A Symphony of Culture, Technology, and War: Tracing a Century of Global Music Evolution

Keywords: Music Evolution, Digital Homogenization, Cultural Convergence, Interrupted Time Series Analysis, Cultural Theory

Extended Abstract

Over the past century, music has been evolving under the background of cultural, technological, and political transformations (Cross, 2001; Frith, 1986; Hesmondhalgh, 2008; Meinhart & Rogers, 2023). Such a rich and dynamic context provides a valuable opportunity to observe how external forces, such as political events and technological innovations, interplay with cultural production.

In this study, we investigate the evolution of music during the last century, with a specific focus on its direction—the shifts in track features over time, and convergence—the extent to which tracks have become more homogeneous across decades (Claidière et al., 2018).

The analysis workflow is shown in Figure 1. The Spotify dataset used in this study was sourced from Kaggle (Ay, 2021). This dataset is validated, having been used in several previous studies (Ochi et al., 2021; Willems, 2021) It includes over 600,000 tracks spanning from 1921 to 2020, providing a comprehensive overview of music evolution across a century. Each track is characterized by various audio-based features, derived from Spotify's advanced algorithm. There are some low-level features, which describe the physical and technical aspects of the music, such as tempo, loudness, and key; there are also some high-level features, which capture stylistic and emotional attributes of the music, such as danceability, energy, and valence. The full list of features is in Figure 2. Additionally, the dataset includes metadata such as release date, artist, and track name.

To identify overarching patterns in the dataset, we applied principal component analysis (PCA) for dimensionality reduction (Paul et al., 2013). Based on the scree plot and cumulative explained variance, nine principal components were retained, accounting for 95% of the total variance. For interpretability, the heatmap (Figure 2) illustrates the contributions of original features to each principal component. The first principal component (PC1) emerged as the most influential (25% of the total variance), which is positively associated with energy, valence, loudness, and danceability, while negatively associated with acousticness, and instrumentalness. For example, vibrant and upbeat tracks like "Blinding Lights" by The Weeknd scored high on PC1, while reflective and acoustic tracks like "All of Me" by John Legend scored low. Other principal components are also associated with specific features, such as the second principal component (PC2) is featured by low speechiness and high duration, and the third principal component (PC3) is characterized by low key and high mode. All the following analysis are based on the PCA results.

To examine the direction of music evolution, we calculated the centroid for each year in the PCA space. Those centroids, calculated as the average of all tracks on different features, represent the overall style of music for that specific year. Figure 3 (left panel) shows the trajectory of centroids in the plane of the first two principal components over the past century. The overall trend shows that music styles have gradually evolved from the lower left to the upper right, reflecting the development of music features towards positive emotions, high energy and danceability. However, there is also a brief period of setback in the

trajectory. During the World War II (1939-1945), music styles moved towards the negative side of the first principal component. This reversal may be due to social unrest, when people were feeling down, thus producing more melancholic music.

Figure 3 (right panel) shows the movement quivers between centroids every two years. The early movement quivers are longer than the later ones, indicating larger changes in music styles in the early years compared to the later years. This implies a gradual convergence of global music over the course of a century.

To further investigate the convergence of music, we examine the within-year homogeneity of music styles. We did not use variance as the measure of homogeneity, because the number of tracks varies each year, making direct cross-year comparisons incompatible. Instead, we considered the distance of a track to the centroid of tracks in its release year. For each year, we binned tracks into length of 1 interval based on the distances, then counted the number of tracks in each bin. Therefore, we got several time series of the number of tracks across years at different innovation levels, as shown in Figure 4.

Generally, the number of tracks at each bin increased over time, while the growth rate was faster for those at relatively low innovation levels (distance to centroid between 1 and 2). Time series analysis confirmed this. The trend components of different innovation levels are steadily positive before 2000.

However, after 2000, a divergence emerged. The number of tracks at different levels showed a cliff-like descent, and after that, relatively low innovation levels tracks exhibited an amplified growth rate, while the growth rate of lower or medium or high innovation levels get slower. For some high innovation levels, the increase even stagnated.

The rise of streaming platforms, starting with Napster in 1999 and accelerated with iTunes and Spotify in the 2000s, may account for this (Hesmondhalgh, 2022; Waldfogel, 2012). We conducted the interrupted time series analysis to investigate the potential impact of streaming platforms (Turner et al., 2021). We set the parameter of streaming effect in terms of slope and intercept, representing the streaming effect on track number or growth rate, respectively.

The result (Figure 5) shows that streaming platforms have a significant impact on music innovation. In terms of intercept, the streaming effect is negative for most of the innovation levels, indicating that the streaming platforms have caused an instant decline in music production. The universal dropdown in track numbers is likely because of the copyright issue of streaming platform (Liebowitz, 2016). In terms of slope, tracks with relatively small distance from the centroid, saw amplified growth, whereas tracks at other innovation levels did not get much benefit much from the streaming era. This implies that the streaming platform selectively increase the creation of relatively low innovation music, which is aligned with previous findings in digital homogenization (Askin & Mauskapf, 2017; Bourreau et al., 2022): Although streaming democratized music creation and access, it also reinforced mainstream trends.

Our findings offer a nuanced perspective on the adaptive progression of music over the past century, which is influenced by both political disruptions and technological innovations. Generally, global music has shown a growing convergence and a trend towards vibrant style, characterized by features like higher energy level. However, during the war period, this trend experienced a reverse setback, while technological innovations, such as the emergence of streaming platforms, has accelerated the process of convergence.

These findings indicate that the evolution of cultural objects, such as music, is not an isolated cultural process, but more likely a reflection of technological and political background, demonstrating the interplaying relationship between cultural concepts and the external world.

References

Askin, N., & Mauskapf, M. (2017). What makes popular culture popular? Product features and optimal differentiation in music. *American Sociological Review, 82*(5), 910–944. https://doi.org/10.1177/0003122417728662

Ay, Y. E. (2021, January 24). *Spotify dataset 1921-2020, 600k+ tracks*. Kaggle. Retrieved from https://www.kaggle.com/datasets/yamaerenay/spotify-dataset-19212020-600k-tracks

Bourreau, M., Moreau, F., & Wikström, P. (2022). Does digitization lead to the homogenization of cultural content? *Economic Inquiry, 60*(1), 427–453. https://doi.org/10.1111/ecin.13015

Claidière, N., Amedon, G. K.-k., André, J.-B., Kirby, S., Smith, K., Sperber, D., & Fagot, J. (2018). Convergent transformation and selection in cultural evolution. *Evolution and Human Behavior, 39*(2), 191–202. https://doi.org/10.1016/j.evolhumbehav.2017.12.007

Cross, I. (2001). Music, cognition, culture, and evolution. *Annals of the New York Academy of Sciences, 930*(1), 28–42. https://doi.org/10.1111/j.1749-6632.2001.tb05723.x

Frith, S. (1986). Art versus technology: the strange case of popular music. *Media, Culture & Society, 8*(3), 263–279. https://doi.org/10.1177/016344386008003002

Hesmondhalgh, D. (2008). Cultural and creative industries. *The SAGE handbook of cultural analysis*, 552569.

Hesmondhalgh, D. (2022). Streaming's effects on music culture: old anxieties and new simplifications. *Cultural Sociology, 16*(1), 3–24. https://doi.org/10.1177/17499755211019974

Liebowitz, S. J. (2016). How much of the decline in sound recording sales is due to file-sharing? *Journal of Cultural Economics, 40*(1), 13–28. https://doi.org/10.1007/s10824-014-9233-2

Meinhart, M., & Rogers, J. C. (2023). Theorizing trauma and music in the long nineteenth century. *Nineteenth-Century Music Review, 20*(1), 3–32. https://doi.org/10.1017/s1479409822000039

Ochi, V., Estrada, R., Gaji, T., Gadea, W., & Duong, E. (2021). Spotify danceability and popularity analysis using SAP. *Arxiv preprint arXiv:2108.02370.*

Paul, L. C., Suman, A. A., & Sultan, N. (2013). Methodological analysis of principal component analysis (PCA) method. *International Journal of Computational Engineering & Management, 16*(2), 3238.

Turner, S. L., Karahalios, A., Forbes, A. B., Taljaard, M., Grimshaw, J. M., & McKenzie, J. E. (2021). Comparison of six statistical methods for interrupted time series studies: empirical evaluation of 190 published series. *BMC Medical Research Methodology, 21*(1). https://doi.org/10.1186/s12874-021-01306-w

Waldfogel, J. (2012). Copyright protection, technological change, and the quality of new products: evidence from recorded music since napster. *The Journal of Law and Economics, 55*(4), 715–740. https://doi.org/10.1086/665824

Willems, B. (2021). *Design and development of a voice controlled music* (Doctoral dissertation, Google).
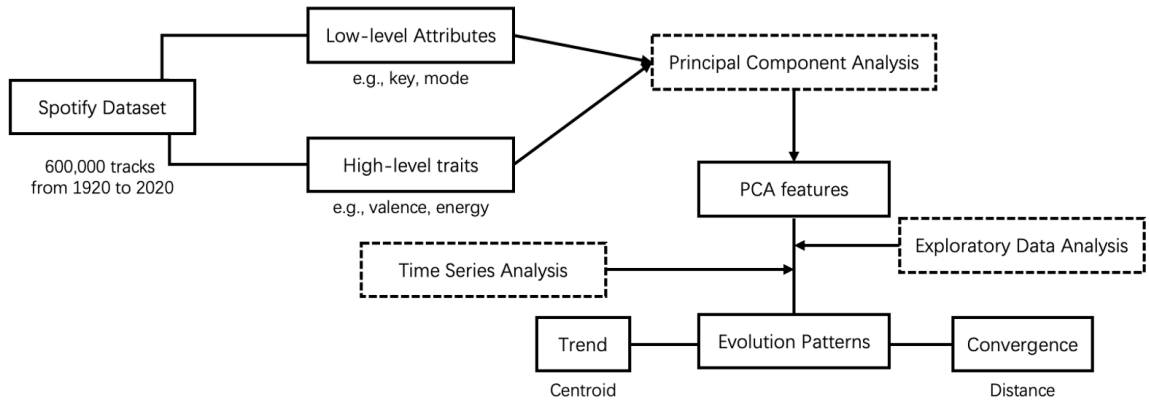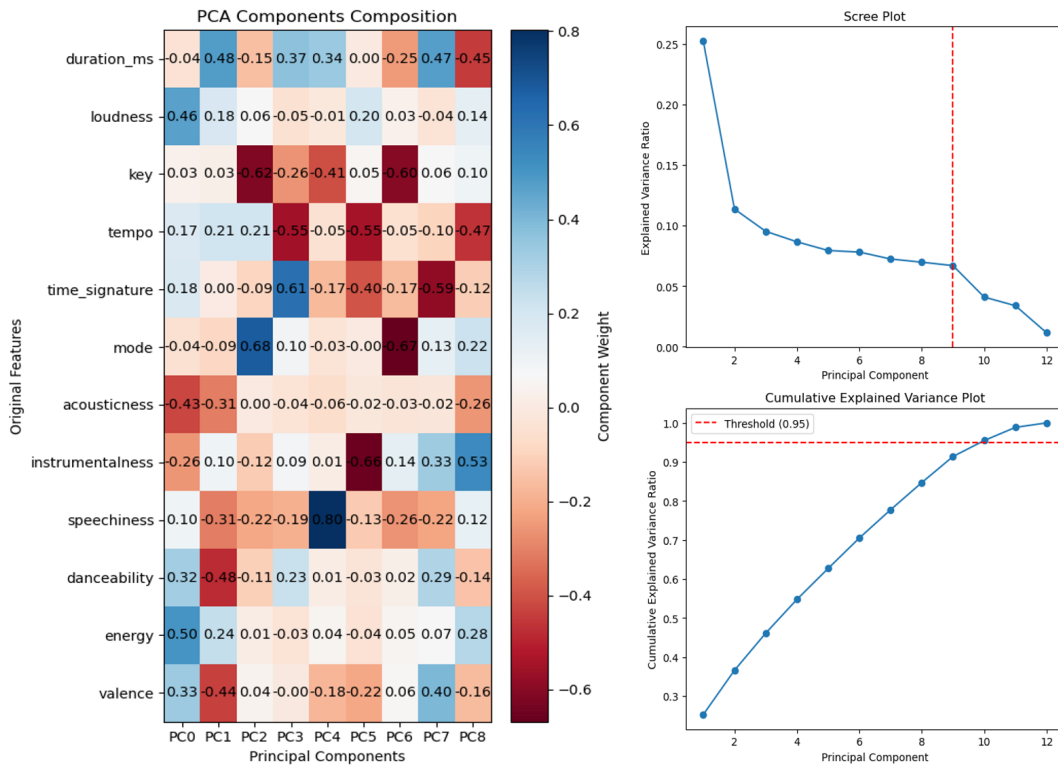
Figure 1. Analysis workflow

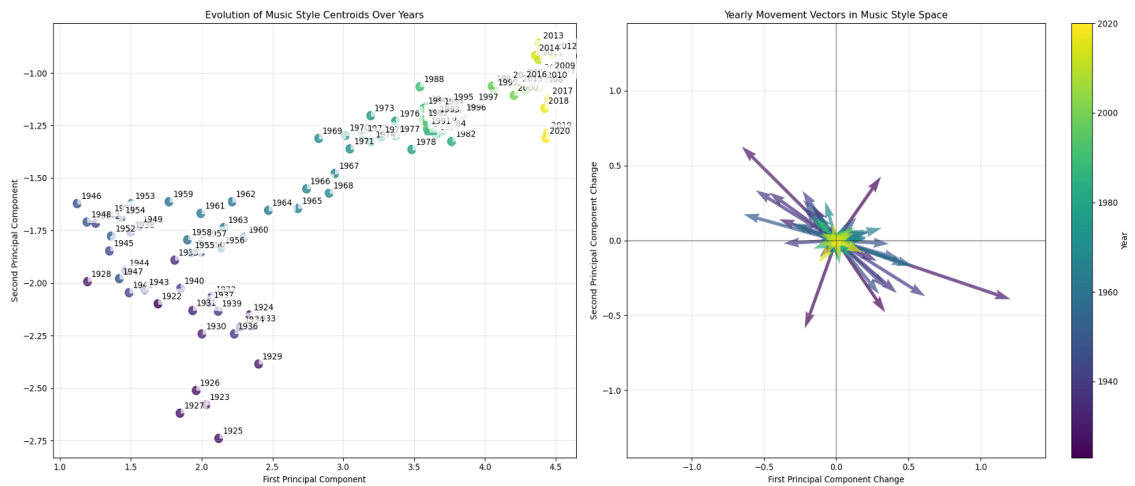Figure 2. Principal component analysis results
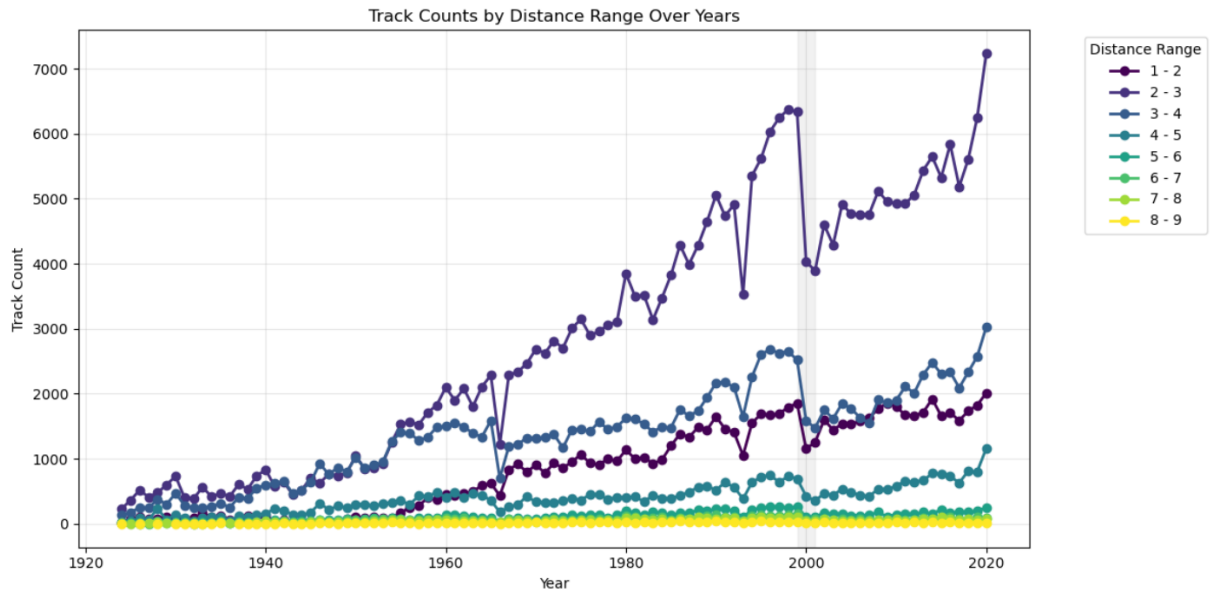

Figure 3. Centroid evolution over time
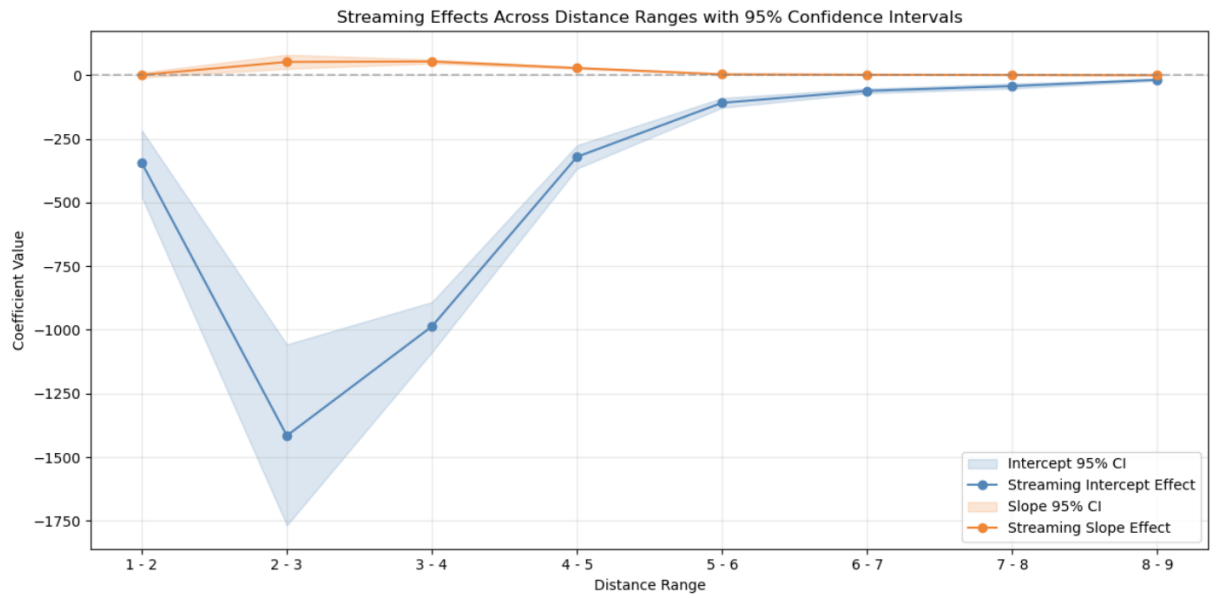
Figure 4. Trend of tracks at different innovation levels

Figure 5. Interrupted time series analysis of streaming effect