

| Problem Chosen | 2021          | Team Control Number |
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|                | Summary Sheet |                     |

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## The Music of Networks

We used **three different directed network graphs** to analyze and quantify the influence process in music evolution. Out-degree and in-degree of the vertices were considered to be our measure to capture the music influence. Using this, we identified the most influencing genres and most influencing artists. To further study the genres' influence, we created a sub graph from the network graphs and studied if there was more influence within the genre or outside the genre. We found out that there is more influence within the genre. Pop/Rock and The Beatles was found to be the most influencing.

We then implemented the **K-means Clustering Algorithm** to classify the artists on the basis of their similarities in musical characteristics into eight different clusters. Using this, we were able to study if artists within the genre were more similar than artists between genres. Artists from Pop/Rock and Electronic genre were found to be in the same cluster. Similarly, artists from Children's, and Easy Listening genre were found in the same cluster. Then we examined what distinguished a genre and its musical characteristics. With this, we compared the musical characteristics between different genres.

After that, we used our network graph to compare the influence between genres using the sub graphs and a **heatmap**. Then we studied whether the influencers affect the music created by the follower, and we found out that the influencers affect most of the music created by the followers. We also looked at the evolution of music through the network graph, and analyzed the influence process over time. We found out the 1960s to be the most influential decade in our data set. We then conducted a further study to examine any revolutionary events in the musical evolution. **Pop/Rock** influenced many other genres, which was highly influenced by **Beatles** in the **1960s**. We also conducted a case study of Pop/Rock and Beatles. We used the sub-network graphs to explain why Pop/Rock and The Beatles are so influential. We analyzed a time series for the evolution of Pop/Rock's different characteristics over time and found out that the musical characteristics have changed over time.

We also conducted a time-series analysis to study the popularity of different genres of music. The 1960s was the beginning of massive popularity for some of the genres because of the factors like cultural and technological advancement. Finally, we examined how the musical characteristics have changed over time.

# **The Music of Networks**

**Control Number 2124614**

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## 1 Introduction

### 1.1 Background

“And their music will live on and on..” as sang by Electric Light Orchestra<sup>1</sup> in their unreleased song, “Beatles Forever,” is a tribute to The Beatles. Music has been a part of our lives and in some case, so essential that they inspire millions of people. It lies in the culture and the core of the human experience. We probably started to sing before we could speak properly with syntactically guided sentences[1]. It has been a fundamental process to our evolution. With time and place of evolution in history, we have different music genres and artists who are part of it. Social and cultural factors, inspiration from other artists/music, and availability of resources can influence artists to create a new musical piece. We can study this using Network Analysis. Network Analysis is an effective tool for understanding the dynamics of a complex social system [7]. It has gained increasing popularity among researchers across various fields. In our case, we use it to study the influence networks among the artists and genres.

### 1.2 Restatement of the Problem

The main goal of this paper is to study the evolution of music(1921-2020) analyze the influence of previously produced music on new music and musical artists. We have been tasked by the Integrative Collective Music(ICM) society to complete the following tasks:

- Create a network of musical influences and study how influencers are connected to followers.
- Analyze the musical characteristics of the songs among various genres, their similarities and influence among the genre and other artists.
- Discuss what distinguishes a genre and how their musical characteristics have changed over time. Also, examine any evolutionary and revolutionary trends.
- Study the process of musical evolution through the changes that occurred in the genre(s) or the artist(s).

### 1.3 Our Approach

- First, we start by creating a network of all the influencers and followers. We create a directed network graph to analyze the influence among the artists and the genres. We used in-degree and out-degree as

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<sup>1</sup>English rock band formed in 1970

a centrality measure to capture music influence.

- We analyze the musical characteristics of different genres and how they are similar or different from each other.
- We implement *K-means Clustering Algorithm* to classify the artists into different or the same clusters based on their musical characteristics. With this, we study the similarities between artists of different genres.
- We study different musical features of the genres and see what makes the genre unique.
- We look at different time series graph to analyze the musical evolution, how the musical characteristics change over time and discuss some major leaps in musical evolution. We also study how the popularity of the genre changes over time.
- We study induced subgraphs and subgraphs<sup>2</sup> to examine the influence of Pop/Rock and The Beatles.
- We analyze the influence processes that occurred over time in one genre and analyzed which decade was the most influential.
- Finally, we look at different factors that played a significant role in the influence of music over time.

## 2 Model Development

### 2.1 Assumptions

- We assume that an artist has only one genre of music they produce and all of their songs are of one genre.
- We analyze the influence of the genre thorough the influence of the artists from that genre.

### 2.2 Definitions

Definitions that were provided in the problem statement<sup>3</sup> are not included here.

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<sup>2</sup>definitions in next page

<sup>3</sup>characteristics of music

- A **Graph** is a set of collection of vertices and edges represented by  $G=(V,E)$  where  $V$  is the set of vertices<sup>4</sup> and  $E$  is the set of edge.
- **Vertices** are sometimes called points or nodes. In our case, we represent each artist as a vertex when we later define a network graph.
- **Edges** are sometime called lines. We represent a relationship between a influencing artist(influencer) and following artist(follower) as an edge.
- A **directed** edge from one vertex to another vertex indicates that the former has a link to the latter in the graph. Our graph is directed because of the relationship between the influencer and the follower.
- A graph  $H = (V_H, E_H)$  is a **subgraph** of  $G$  if  $V_H \subseteq V$  and  $E_H \subseteq E$ .
- A graph  $H$  is a **induced subgraph** of  $G$  if whenever  $u$  and  $v$ , are vertices of  $H$  and  $uv$  is an edge of  $G$ .
- The **degree** of a vertex in a Graph is the number of vertices adjacent to it. In a directed graphs like ours, we consider out-degree and in-degrees.

## 2.3 Data Preparation

We were given with four different data sets:

- *influence\_data*, which contained the influencers and followers relation for 5,584 artists in last 90 year according to the decade.
- *full\_music\_data*, which contained 16 variables describing musical characteristics<sup>5</sup> for 98,340 songs.
- *data\_by\_year* contained the mean of all the musical characteristics from 1921 to 2020.
- *data\_by\_artist* contained the mean of all the musical characteristics for 5,584 artists.

From Figure 1 we can see that more than 50% of the songs are Pop/Rock. Because of this, Pop/Rock are seen in almost all of the network graphs. This prevents us from making an entirely accurate comparison between the influence of different genres. However, we have tried our best to keep this in regard while making our conclusions.

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<sup>4</sup>singular: vertex

<sup>5</sup>for example: danceability, tempo, loudness and popularity

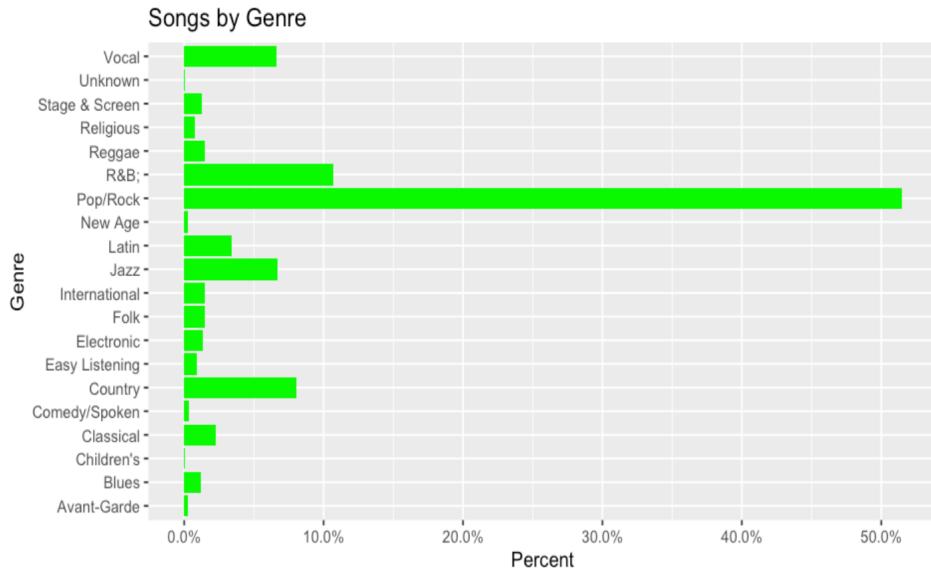


Figure 1: Percentage of songs distribution according to the genre.

From the data provided, we create an edge list<sup>6</sup> and a vertex list<sup>7</sup> with their attributes. We then use this edge list and vertex list to construct our network graph. We have 42,771 edges and 5,584 vertices in our network graph. We also created induced subgraphs and subgraphs in instances where we needed to look at a genre or an artist separately.

## 2.4 Network graphs

We started with the network graph of all the artists and their relationship(influence represented by an edge). We can see our complete network graph from Figure 2. The different colour of the points represents their genre. Since we have 42,771 edges, we cannot see the edges clearly from the graph. That

The measure of our influence is out-degree and in-degree. We use out-degree to measure how influential an artist or a genre is. Similarly, we use in-degree to see how influenced an artist or a genre is. From Figure 3 we can see the distribution of out-degree and in-degree. The log of the degree was taken to scale the histogram. We can see that there are many artists with zero in-degree and out-degree. This means that many artists are not influenced or have not influenced others. We can also see that few artists have high in-degree and out-degree. Table 1 lists the artists with top 5 out-degree and in degree. We can see all the artists in the

<sup>6</sup>using the influencer and follower relationship

<sup>7</sup>list of all artists with their genre

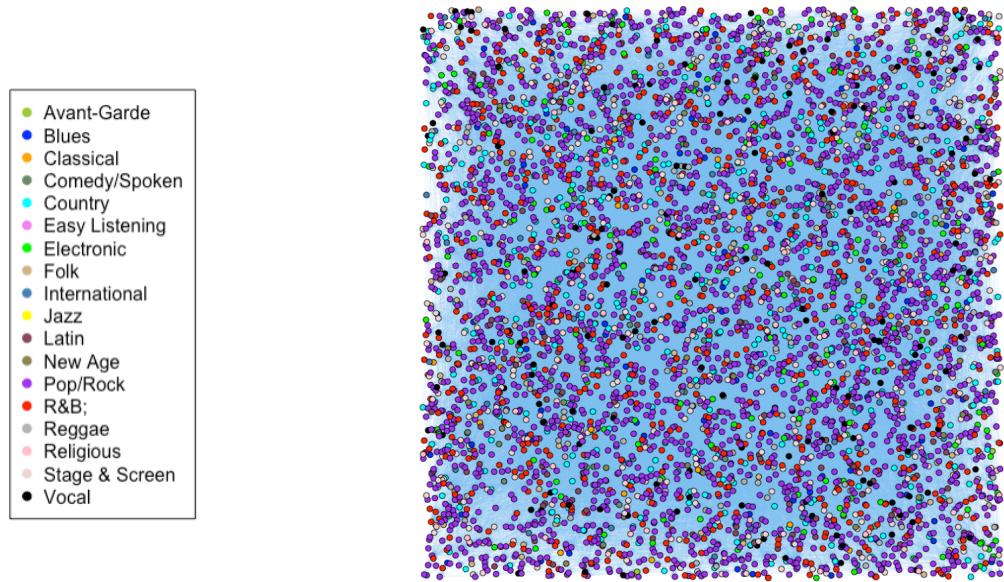


Figure 2: The network graph of all the actors and their influencer-follower relationship

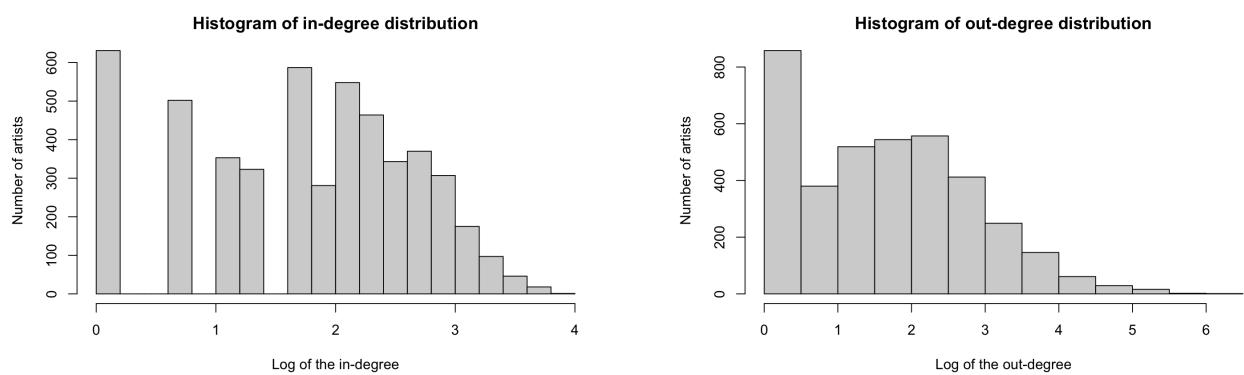


Figure 3: Histogram of the degree distributions

| Artist             | Genre    | Out-degree | Artist        | Genre    | In-degree |
|--------------------|----------|------------|---------------|----------|-----------|
| The Beatles        | Pop/Rock | 615        | The Darkness  | Pop/Rock | 47        |
| Bob Dylan          | Pop/Rock | 389        | Norah         | Pop/Rock | 44        |
| The Rolling Stones | Pop/Rock | 319        | Matthew Sweet | Pop/Rock | 43        |
| David Bowie        | Pop/Rock | 238        | Blur          | Pop/Rock | 41        |
| Led Zeppelin       | Pop/Rock | 221        | Beck          | Pop/Rock | 40        |

Table 1: Top 5 out degrees and in degrees

table are from Pop/Rock. This is partly because of the large percentage of Pop/Rock in our data set, but also because of the popularity of some of the artists like The Beatles.

### 3 The Genres

#### 3.1 Similarities Among the Genres

Music has different characteristics, and those characteristics define a genre. We studied if there are any similarities between musical characteristics among the different genres. We used clustering as a measure of music similarity, which is an unsupervised machine learning task that automatically divides the data into clusters, or groupings of similar items. K-means clustering algorithm was used to group similar artists based on the danceability, energy, valence, tempo, loudness, mode, key, acousticness, instrumentalness, liveness, speechiness, and duration of their songs. The K-means algorithm assigns each of the n rows of a dataset to one of the k clusters, where k is a number that has been defined ahead of time. The primary goal in K-means clustering is to minimize the differences within each cluster and maximize the differences between clusters. The k-means algorithm treats column values as coordinates in a multidimensional feature space. In this case, we have 13 musical characteristics. Therefore, the algorithm will treat the values of the musical characteristics in a 13-dimensional space. To run K-means clustering algorithm on a data, we need to set the initial number of cluster centers, and then the other rows are assigned to the cluster center that is most similar or nearest according to the Euclidean distance function. The formula for Euclidean distance between row x and row y is given by:

Table 2: Result from K-Means Clustering Algorithm

|           |   |
|-----------|---|
| Cluster 1 | Pop/Rock, Electronic                    |
| Cluster 2 | Folk, country , Religious, Avanta-Garde |
| Cluster 3 | Vocal, Ragge                            |
| Cluster 4 | Comedy/Spoken, Classical                |
| Cluster 5 | Latin , R&B                             |
| Cluster 6 | Jazz, 10 Stage & Screen, New Age        |
| Cluster 7 | Children's , Easy Listening             |
| Cluster 8 | International , Blues                   |

$$dist(x, y) = \sqrt{\sum_{k=1}^n (x_i - y_i)^2} \quad (1)$$

where, n is the number of features. In this case, n = 13.

Since the algorithm uses the distance function, it is better to re-scale features. The re-scaling of features was done by min-max normalization. This process transforms a column such that all of its values fall in a range between 0 and 1. The formula for re-scaling of a feature is given as follows:

$$X_n = \frac{(X - \min(X))}{(\max(X) - \min(X))} \quad (2)$$

After the initial phase of the assignment, the k- means algorithm moves to the update phase which involves shifting the initial centers to the centroid's location (the mean value of the points that are assigned to the cluster). As mentioned above, to begin the K- means clustering algorithm, we need to set the value of K. A randomly chosen value of K can lead to sensitive results. Several statistical methods can help find the suitable value of K. We used elbow method to see the difference in homogeneity and heterogeneity within the clusters for different values of K. This method runs K means clustering algorithm on several values of K and then for each value of K calculates the sum of square distances from each point to its assigned center. The point of inflection on the line chart of the sum of squares versus K gives the optimal number of cluster. From figure 5, we can see that the optimal value for our data set as suggested by the elbow method is 8. Although we had 19 different types of genres in our data, the optimal number of clusters was found to be 8. Therefore, artists between different genres seem to have some similarities in their musical attributes. For instance, from Table 2, we can see that there are similarities in the musical characteristics of pop/rock and electric artists.

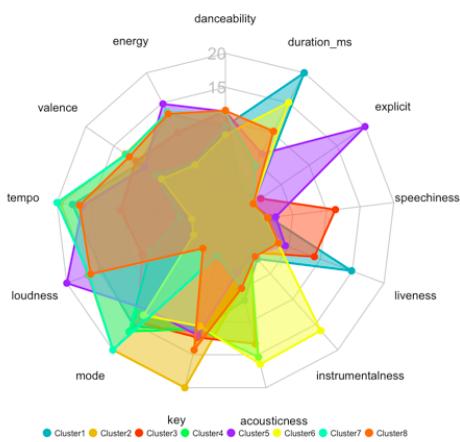


Figure 4: Radar chart for different number of clusters

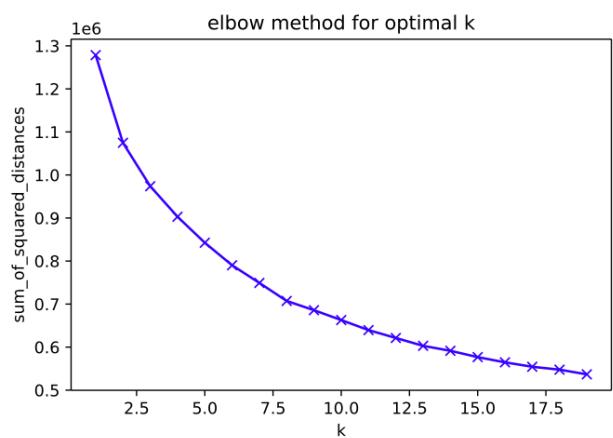


Figure 5: Elbow graph for different number of clusters

However, artists from Rock/Pop and Electric music tend to have different musical characteristics than that of the artists from Folk, Country music, Religious Music, and Avant-Garde.

### 3.2 Differences Among the Genres

We created a radar plot of different genres by using the full music data set to see the differences in musical characteristics among genres. Initially, the data set did not have any information about the genre of a song. Therefore, we merged the full music data set and influence data set to get the song's genre information in the full music data set. We assumed that the song in full music data set has the same genre as that of the artist's primary genre. From the figure below, we can see that every genre is unique because of their musical characteristics. We can visualize the variation in music characteristic between genres through the radar plot below. The key points that we can conclude from the radar plot, as shown in Figure 6 are as follows:

- Electronics has the highest popularity score and classical has the least popularity score among all genres.
- Pop/Rock, R & B, Electronics, and Religious are among the genres with the highest degree of loudness.
- Most of the genres have higher degree of loudness and tempo and negligible explicitness.
- Different genres could be classified in different clusters based on their similarities and differences. For instance, the radar plot of Electronics and Pop/Rock are almost similar. Therefore, they can be

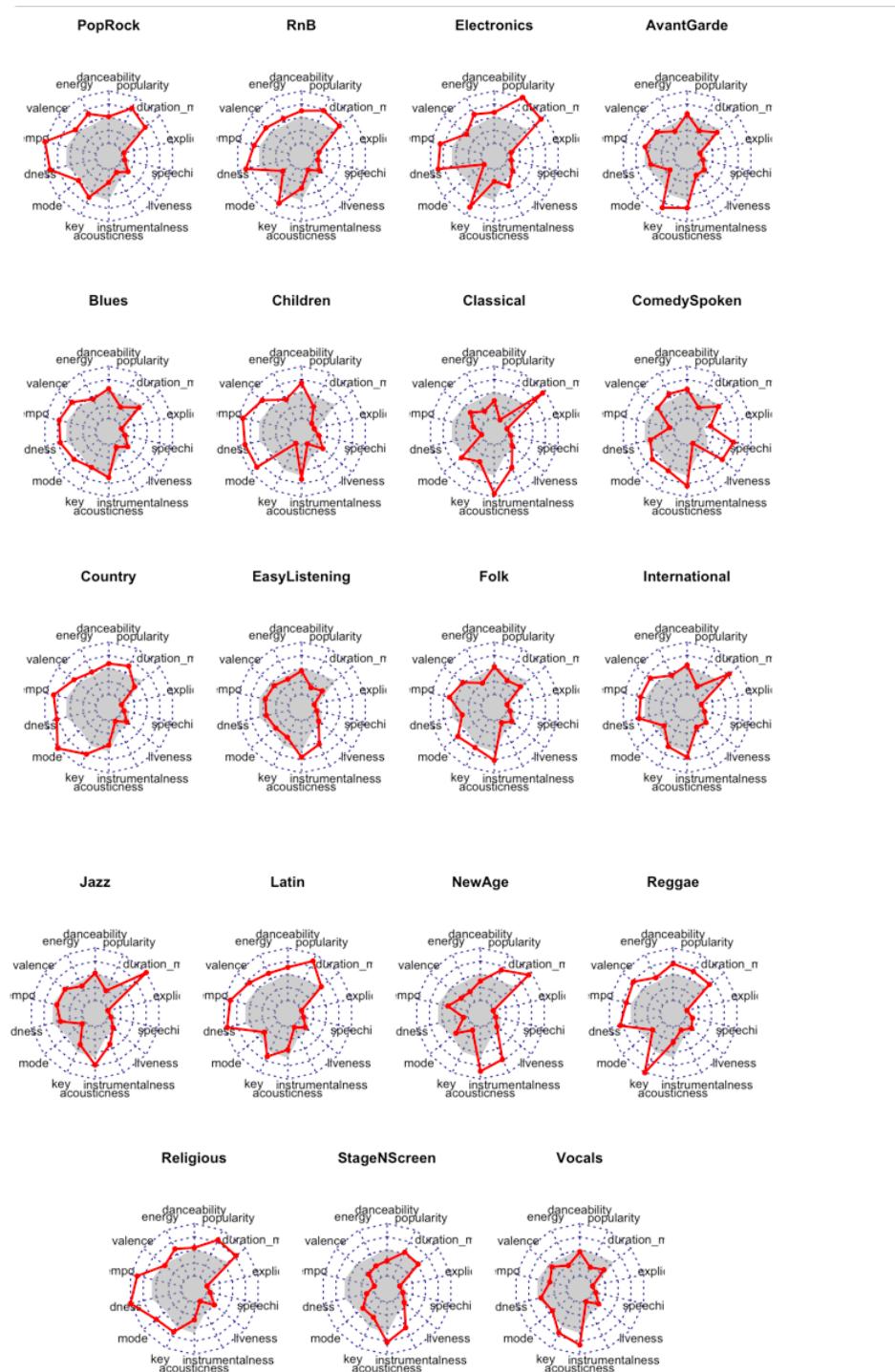


Figure 6: Musical characteristics of different genres

grouped into one cluster based on their similarities of musical characteristics. However, the radar plot of Pop/Rock is entirely different from the radar plot of Classical genre. Therefore, they cannot be grouped in the same cluster.

## 4 The Influence

### 4.1 Influence Among the Genres

To visualize the similarities and amount of influences between and within genres, we created the heat map in the figure below using the influence\_data data set. To create a heat map, we created a socio-matrix with the cells reflecting the edge weight. Row and column names are defined for the margin labels, in this case “the main genres of influencers and followers”. Since our network is directed the rows represent the “influencers” and the columns represent the “followers”. The entry in the  $m^{\text{th}}$  row and  $n^{\text{th}}$  column of a heatmap represents the proportion of influence genre  $m$  has on genre  $n$  as suggested by our directed network graph. If the hue is darker, it means that a more significant influence on genre  $n$ . From the heat map we can

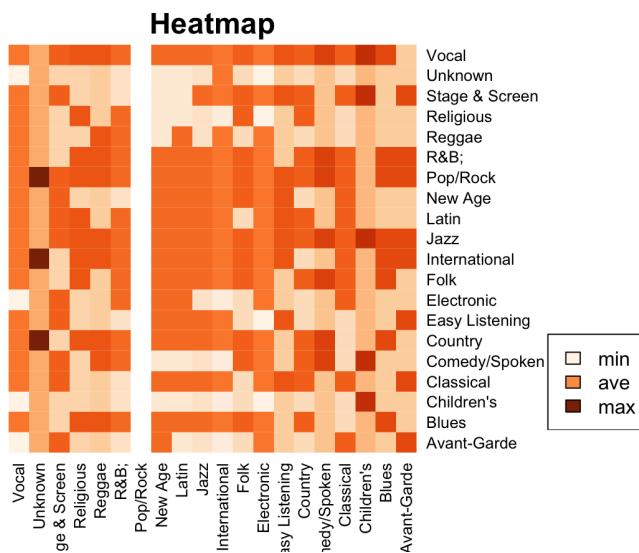


Figure 7: Heat map of all the genres

observe that:

- Each and every genre give their highest influence contribution to themselves and most of the genres give their second highest contribution of influence to vocal, pop/rock, R & B, and Jazz.

- Rock/Pop, Electronic, Vocal are among the most influencing genres. These genres give their influence contribution to almost every other genres.
- Children's, Blues, and Avant-Garde appear to be the least influencing genres(outsides of their genres).

Let us look at the network graphs, as shown in Figure 8 and Figure 9. The four graphs show us the influence network of Blues, Country, RB; and Electronic. We can see that all of the genres have influenced Pop/Rock and themselves. Besides that, Blues has influenced Rb;, Country, Reggae, Folk, and other genres in small number. Similarly, we can look at the rest of the influence network and examine the genre they influenced by looking at the different colour of vertices <sup>8</sup>.

## 4.2 Influence Among the Artists

To study whether the influencers affect the followers' music, we considered a subnetwork consisting of one major influencing artist and his/her followers as suggested by the data\_influence data set. Then we calculated the ratio of number of edges in which both nodes have the same genres to the total number of possible edges in the directed subnetwork. For instance, according to data\_influence data set, Bob Dylan is one of the major influencers, and he influences 389 other musical artists. More than 82% of the followers' artist have the same genre as Bob Dylan, i.e., Pop/Rock. Similarly, more than 85 % of the followers of highly influential artists such as David Bowie and the Beatles have the same genre. From these statistics, we can see that the 'influencers' actually affect most of the followers' music.

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<sup>8</sup>legend for all the graphs is given in Figure 2

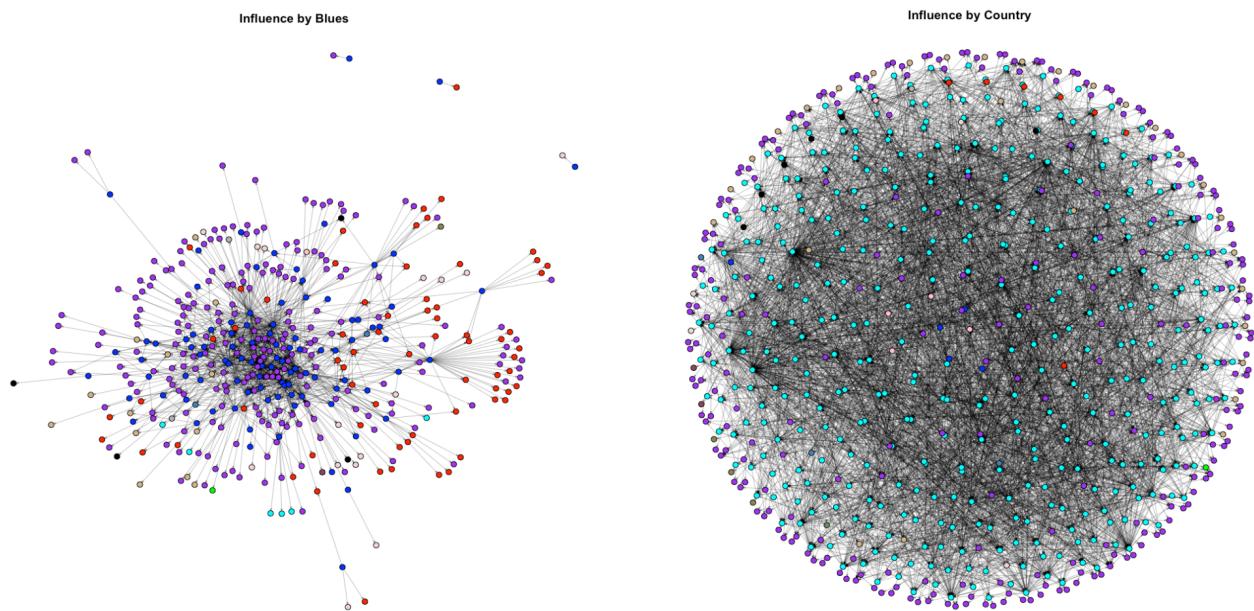


Figure 8: Subgraph showing the influence of Blues and Country

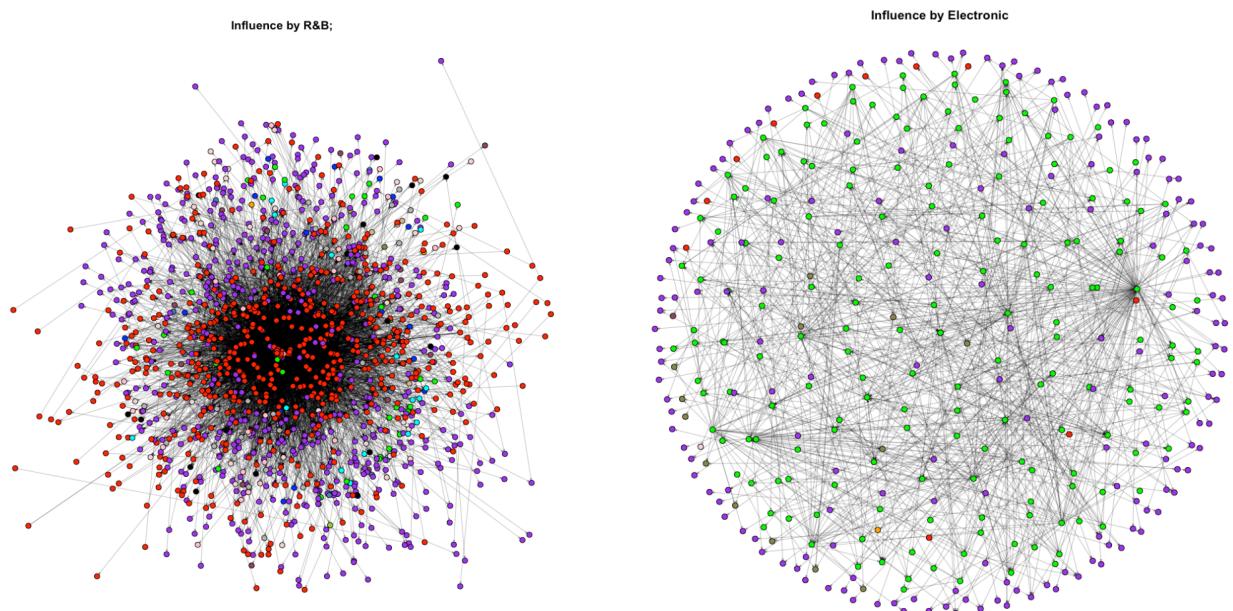


Figure 9: Subgraph showing the influence of RB; and Electronic

## 5 The Evolution of Music

### 5.1 Influence process over time

| All genres |           |          | Pop/Rock |           |          |
|------------|-----------|----------|----------|-----------|----------|
| Year       | OutDegree | InDegree | Year     | OutDegree | InDegree |
| 1930       | 2409      | 193      | 1930     | 21        | 2        |
| 1940       | 2957      | 741      | 1940     | 66        | 8        |
| 1950       | 6643      | 2860     | 1950     | 2064      | 403      |
| 1960       | 12640     | 6478     | 1960     | 8594      | 2547     |
| 1970       | 7996      | 6781     | 1970     | 5857      | 3801     |
| 1980       | 6083      | 8523     | 1980     | 4858      | 6035     |
| 1990       | 3646      | 10911    | 1990     | 2418      | 7257     |
| 2000       | 376       | 5472     | 2000     | 251       | 3652     |
| 2010       | 20        | 811      | 2010     | 12        | 436      |

Table 3: Outdegree and Indegree for a subgraph according to influencer year.

For the influence data, we were given the influencer-follower according to the decades from 1930 to 2010. We wanted to examine which decade was the most influential in music history. We created an edge list using the *influencer\_active\_start* and *follower\_active\_start* and a vertex list using different decades as the vertex. A network graph using that edge list and the vertex list was created and the out-degree and in-degree as recorded. Table 1 shows the out-degree and in-degree for all the decades. We can see that 1960 has the maximum out-degree and 2010 has the lowest in-degree. This means 1960 is the most influential decade, and 2010 is the least influential decade. Since 2010 has low in-degree might be because influence is not completed in 10 years, it is a long ongoing process. Although 1960 is not the oldest decade in our consideration, it has been the most influencing decade. 1970 and 1980 also have higher influential. On the other hand, 1990 is the most influenced decade among all.

One major factor for 1960 being so influencing is the rise of Pop/Rock around 1960s. Therefore, we did the similar process as above by taking a subgraph that contained influencers from Pop/Rock, and we get Table 3. As discussed above, Pop/Rock also follows almost the same pattern. 1960 has the highest

out-degree with 1970 and 1980 also having higher out-degree. As seen at the beginning, Pop/Rock artists such as The Beatles, Bob Dylan, The Rolling Stone were the top influential artists. They all have the start year of 1960 and that is the reason for 1960 being so influential.

## 5.2 Evolution of Musical Characteristics

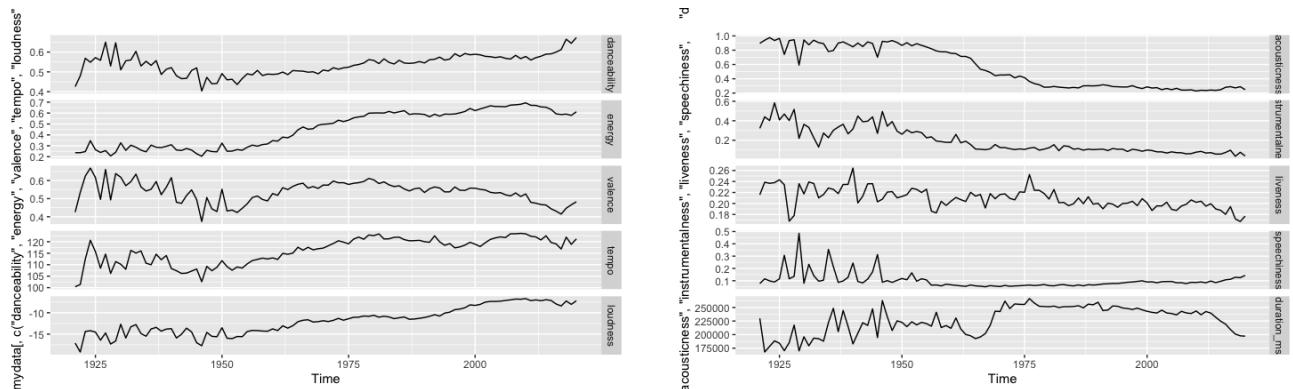


Figure 10: Time series plot for the evolution of Musical Characteristics

From Figure 10 we can see that there is a change in musical characteristics around the 50s and 60s. This further supports our discussion above that 60s is the most revolutionary and evolutionary decade for the music. Musical characteristics like danceability, energy, loudness have increased over time, but characteristics like speechiness, liveness, and acousticness have decreased over time.

## 5.3 Popularity of Music

This streamgraph uses genre, popularity and year as the parameters to create this graph. We used data from two datasets *influencer\_data* and *full\_music\_data* to get these parameters. Streamgraph shows how the popularity of various genre increases and decrease over time. As popularity is high or low, the graph expands and shrinks accordingly. From the streamgraph, it is visible that Jazz was the most popular genre in the mid-1920s, followed by vocals and pop/rock. In the early 1930s, Avant-Garde became the most popular genre, followed by vocals and Jazz. New Jazz music was brought by the African American migrants moving to the cities post-world war I in the 1920s. The rise of radio broadcast also played a role in the rise of music during this time. Late 1940s Jazz started to become a popular genre, and by the mid-1940s, vocals took over the popularity. The late 1940s became the rise for country music, vocals and Jazz. Late 1950, Vocals,

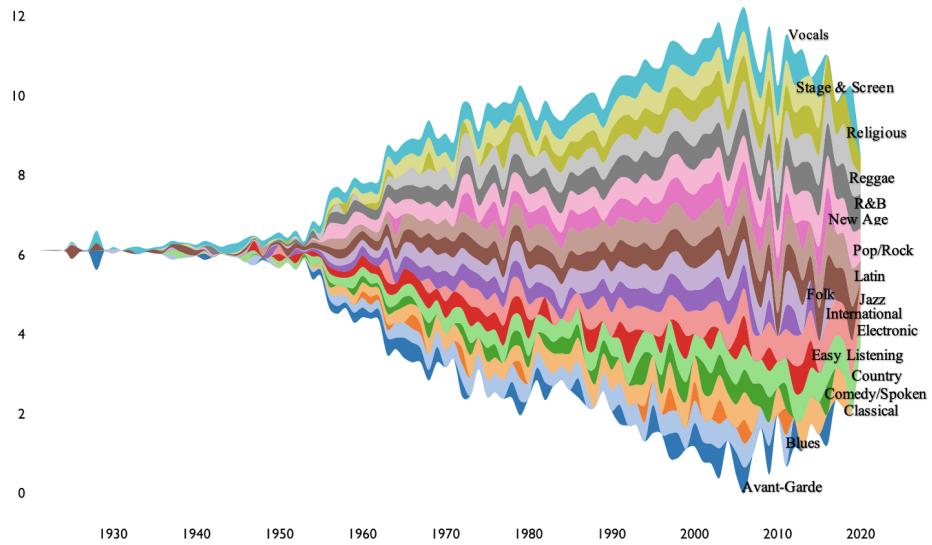


Figure 11: Streamgraph showing the popularity of various genre

Easy Listening and RB, started to gain popularity with Pop/Rock, starting to gain some popularity while Jazz remained popular among all genres.

Early 1960s was a better year for music evolution because most of the genre started to gain some popularity. As discussed above, 1960s is the most influential decade. Development of radios and portable handheld musical devices gave access to rock-n-roll to many during this period. Mid 1960s was when Children's genre started to gain some popularity and rise for many other genres. Pop/Rock became a trademark of this generation and hence the increased popularity and high influence of 1960s in the music evolution. The Beatles had their first No.1 hit in 1964.

#### 5.4 Pop/Rock: A Study

Pop/Rock is highly influenced by itself. This shows that Pop/Rock has been influenced by itself than other genres. This can be seen by looking at Figure 12. We can see there are vertices of different colors. This represents the broad influence of Pop/Rock in other genres. RB, Country and Electronic are the highly influenced genres by Pop/Rock. Because of the strong influence and popularity of Pop/Rock, we study this genre on its own.

Pop/Rock has changed much overtime with different influencers and followers. We used time series plot on Pop/Rock to analyze how Pop/Rock's musical characteristics change over time. We plot the musical

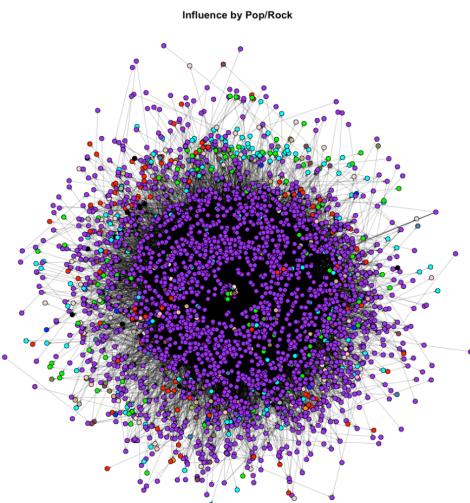


Figure 12: Subgraph depicting influence by Pop/Rock

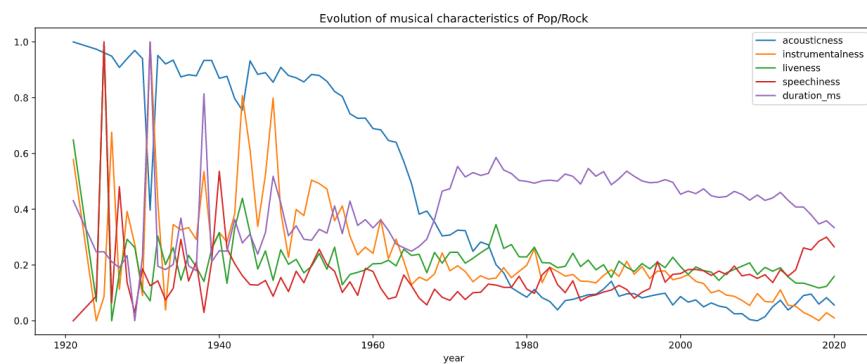


Figure 13: Time Series of musical characteristics of Pop/Rock

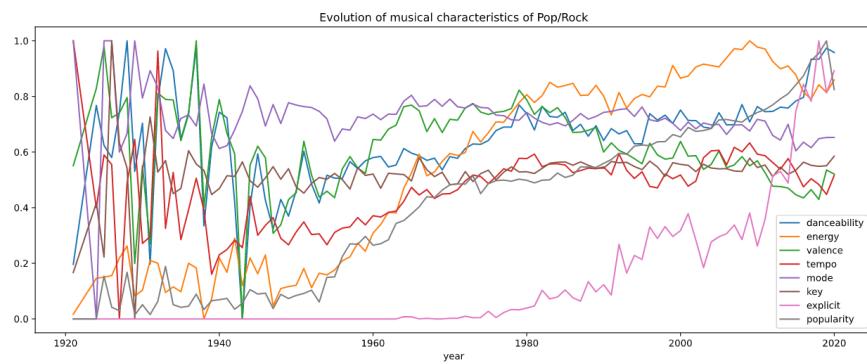


Figure 14: Time Series of musical characteristics of Pop/Rock

characteristics in two graphs, Figure13 and Figure 14. Figure 13 we can see a decline of acousticness, especially around the mid-1960s. This was because more musical devices such as amplifier started to become popular. For example, Marshall JTM45 Amplifier came out in 1962. We can see some clear decline in instrumentalness and duration\_ms as well. Looking closing into Figure 14, we can see that explicit characteristics have grown in average exponentially overtime. After some research behind this growth, it was seen that the predominant topic of pop music was romantic and sexual relationship. According to a study, most American music often implied sex within love songs around the 1960s but late 1990s and early 2000s, sexual references became far more explicit[2]. Pop/Rock has developed into more energetic and danceable music. The growth of energy and danceability can be seen in Figure 14. From Figure 13 and 14 we can see that there is some change in pattern around 1960. As mentioned 60s is a year of influence and changes for many genres including Pop/Rock. The Pop/Rock artists like Bob Dylan, The Rolling Stone and The Beatles had the start year of 1960 and had the most influential factor among all the artists. The Beatles helped to reshape Western pop music and were the most successful band ever. Therefore, we conducted a further study to analyze the influence network of The Beatles.

#### **5.4.1 The Beatles: a Further Study**

From the study we have done so far, Pop/Rock seems to be the most influential genre, and The Beatles are the most influencing. The Beatles have so many world records when it comes to music, some of them being the best-selling group, most-recorded song, the longest gap between the UK number one, most US number one albums and the list goes on [5]. Let us look at a subgraph which contains the artists influenced by The Beatles. From Figure 15, the Beatles most influential artists from Pop/Rock, but they have also influenced artists from various other genres like RB;, Country, Reggae etc. The Beatles have the most influence over the artists and genres in general.

### **5.5 Discussion**

From our study above, we can see that there have been different social and technological factors that has influenced the music evolution. These effects can be identified within the network by searching for the nodes with the higher out-degree and in-degree. During 1960s, the number of high school teenagers increased from 5.6 million to 11.8 million in the U.S. This generation of audience had more leisure and more money than any previous generations[6]. We can see the impact of this social change through our network in the

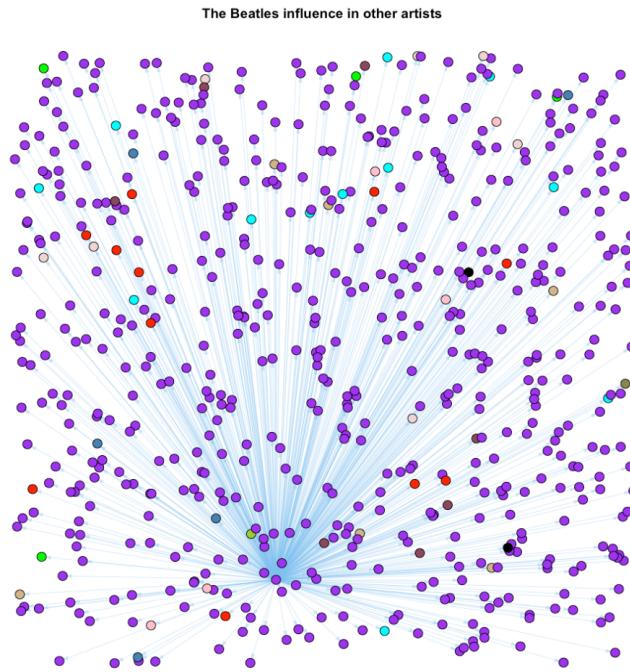


Figure 15: Influence of The Beatles in other artists

form of 1960 having the highest influence factor. In the year 1960, many other renowned artists of all time such as Bob Dylan and The Rolling Stone started their career. Moreover, As mentioned above, the year 1960 had the highest out degree. With further research, we got to know that Singers Bob Dylan and Joan Baez led the movement, and Dylan's "Blowin' in the Wind" [3] became a civil rights anthem.

Late 1970s, electronics and pop/rock music started to gain popularity as that can be clearly seen in the graph. Sony Walkman developed in 1979 was fashionable, convenient, and portable, which was a technological advancement for the music audiences[4]. In 1990s, we can see a huge growth in electronic and other pop songs genres as Autotune was invented in that time. Electronic, Jazz, RB, Pop/Rock was the most popular genres of 2000s. From our network model for the time influence, we saw 1990s had the most in-degree and hence the most influenced year. Therefore, according to our network there must have been some revolutionary change in the society. During the year 1990, computer scientist Tim Berners-Lee invented the World Wide Web and artists had access to tremendous amount of past and recent songs. Therefore, many artists were influenced by the renowned artists from past such as Bob Dylan, the Beatles, etc. People were able to explore more of the music world and hence get more influenced. Different streaming service like iTunes and Spotify also played a great role in music evolution.

## 6 Wrap up

### 6.1 Major Findings

Using our network graph model and the clustering algorithm, following are the major findings of our study:

- Although music genres are different types of musics, we did see similarities between some genres through the clusters.
- The influencer does influence the music produced by the follower for most of the cases.
- Most genres influence themselves, but we saw some genres influencing one more than other. PopRock is the most influential genre among all, and it is also the most influenced genre.
- The Beatles, Bob Dylan and The Rolling Stone are the top influencing artists. All of them had a start year in 1960s. This also played a great role in the revolution of music that came in 1960. The Beatles is the most influential artist among all.
- The 60s, 70s and 80s are the most important decades in the music history. We found 60s to be the most influential, while the 90s is the most influenced decade.
- We studied the effect of social and technological changes through our network and discovered that they have played an important role in the evolution of music and musical characteristics over time.

### 6.2 Strengths and Weakness

#### Strengths:

- We can visualize the individual influence of the genre by looking at the network graphs. It allows us to fully understand how one genre is being influenced by other genres.
- Most of the questions regarding the evolution and influence of music can be answered through our parameter of musical influence.
- Our network analysis can identify the effects of social, political or technological changes (such as the internet) within the network.

- Our solution is robust to capture the musical influence, to compare different genres on the basis of their musical characteristics, to compare the artists between different genres, and to analyze the musical evolution and the change in musical characteristics over time.

**Weakness:**

- Our measure for studying if the 'influencers' actually affected the music created by the followers can be further strengthened by making proper use of the *data\_by\_artist*.
- Our analysis is unable to hypothesize if some music characteristics are more 'contagious' than others, or they all have similar roles in influencing a particular artist's music.

### 6.3 Future work and Conclusion

First of all, the measure for studying, "if the 'influencers' actually affected the music created by the followers" can be further strengthened by making proper use of the *data\_by\_artist*. Secondly, we can work on our analysis to hypothesize if some music characteristics are more 'contagious' than others, or they all have similar roles in influencing a particular artist's music by looking at the network structure of the different musical characteristics . Most importantly, we can study our network through different measures such as betweenness centrality, eigenvector centrality, and closeness centrality and develop more statistically strong parameter to tell the story from the data in the best way possible.

Network systems is an effective tool to model complex social systems. We were able to understand and measure the influence of one genre over other throughout the musical evolution. The musical community is highly influenced by its history and its members. Like most of the things in this world, music is also ever changing and evolving as the time passes. It will be interesting to see how the music evolves in next few decades.

*"I'm talking, talking, talking, talking, talking in my sleep.  
I'm walking, walking, walking, walking, walking in the street  
Time is passing, I grow older, things are happening fast  
All I have to hold on to is a simple song at last"*

- Sing a Simple Song, Sly The Family Stone

# Memorandum

TO: ICM

FROM: Team 2124614

DATE: February 08, 2021

SUBJECT: Network analysis of musical influence

The influence of previously produced music on new music and musical artists can be represented through a complex directed graph network. This network can help us understand and measure the influence of previously produced music on new music and musical artists. Our paper presents a network analysis approach to quantify music evolution. We made three different networks to study the music influence: musical influence among the artists, genre influence and decade wise influence in the music evolution.

We implemented the K-means clustering algorithm to classify the artists into clusters based on their songs' musical characteristics. We look at different time series graph to analyze the musical evolution and the change in musical characteristics over time. Our solution is robust to capture the musical influence, compare different genres based on their musical characteristics, compare the artists between different genres, and analyze the musical evolution and the change in musical characteristics over time. Music had become a vehicle for social change. The protest songs and psychedelia of the 1960s were the soundtracks to a sexual revolution and anti-war marches[3]. Thus, the degree of centrality measure helps our network analysis identify cultural and social changes in society. These technological changes can also be captured through the degree centrality measure in our network.

With richer data, our solution would almost be the same to study music influence and evolution. However, most of the artists' primary genre is Pop/Rock in the two problem data sets. Therefore, the data might lead to a bias that the Pop/Rock genre influences most artists. With richer data, we would use stratified sampling to improve the accuracy and representatives of the results by reducing the bias. In the last two decades, there has been a massive cultural change in the world due to the internet and international influence growth. Other music genres like K-Pop, EDM are gaining popularity, and producing, sharing and listening to music has never been easier. We recommend doing further analysis of the last two decades and study how the cultural shift and technological advancement will construct the path for future music evolution.

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