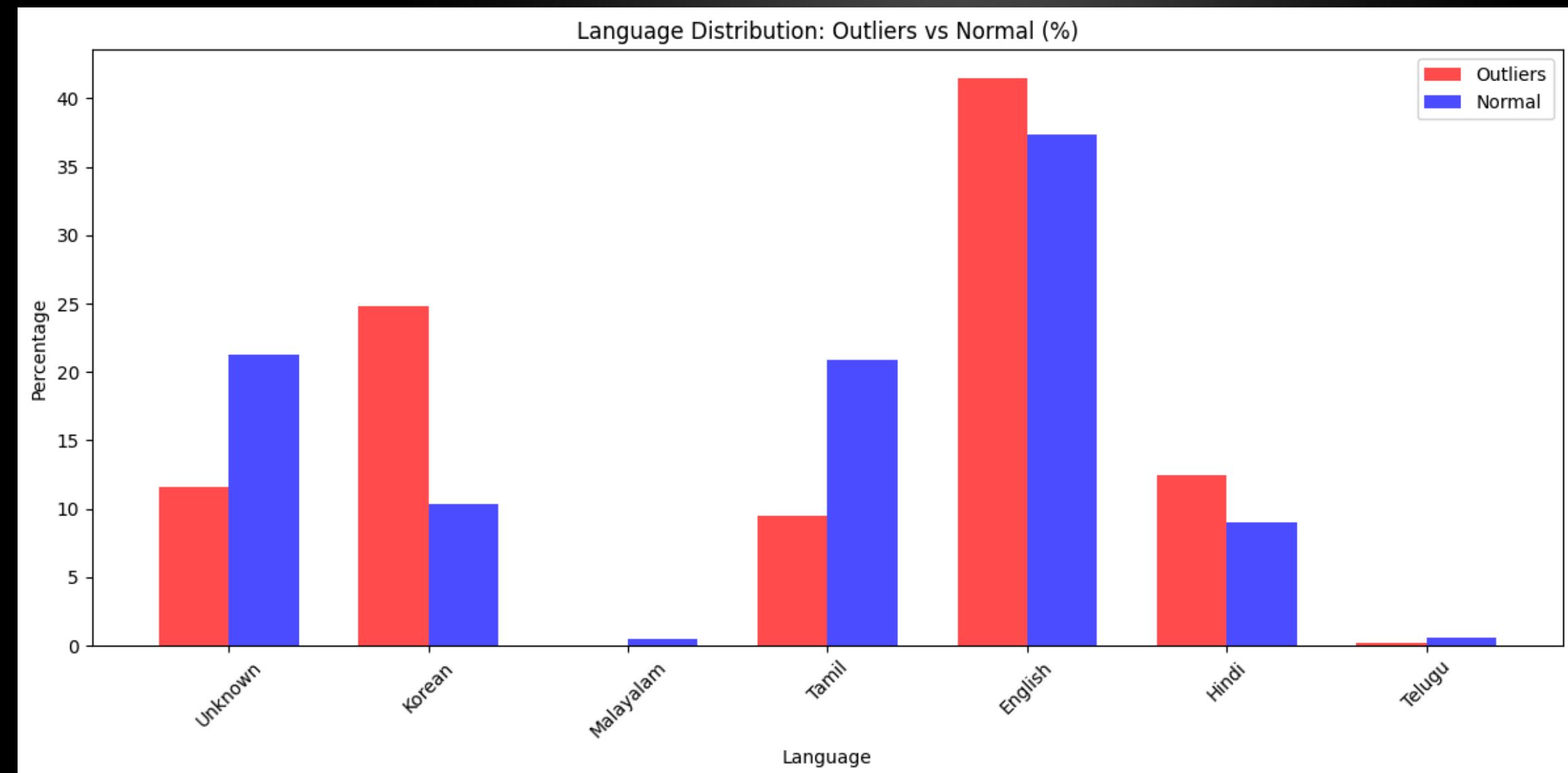
- *Normal tracks (blue): Spread across all popularity levels.*
- *Outliers (red): Concentrated in high popularity zone (>50).*
- *Implies that highly popular songs often have unusual danceability scores*

# POPULARITY DISTRIBUTION COMPARISON



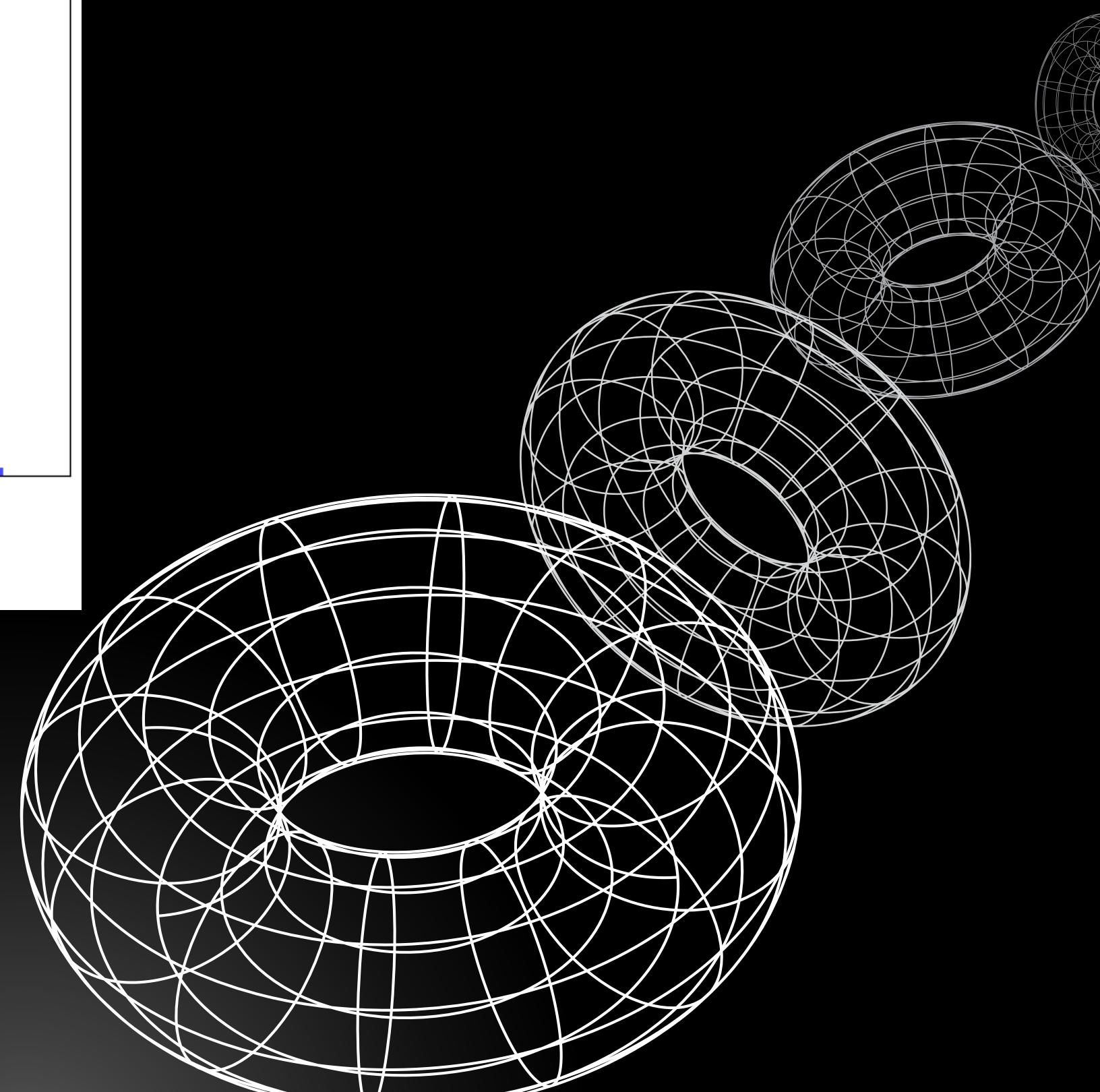
- Normal tracks: Peak near low popularity scores.
- Outliers: Clustered around higher popularity (~60).
- Suggests that outliers represent more popular songs, while most tracks are relatively unknown.

# LANGUAGE DISTRIBUTION: OUTLIERS VS NORMAL (%)

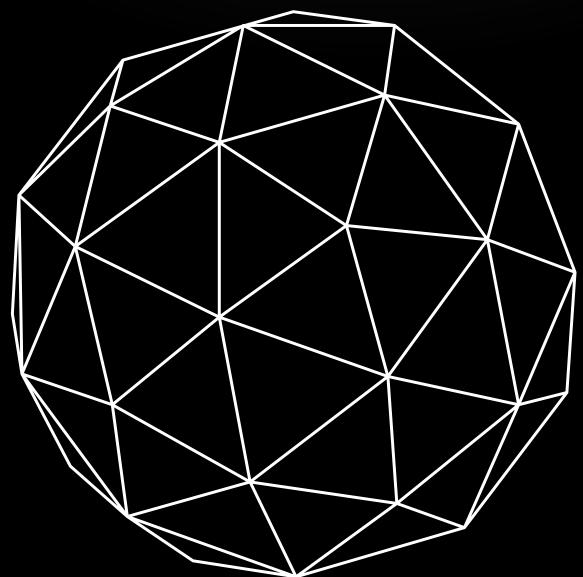


- English dominates both groups, slightly more in outliers.
- Tamil also shows higher percentage in outliers.
- Other languages like Hindi and Telugu are underrepresented.

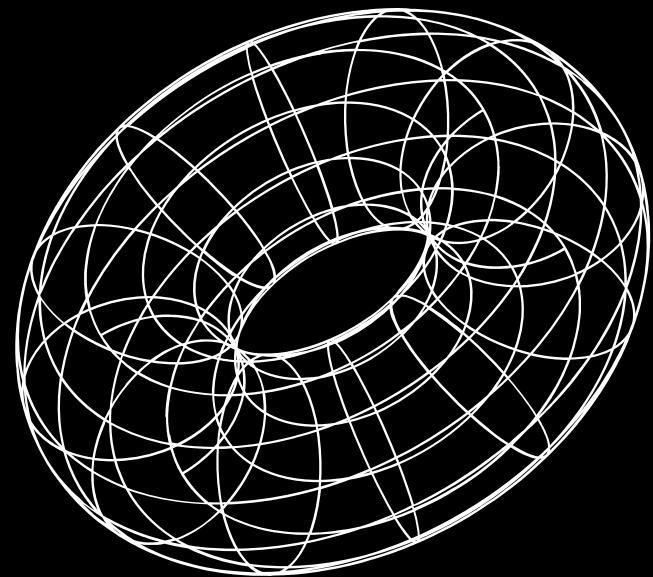
Suggests English and Tamil songs are more likely to be outliers in popularity or features.



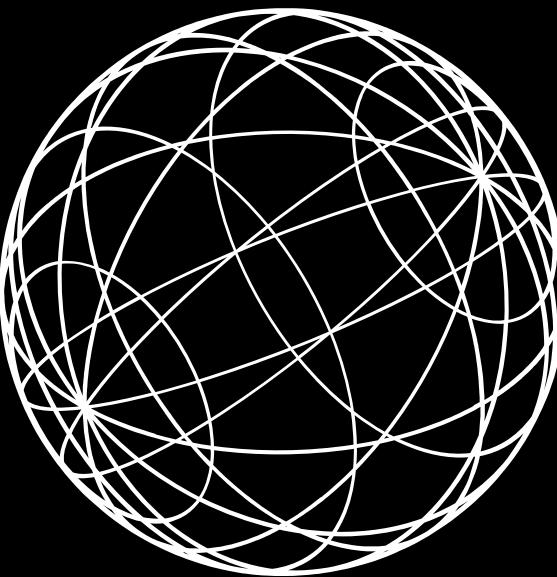
# OVERALL ANALYSIS KEY-POINTS



**Data Quality  
Insights**



**Audio Features Reveal  
Strong Correlations**

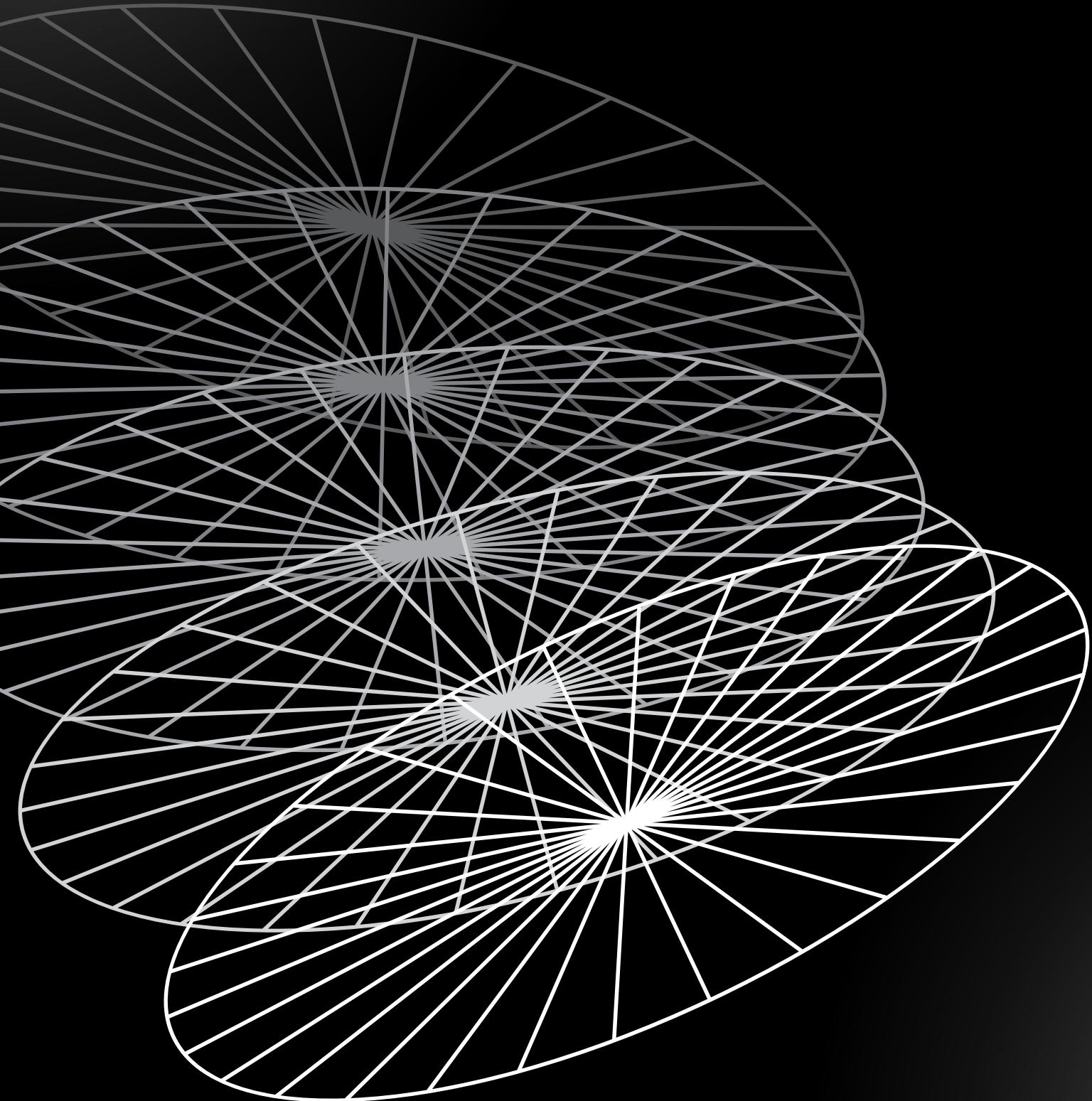


**Language Plays a  
Major Role**



**♪♪ Track  
Characteristics**

# Summary



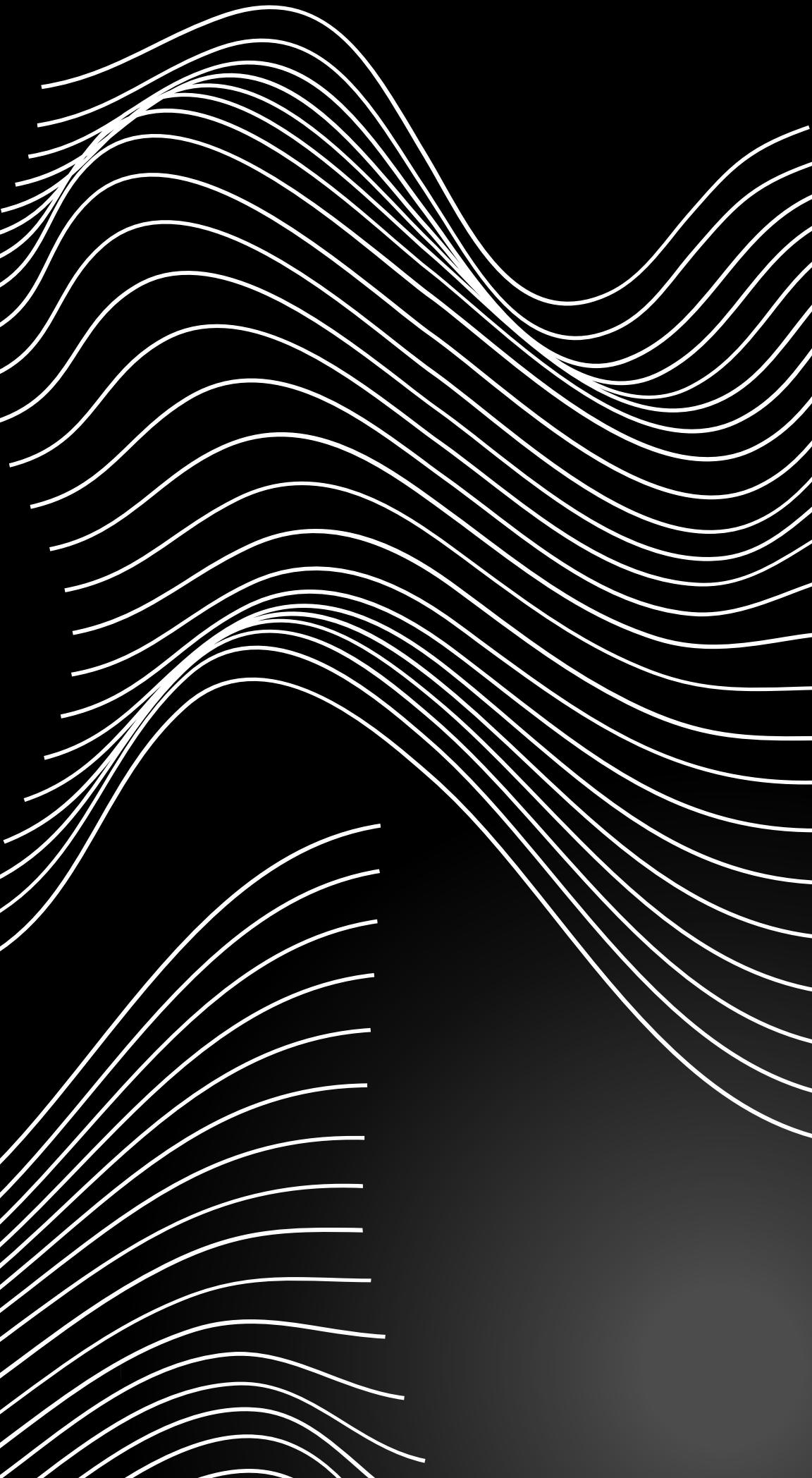
- *Popularity is highly skewed: Most tracks have low popularity; outliers dominate the high end.*
- *Audio features show strong patterns: Energy, loudness, and danceability are tightly linked; popularity is weakly correlated with features.*
- *Language and artist influence is significant: English leads overall, but regional languages like Tamil and Hindi show strong engagement; a few artists dominate by language.*
- *Outliers reveal key insights: Popular tracks often have extreme feature values and are concentrated in specific languages and artist groups*

# RECOMMENDATIONS

## Optimize Musical DNA for Popularity

### IMMEDIATE STRATEGY (0-3 Months)

- Replicate the "Korean Model": Deconstruct the high-performing audio features (Energy, Danceability) of Korean tracks (Avg. Popularity: 27.55) and apply this formula across other languages.
- Enhance Key Audio Features: Systematically increase Energy (the feature most correlated with popularity) and Danceability in new productions.
- Actionable Tactic: Implement A/B testing for different musical arrangements to identify the most effective feature combinations for each target market.

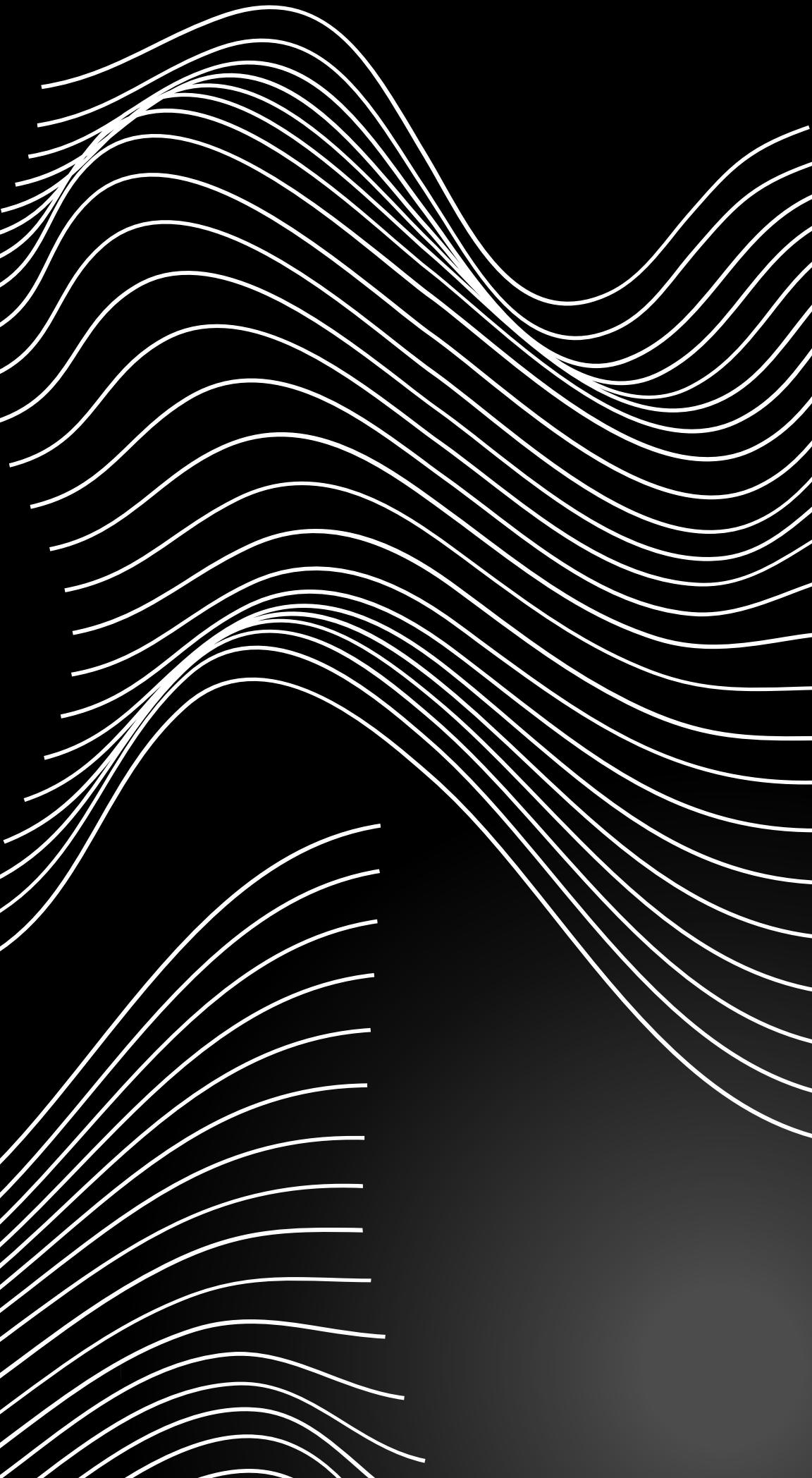


# RECOMMENDATIONS

## Execute a Tiered Language Market Strategy

### SHORT-TERM STRATEGY (1-6 Months)

- Established Markets: Deepen engagement in English, Korean, and Tamil (73% of portfolio) by increasing release frequency with optimized tracks.
- Develop High-Potential Markets: Strategically expand in Hindi, Telugu, and Malayalam by allocating dedicated production resources and creating targeted, culturally resonant hits.
- Actionable Tactic: Launch pilot projects in emerging markets, adapting winning musical formulas from top-performing languages.

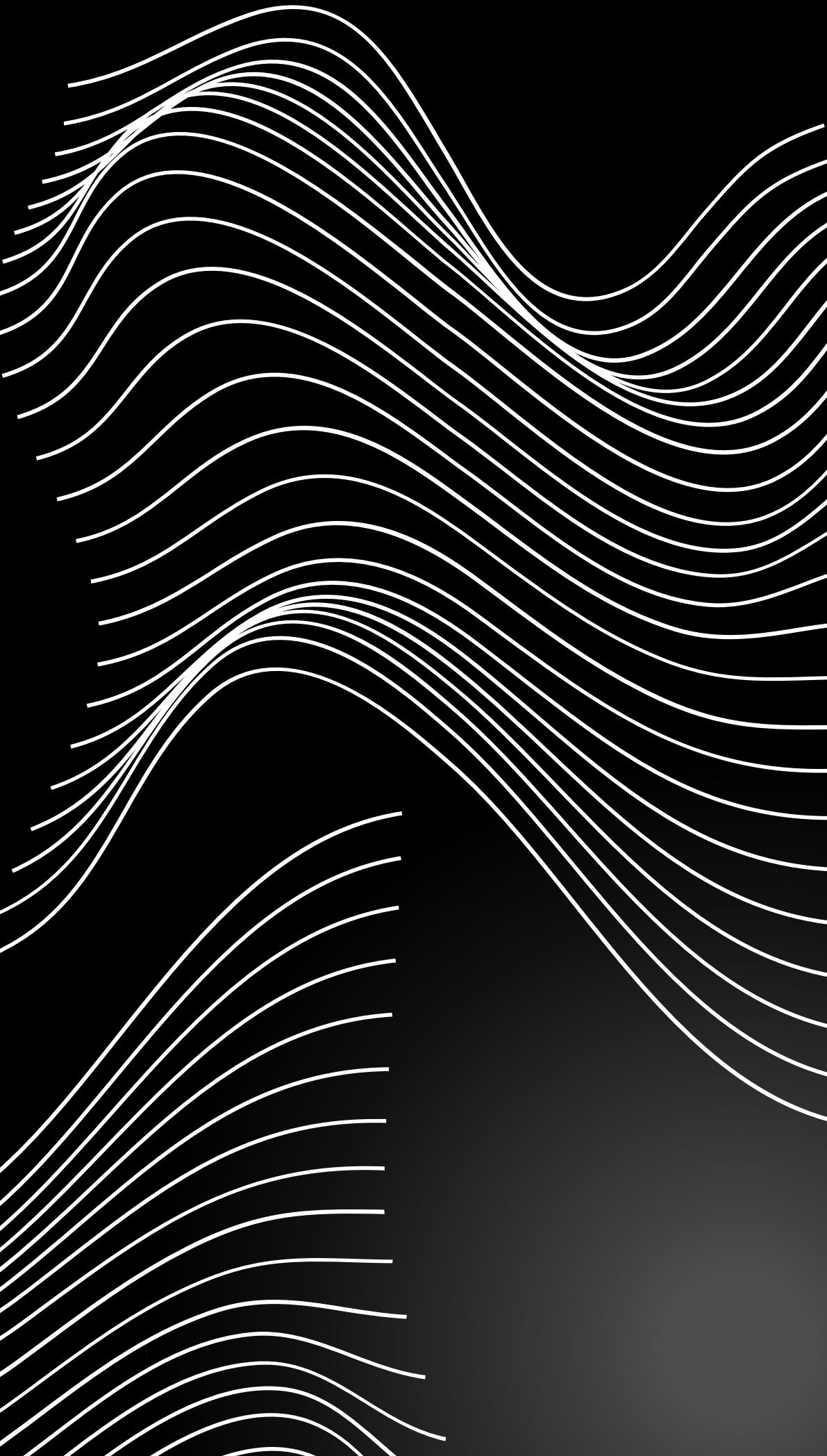


# RECOMMENDATIONS

## Implement a Data-Driven Release Roadmap

### LONG-TERM STRATEGY (3-12 Months)

- Leverage Temporal Trends: Analyze historical success patterns (e.g., peak popularity years) to inform the timing and musical style of future releases.
- Build a Predictive Model: Develop forecasting tools to anticipate popularity trends and plan a multi-year, cross-language release calendar.
- Actionable Tactic: Create a "musical evolution roadmap" to balance consistency with innovation, ensuring the artist's sound remains fresh while retaining core popular elements.



# RECOMMENDATIONS

**("Replace intuition with evidence.")**

## STRATEGY: AMPLIFY THE WINNING SIGNAL

- Double down on Energy - It's your strongest popularity driver
- Replicate the Korean blueprint - Highest performing market (27.5 avg)
- A/B test danceability variants - Systematic optimization beats guesswork

## STRATEGY: FORTIFY & ATTACK

Fortify: English/Korean/Tamil (73% of portfolio)

Attack: Hindi/Telugu with Korean-style productions

Incubate: Malayalam as experimental market

## STRATEGY: DATA-DRIVEN RELEASE ENGINE

Weaponize temporal patterns from 1976 & 2020 peak years

Build predictive scoring for track potential pre-release

Implement portfolio balancing across languages/features

# THANK YOU