Hit Tracks From 50's Blues to 20's Rap: Analyzing Features of Billboard's Hottest Songs

Ashton Cho, Deric Liang, Wes Morberg

Github: https://github.com/UC-Berkeley-I-School/Project2_Cho_Liang_Morberg.git

Introduction

The concept of song popularity as we know it today largely originates from Billboard magazine. Each week, Billboard ranks songs based on radio airplay and streaming activity, which they then publish as part of their Billboard Top 100 and Top 200 lists. Through these publications, Billboard has established itself as an entity commanding the highest respect from casual listeners to veterans across the music industry. It provides a resource for anyone to assess music trends and learn what music listeners want, which we take advantage of in this project.

We seek to answer the following question: what characteristics most strongly indicate the most popular songs, as defined by song presence, rankings, and longevity on the Billboard charts? Our analysis will combine Billboard metrics with song attributes available through the Spotify API, which include audio features, song length, key signature, genre, and more. We hypothesize that we will observe the following:

- A positive correlation between Billboard rank and Spotify popularity score metrics
- Audio features influence songs' rank and popularity scores
- Genres have distinct audio feature characteristics and vary between genres (loudness, energy, danceability, etc.)
- Chronological shifts exist in genres and features of popular tracks, from 1958-2021
- Artists with the most Billboard hits will include Taylor Swift, Kanye West, The Beatles, Drake, The Weeknd, and Michael Jackson
- Higher popularity for songs in major keys and songs 2:30-3:00 minutes in duration

At the end of this study, we aim to provide conclusions on song attributes presenting the strongest correlations and relationships with the most popular songs. This will provide the general audience with an overview of their own listening trends, as well as players in the music industry with insight on what their audiences seek from their music.

Data Processing

To prepare the data for analysis, the Billboard and audio_features csv files were loaded into separate pandas dataframes. The Billboard file recorded the rise and decline of a song's rank in the Billboard Hot 100, spanning decades, from 1958 to 2021. The audio_features file showed various data about the songs found in the Billboard file, including the song artist, genre, duration, key, and popularity. This file also contained the audio features of these songs found in the Spotify api, such as energy, danceability, speechiness, acousticness, valence, etc.

After an initial observation of the two dataframes, we found that the number of rows in the Billboard dataframe were several times that of the number of rows in the audio_features

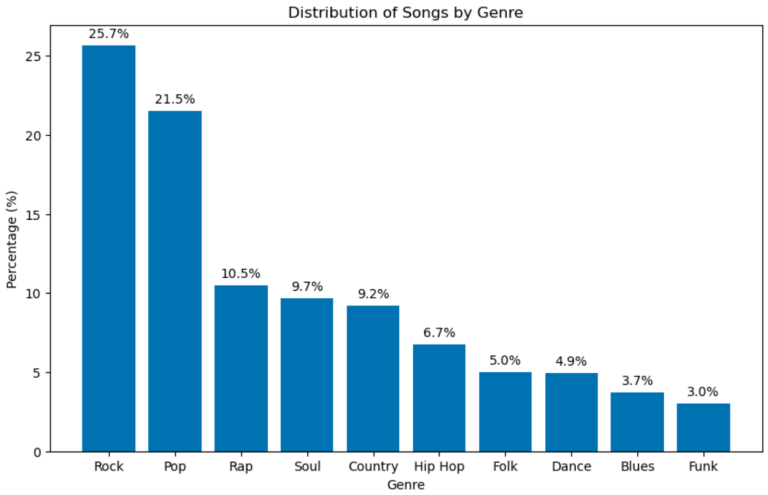
dataframe. This was because the Billboard data contained a row for every week the song was on the Hot 100 chart, from its first appearance on the chart to its peak position to its decline. Thus, only four of the columns from the Billboard dataframe were kept to be merged with the audio_features dataframe: ‘song_id’ (a concatenation of the song and artist name, to be used as the column to join on), ‘peak_position’, ‘week_id’ (the week that the song hit its peak), and ‘weeks_on_chart.’

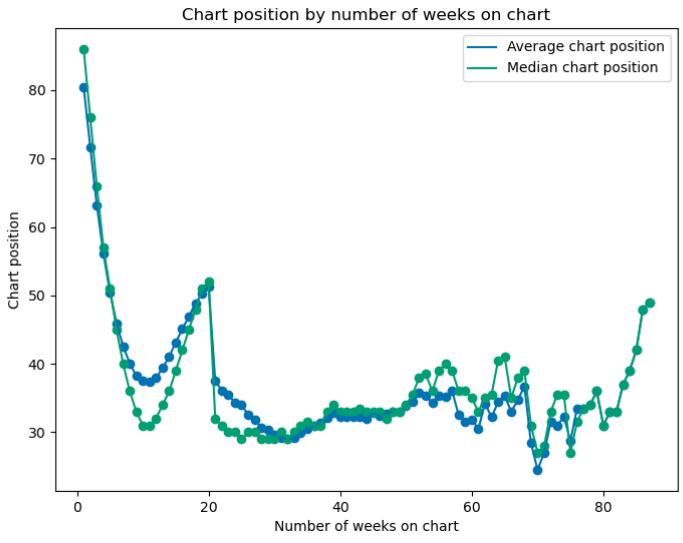
However, before the two dataframes could be merged, the ‘song_id’ column showed some inconsistencies. Though the song and artist names were the same, the case differed for a few rows. The inconsistencies were found and replaced. The data frames were merged, and 24,224 complete rows with unique songs were saved to a new csv file for analysis.

In order to analyze popularity metrics and audio features of songs by genre, additional data preprocessing was required. In the raw dataset from the Spotify API, multiple subgenres were assigned to each song and stored as a list as shown to the right:

	song_id	performer	song	spotify_genre
17965	All I Want For Christmas Is YouMariah Carey	Mariah Carey	All I Want For Christmas Is You	['dance pop', 'pop', 'r&b', 'urban contemporary']

The Pandas explode() function was then used to iterate through each element of the spotify_genre list to generate a new row per element. In the case above, four rows would be generated, where each value represents one of the subgenres provided by Spotify. Each of these subgenres were then assigned, if applicable, to 1 of 10 most popular genres as determined by a separate analysis, and dropped rows that did not meet these criteria. This bar chart provides a breakdown of distribution of



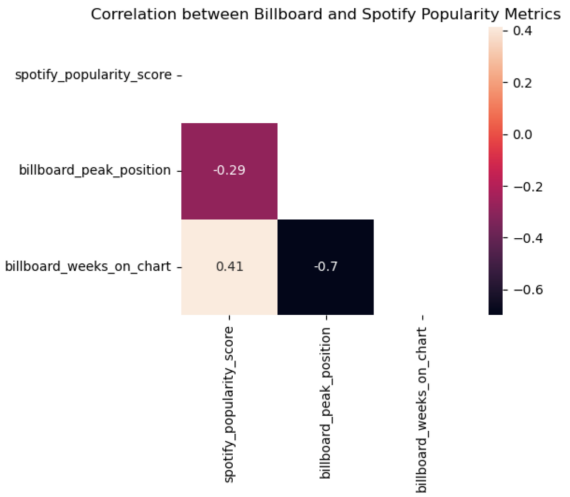


Basics on Chart Positions and Correlations

Discourse around Billboard’s charts usually involve two metrics: a song’s rank/chart position, and how long a song has charted, in number of weeks. Logically, a song’s chart position can be an indicator of a song’s current popularity, and the number of weeks a song has

charted can be an indicator of a song's newness or long-term popularity. First, we are interested in observing how a song's popularity changes with how new it is.
This line and scatter plot shows the average and median chart position for a song for each number of weeks it has been on the charts. From this plot, we observe that songs gradually become more popular over the first 10 weeks, rather than starting off hot. After week 10, the song starts to cool in popularity. Interestingly, after week 20, we suspect that this threshold is when a song has demonstrated a capability for long-term popularity, and thus the chart position trends back to a more popular range and maintains its high level of popularity over many more weeks. Overall, this tells us that a song's popularity may be highly influenced by charting for 10 weeks or for more than 20 weeks.

Expanding our scope, we want to explore more metrics that usually represent how popular a song is. In addition to the number of weeks on the Billboard charts, additional metrics include streaming numbers, a song's peak position on the Billboard charts. We aim to see if these metrics of popularity are highly correlated, and thus substitutable.



The plot to the right is a correlation heatmap between Spotify popularity score (which is partially based on streams), Billboard peak position, and Billboard weeks on charts. Surprisingly, we observe that the Spotify popularity score has a weak relationship with the Billboard popularity metrics. We believe that this occurs because many of the older songs in the data which were once popular but are no longer popular will have low streaming numbers, such that these popularity metrics may only be substitutable for recent songs released in the streaming era.

Exploration of Audio Features and Trends over Time

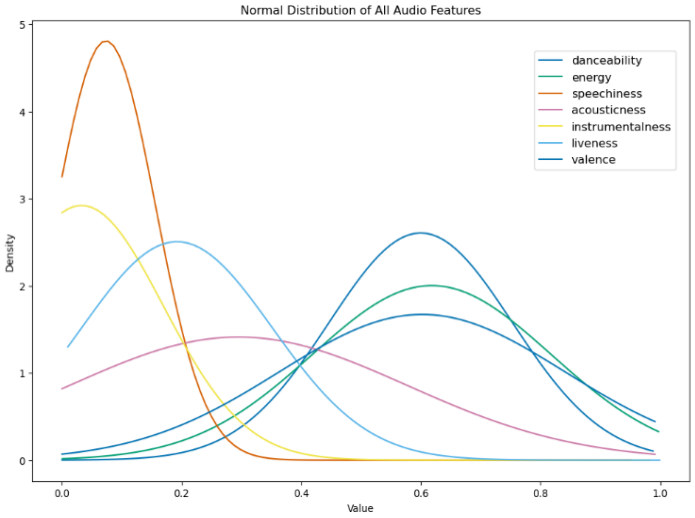
The Spotify API documentation describes the audio features as follows:

- Danceability: how suitable a track is for dancing based on a combination of musical elements including tempo, rhythm stability, beat strength, and overall regularity.
- Energy: a measure of intensity and activity.
- Speechiness: the presence of spoken words in a track.
- Acousticness: a confidence measure of whether the track is acoustic.
- Instrumentalness: predicts whether a track contains no vocals.
- Liveness: detects the presence of an audience in the recording.
- Valence: the musical positiveness conveyed by a track

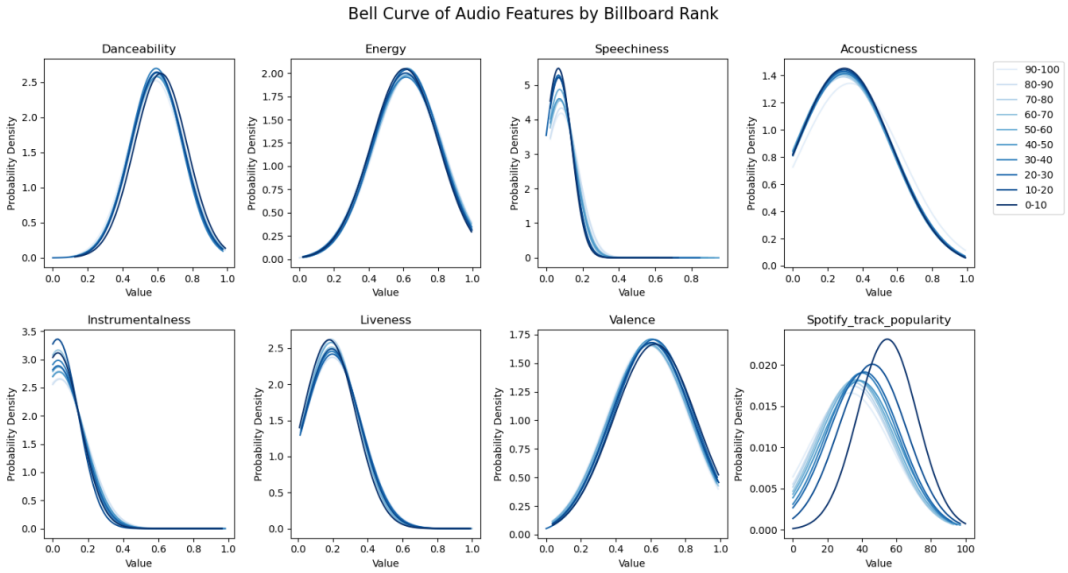
The full description of the features is provided in the audio_features_analysis.ipynb file.

Using the scipy module, bell curves of all the attributes were plotted. The range of the audio feature values span from 0 to 1. The “mean” values correspond to the peak of the bell curves, and the ‘std’, or standard deviation, values determine the steepness of the curves.

The graph to the right details the audio feature values of all the tracks in the data set.



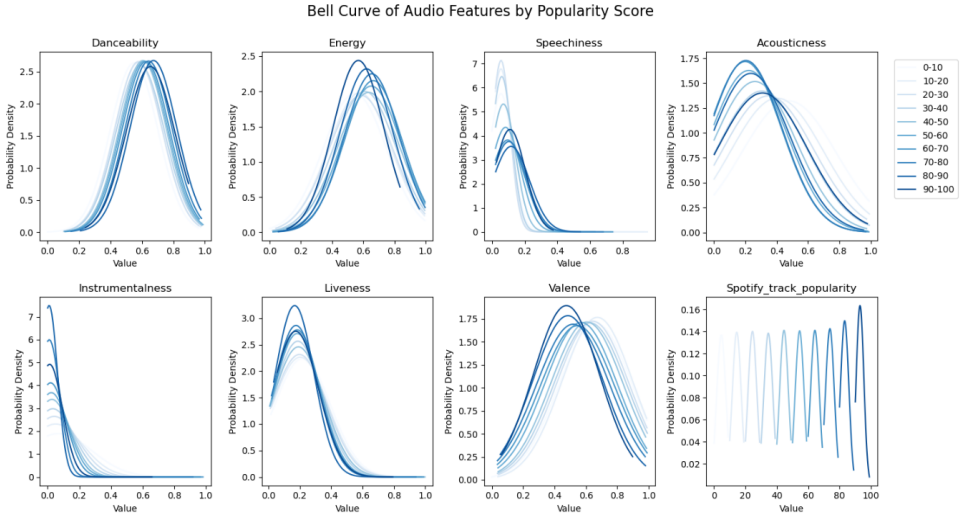
First, the audio features will be separated by the songs’ Billboard rank to understand if there are any audio features that correlate with a high or low Billboard rank. In addition to the features, the track popularity will be plotted as well to understand its correlation to rank.



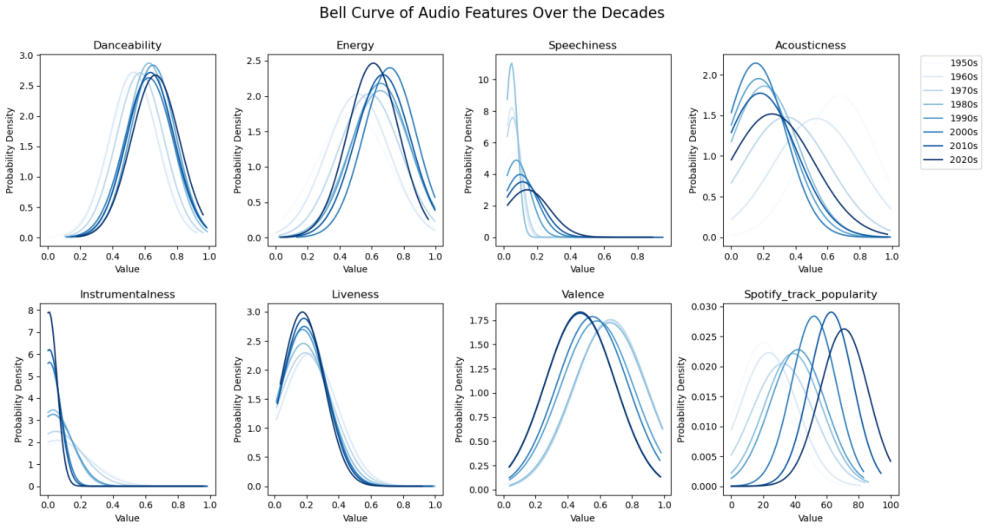
As seen in the plots above, most of the audio features are very similar in value and density regardless of the rank. The speechiness and instumentalness value slightly decreases in correlation to rank. This suggests a small positive correlation between a song's rank and the likelihood of it featuring lyrics or vocals.

Since grouping by Billboard rank provided little insight into the audio features of successful songs, we move on to grouping songs by the spotify popularity score. Track popularity, ranging from 0 to 100, is primarily determined by the total number of recent plays. Higher popularity scores indicate songs that are currently receiving more plays, emphasizing the influence of

recent listening trends over historical play counts. This confirms the lack of correlation between popularity scores and Billboard ranks as ranks are unchanged over time.



Several details can be seen in the plots above. Tracks with higher popularity scores are seen to have slightly higher danceability and speechiness values and slightly lower instrumentalness, liveness, and valence values. Acousticness values seem to be lowest for songs around the median popularity score.

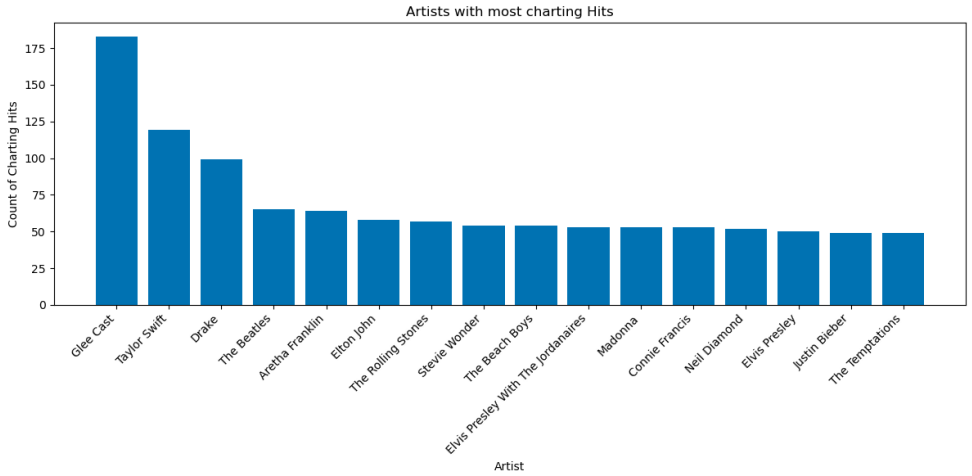


The plots above indicate that danceability, energy, and speechiness values slightly increased over time, whereas acousticness, instrumentalness, and valence values slightly decreased over time.

Exploration of Other Song Attributes

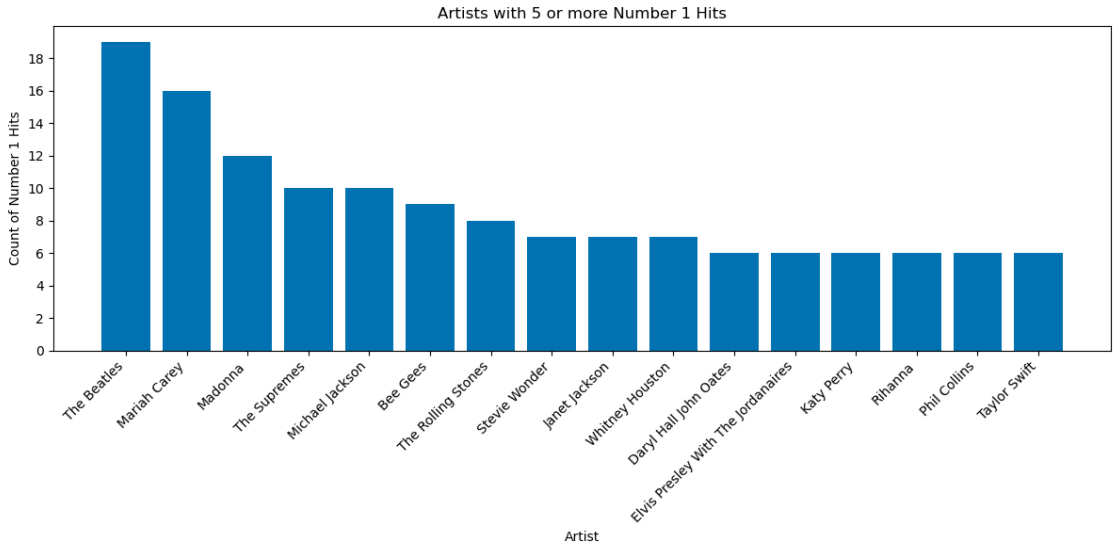
This section explores other common characteristics behind the most popular songs, including common artists, key signature, and song duration. First, we prepare a bar plot to visualize which artists have the highest count of songs on the Billboard charts. This knowledge could allow

music industry executives to focus their research into a select list of artists to study what made these artists so successful.



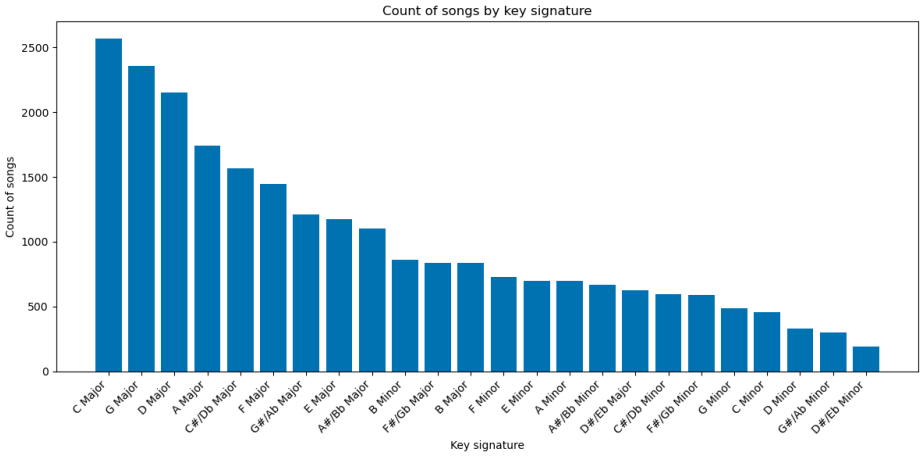
The above plot, surprisingly, shows that the Glee Cast far and away has charted the most Billboard hits compared to other artists, with the next highest (Taylor Swift), having over 50 less songs on the charts. However, this finding makes sense because the Glee Cast has the ability to draw on and essentially re-release already popular songs from many different artists, making it easy for them to accumulate a large number of hits. Unsurprisingly, we also see familiar names such as Drake, The Beatles, Aretha Franklin, and Elton John who have been industry giants in the present and past.

However, having your song chart versus having your song reach number one are completely different accomplishments. Having your song reach number one means that the song has reached the forefront of music culture in that current period of time. Therefore, we are interested in seeing if the artists with the most charting songs also see a much higher level of success in achieving number one hits.



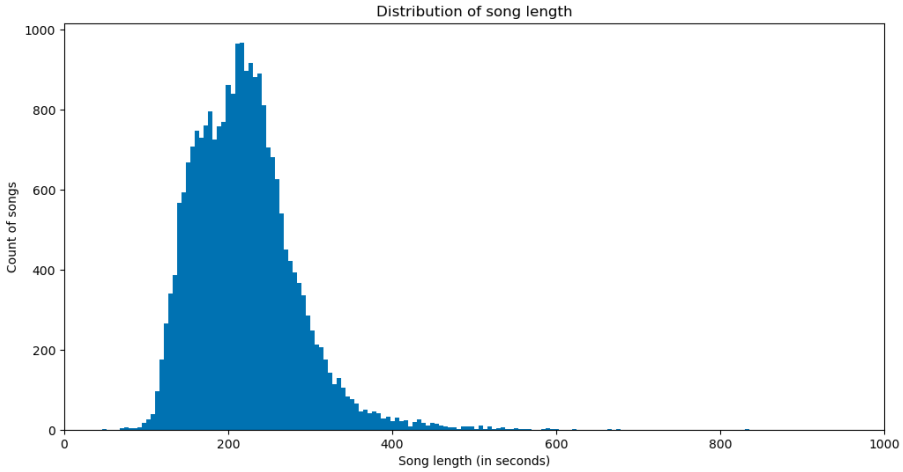
The plot above displays a bar chart of the artists with five or more Number 1 songs. Compared to the previous bar chart, it seems that The Beatles are the only artist able to elevate their success from having a large number of charting songs to a large number of Number 1 songs. Even the modern cultural landmarks of the music industry as seen in the previous chart, Taylor Swift and Drake, pale in comparison, with Taylor Swift having almost 15 less Number 1 songs than the Beatles, and Drake not even having five Number 1 songs.

Next, we explore how key signature affects a song's success. Are there certain key signatures that the most popular artists choose for their songs, or that audiences drive to popularity? We answer this question through the below bar plot of the count of songs charting, grouped by key signature.



The bar plot above shows several sensible results. First, it seems that audiences are drawn towards songs in major keys, or in other words, happier-sounding songs. The top nine key signatures are all major keys. The keys that are the easiest to learn from a music theory perspective and are typically learned first by musicians (C, G, D, A Major) are the top key signatures, which may also indicate that mainstream artists typically take simpler approaches to writing their songs. In contrast, many of the least popular keys are minor keys, or sad-sounding songs. From a music theory perspective, it also makes sense that the two least popular keys, G#/Ab Minor and D#/Eb Minor, are some of the most difficult keys to play. These findings indicate that musicians looking to become popular could be advised to write happier, upbeat songs, as well as not stress about using complicated key signatures.

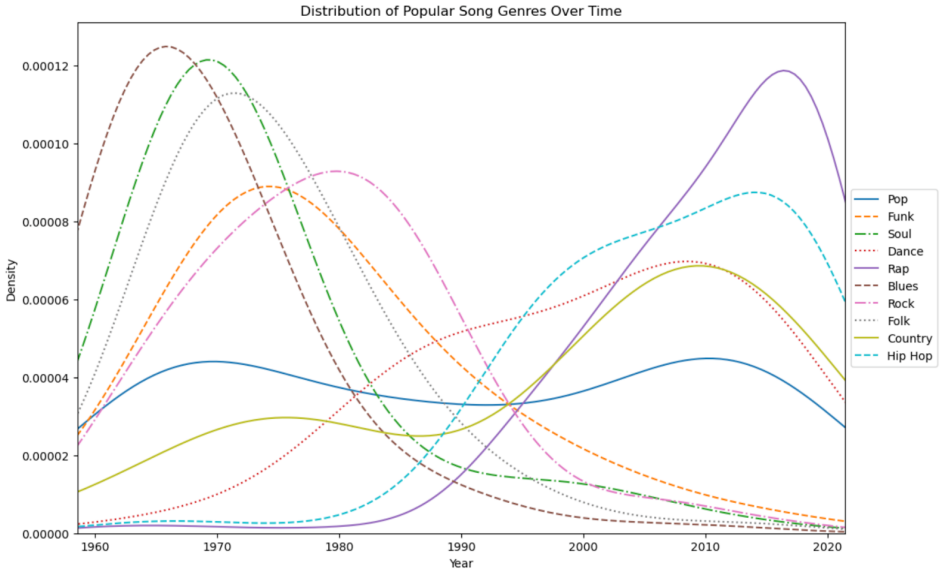
Finally, we conduct an exploration of the common time lengths of the most popular songs. In the last several decades, people have speculated that audiences' attention spans have decreased and that most songs have started to take a verse-chorus-verse… structure which has been optimized for songs around 2:30-3:00 minutes in length. In the below plot, we generate a histogram showing the distribution of lengths for all the Billboard songs in the data.



We see from the histogram that songs typically center around 3:30 minutes in length. There is also a high concentration of songs around the 3:00 to 3:30 minute marks. This suggests that artists should respect the attention spans of their audiences and deliver on the typically verse-chorus-verse… structure that has popularized over the past several decades. The histogram does show through its large tail that extremely long songs can become popular, but few of them do.

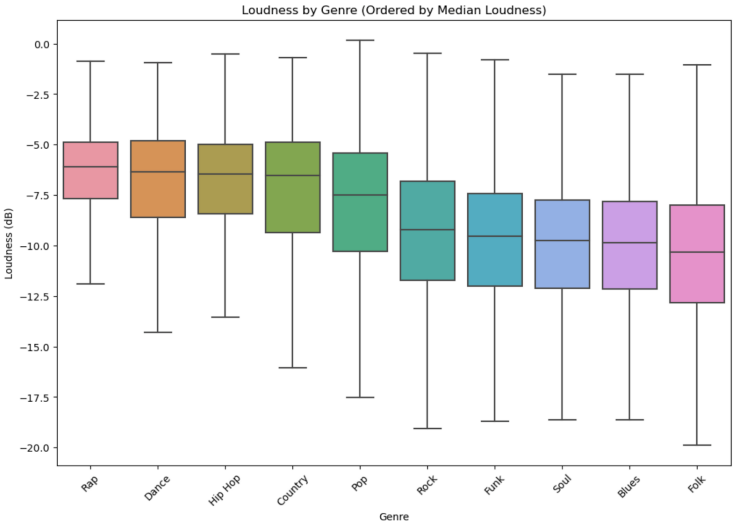
Genre Breakdown

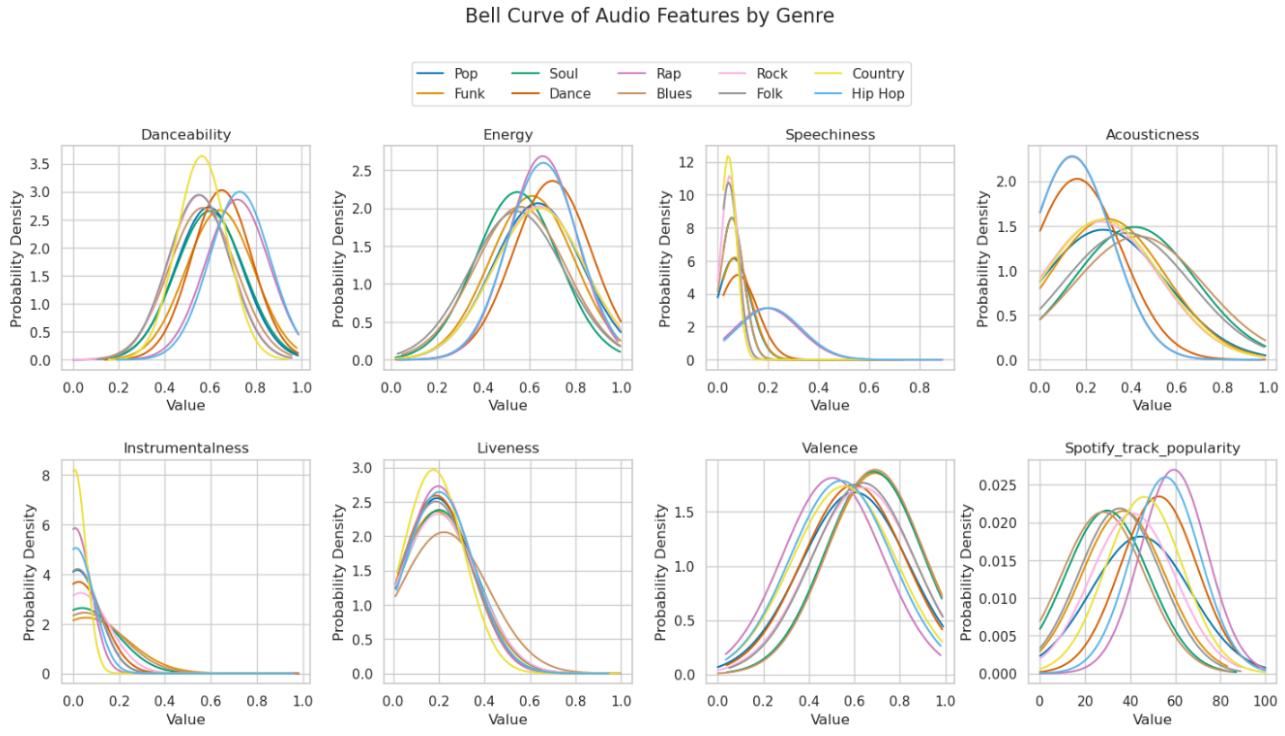
After processing the genre data as described in the Data Processing section, we first want to observe whether genre popularity has shifted over time. In order to visualize this, we used a Kernel Density Estimate (KDE) plot native to seaborn, which more or less functions like a "smoothed" histogram. This resulted in a cleaner visual representation when attempting to analyze 10 separate distributions as shown below:



From the visual above, we can make several observations. First, as indicated by the peaks in frequency of each distribution, genre popularity has shifted substantially from 1958 to 2021. The most popular genres during the 1960's to 1970's were blues, soul, and folk. Funk and rock peaked in popularity from the 1970's to 1980's. From the 1990's until now, rap, hip hop, and dance have dominated the Billboard charts. Pop and to some extent country have been fairly consistent in popularity throughout this time period.

Next, we generated box and whisker plots by genre and loudness (as measured in decibels) to observe whether modern popular genres as indicated in the prior KDE plot tend to be louder. The box plot to the right displays the inner 25th to 75th percentiles within each box, the inner line representing the median value, and outer "whiskers" to represent the 1.5 times the interquartile range (IQR). Modern genres including rap, dance, hip hop, and country show much higher loudness distributions in contrast to older genres like folk and blues.





Lastly, as shown above, we generated a normal distribution facet grid of each audio feature broken out by genre to examine key differences, if any, across genres. Each of these variables generated by Spotify's algorithm represent a score from 0-100 for each characteristic. Hip hop, rap, and dance all share distinctly higher and narrower curves, suggesting that this characteristic is a cornerstone of the track. Similarly, both rap and hip hop tend to incorporate more vocals on average than other genres, which explains the differences in the speechiness feature. Lastly, rap, hip hop, and dance tend to score higher in popularity as measured by Spotify's popularity score, likely because users skew towards preferences of modern genres.

Conclusion

How well did our findings support our hypotheses? Below, we present a summary of our findings in response to what we hypothesized we would observe:

- A positive correlation between Billboard and Spotify popularity score metrics: We surprisingly found that Billboard and Spotify popularity metrics have little correlation.
- Audio features influence songs' rank and popularity scores: Audio features have little influence on the rank and popularity scores.
- Genres have distinct audio feature characteristics and vary between genres (loudness, energy, danceability, etc.): This hypothesis holds true from the varying density distributions of audio features broken up by genre.
- Chronological shifts exist in genres and features of popular tracks, from 1958-2021: We observed the growth of hip-hop, rap, country, and dance. Pop has maintained its popularity throughout the decades. Soul, blues, folk, funk and rock saw declines.
- Artists with the most Billboard hits will include Taylor Swift, Kanye West, The Beatles, Drake, The Weeknd, and Michael Jackson: Kanye West and The Weeknd were absent from the top rankings of Billboard presence, while the others saw Billboard success.
- Higher popularity for songs in major keys and songs 2:30-3:00 minutes in duration: We were correct that songs in major keys see more popularity, but the most popular song duration was around 30 seconds longer than we had anticipated.

Further studies of this topic could explore data more recent than 2021 to observe how these change with new data, pursue a more granular analysis of how popular attributes vary between genres, or create statistical models to measure correlations between song popularity and song attributes, controlling for genre.