

Clustering Analysis of MAMA 2024 Song of The Year Nominees Based on Musical Elements and Popularity Indicators

Libelda Aldinaduma Harahap^{1*}; A'yunin Sofro²

¹⁻²Mathematics Department, Faculty of Mathematics and Natural Sciences,
Surabaya State University East Java, Indonesia 60231

¹libelda.harahap@gmail.com; ²ayuninsofro@unesa.ac.id

Received: 5th January 2025/ Revised: 19th June 2025/ Accepted: 19th June 2025

How to Cite: Harahap, L. A., & Sofro, A. (2025). Clustering analysis of MAMA 2024 Song of The Year nominees based on musical elements and popularity indicators. *ComTech: Computer, Mathematics and Engineering Applications*, 16(2), 81–98. <https://doi.org/10.21512/comtech.v16i2.12860>

Abstract - As K-pop continues to dominate global music charts, understanding the factors behind the success of songs has become increasingly essential. This study explores how musical elements and popularity indicators reveal patterns among top-performing songs. A total of 57 songs nominated for the 2024 Song of the Year category were grouped using hierarchical cluster analysis. The genre variable was consolidated into six broader categories and converted into numerical labels. All variables were normalized using the Min-Max normalization method before clustering. The data included musical elements such as genre, tempo, danceability, energy, and happiness, as well as popularity indicators like YouTube views and Spotify streams. The analysis employed single, complete, and average linkage methods. Among these, the average linkage method yielded the best results, with an agglomerative coefficient value of 0.8167. Seven distinct clusters were identified: Cluster 1 featured R&B and hip-hop styles with varied energy and rhythms; Cluster 2, the largest group, included high-energy pop, hip-hop, and dance-pop tracks that are popular on streaming platforms; Cluster 3 contained indie and experimental tracks; Cluster 4 emphasized high-energy stage performances; Cluster 5 was an outlier with experimental traits; Cluster 6 highlighted R&B and funk with global appeal; and Cluster 7 included emotional OSTs and ballads with slower tempos. By combining musical elements and popularity indicators, this study uncovers patterns of success in K-pop songs. These findings offer actionable insights for artists, producers, and marketers, providing a data-driven reference for creating music that resonates with modern audience preferences.

Keywords: hierarchical clustering, musical elements, popularity indicators, MAMA 2024, song analysis

I. INTRODUCTION

Music has evolved into a more expansive and diverse form, particularly in modern and contemporary contexts. It is considered a universal language that serves as a medium for self-expression, entertainment, and the conveyance of social and political messages (Hibatullah et al., 2024). During this period of growth, the music industry—especially in Indonesia—has produced a wide variety of genres, including pop, rock, hip-hop, electronic music, and more, each showcasing its own unique characteristics and stylistic features.

K-pop, short for Korean Pop or Korean Popular Music, is one of the fastest-growing and most popular music industries today. This genre has rapidly expanded and gained immense popularity among fans of all ages, ranging from teenagers to adults. It encompasses a diverse array of styles, including pop, ballads, rock, hip-hop, R&B, electronic music, and dance music. K-pop has not only captivated audiences in South Korea but has also gained a global following, particularly in Indonesia, where it has cultivated a large and diverse fan base.

Since the 1990s, K-pop has become a key component of Hallyu, also known as the Korean Wave. This cultural phenomenon began to spread from East and Southeast Asia, including countries such as Japan and Taiwan, to global regions like the United States, Europe, and South America in the early 2000s (Cho, 2016). K-pop continues to expand its global presence, particularly with the success of South Korean idol groups like BTS and Blackpink, which have garnered international recognition for their achievements on the Billboard charts and at major award shows. Additionally, PSY's "Gangnam Style" became a worldwide sensation, making history as the first music video on YouTube to reach one billion views in 2012 (Billboard, 2022).

The popularity of K-pop has significantly impacted both the social and economic landscape of South Korea. It has influenced not only the cultural industry but also various sectors, including tourism, beauty, fashion, and technology (Park, 2023). The South Korean government supports the creative industry through substantial investments. This includes the establishment of Korean Cultural Centers in various countries and the funding of diverse cultural projects.

The K-pop and Hallyu phenomenon have significantly enhanced South Korea's global image, transforming it into a cultural powerhouse. In 2021, the booming industry attracted millions of tourists eager to experience the vibrant culture firsthand, while also generating an impressive \$12.4 billion in cultural export revenue. This substantial figure not only highlights the global appeal of Korean pop culture but also dwarfs the earnings from other sectors, such as consumer electronics, which reached only \$4.7 billion that same year (UN Trade & Development, 2024).

As K-pop continues to gain popularity, music labels must understand the key factors contributing to the success of K-pop songs in the global market. The success of a song relies not only on promotion but also on the musical elements that comprise it. This research addresses the following questions: (1) Which hierarchical linkage method (single, complete, or average) produces the most cohesive clusters of nominees for the 2024 MAMA Song of the Year based on musical elements (such as genre, tempo, danceability, energy, and happiness) and popularity indicators (including YouTube views and Spotify streams)? (2) What patterns can be observed in the resulting clusters based on the musical and popular characteristics of the songs?

This research focuses on songs nominated for the 2024 Mnet Asian Music Awards (MAMA) for Song of the Year, reflecting the latest trends in K-pop music. The eligible songs for the 2024 awards were released between October 1, 2023, and September 30, 2024 (Kim, 2024). The analysis examined various elements, including genre, tempo (measured in beats per minute, or BPM), danceability, energy, and happiness. It also included popularity metrics such as the number of YouTube views and Spotify streams. These factors are crucial in determining a song's appeal, particularly in the global market, while popularity indicators highlight their role in attracting an audience. The method employed is hierarchical cluster analysis, utilizing single, complete, and average linkage. This approach categorizes songs based on the similarity of their musical elements and popularity, offering insights into the characteristics that contribute to hit songs.

Several previous studies have utilized cluster analysis across various fields and cases. In the research titled "Song Similarity Analysis With Clustering Method On Korean Pop Song" by Wijaya and Oetama (2021), the K-Means clustering and Self-Organizing Map methods were employed to analyze the similarities among K-Pop songs based on musical

characteristics such as tempo and mood. The results indicated that K-Pop songs typically feature an energetic, loud, and dance-friendly musical structure, with the Pop and Dance genres dominating the charts due to their appealing musical patterns.

Meanwhile, the study "Cluster Analysis of Musical Attributes for Top Trending Songs" by Al-Beitawi et al. (2020) also used K-Means clustering to examine the 100 most popular songs on Spotify. Their findings revealed that high danceability and low instrumentality are key attributes contributing to a song's popularity. Both studies emphasize the significance of elements such as tempo, danceability, and energy in determining a song's appeal, as well as the utility of employing a clustering approach to help musicians comprehend the patterns that contribute to success in the music market.

Unlike previous studies that focused solely on musical characteristics or clustering with limited variables, this study offers a novel approach by combining musical elements and popularity indicators in analyzing K-pop song success. This dual-variable clustering of 2024 MAMA Song of the Year nominees provides a more comprehensive view of both musical composition and audience reception. While prior research has utilized K-Means and Self-Organizing Maps on general K-pop or global songs, this study employs hierarchical clustering with validation using the agglomerative coefficient, providing deeper analytical insights and practical guidance for artists, producers, and strategists in today's music industry.

Using hierarchical cluster analysis, this study will examine various elements to understand patterns of song success, providing valuable insights for music labels, the industry, and artists in creating works that resonate with market preferences. The research focuses on clustering songs nominated for the 2024 MAMA Song of the Year by applying hierarchical clustering to both musical elements, such as genre, tempo, danceability, energy, and happiness, as well as popularity indicators, including YouTube views and Spotify streams. By doing this, this study aims to identify distinct groupings of songs and explore how these features relate to success on streaming platforms. Ultimately, it will offer actionable insights for music labels and artists looking to align their creations with current audience preferences.

II. METHODS

This research was conducted through a literature review, which involved gathering references from various sources, including journals, final projects, theses, books, and the internet, relevant to the topics discussed. The data used in this research were secondary. Data on 57 songs and artists nominated for Song of the Year at MAMA 2024 was obtained from Soompi. This South Korean entertainment website offers news, articles, and information about K-pop, Korean dramas, movies, and Korean culture. Soompi was chosen for its reputation as a reliable English-

language source for K-pop industry news and award announcements. Additionally, information about music genre elements was collected from various online sources, including streaming platforms, official artist websites, and publicly available databases. For songs lacking clear genre classifications, manual analysis was performed based on common characteristics of the music.

The tempo (BPM), danceability, energy, and happiness level data were obtained from Tunebat, a music database powered by the Spotify Web API. Tunebat is widely used for music data analysis, providing accessible and detailed metadata on songs, including tempo, key, duration, energy, and other audio features relevant to computational studies. Additionally, song popularity data were sourced from two platforms: YouTube, which provided the number of music video views, and Spotify, which offered the number of song streams. All data collection was conducted manually and was based on information available as of November 28, 2024. The final dataset includes 57 entries and eight variables: genre (categorical), tempo, danceability, energy, and happiness (on a scale of 0–100), as well as YouTube views, Spotify streams (numeric), and release date (in date format).

The quantitative analysis method was carried out in several stages to categorize the musical elements and popularity indicators of the songs nominated for Song of the Year at the 2024 MAMA. A total of 57 songs were included, representing the entire population of nominees in this category. No sampling techniques were applied, as all officially nominated songs were used without any additional selection or filtering. This category was chosen because it is regarded as the most representative and prestigious award at MAMA, reflecting the most popular and impactful songs of the year.

The initial stage of the research involved manually collecting secondary data from relevant online sources, including academic journals, government reports, and industry publications. This comprehensive approach ensured that the dataset was rich and appropriate to the topic under investigation. The second stage focused on data cleaning, where the dataset was systematically examined for missing values and duplicate entries. This careful review process was crucial for maintaining the integrity of the data; fortunately, it revealed no discrepancies or issues.

In the third stage, data transformation and normalization were conducted. The genre variable initially contained 27 categories, which were grouped into six broader categories for simplicity and clarity: Contemporary Pop, Hip-Hop Music, R&B and Soul, Electronic Music, Variative Rock, and Ballad. As genre is a categorical variable, it was converted to a numeric format using Label Encoding. All variables were then normalized using the Min-Max method, ensuring that their values fell within a range of 0 to 1. This approach helped maintain a uniform scale across all variables,

preventing any single feature from dominating the clustering process. All data processing was performed using Microsoft Excel.

The fourth stage involved calculating the distance between objects using the Euclidean distance method. This process produced an $n \times n$ proximity matrix, where each element represented the distance between two objects in the dataset. In the fifth stage, clustering was conducted using single linkage, complete linkage, and average linkage methods. Each approach generated a hierarchical structure, known as a dendrogram, which illustrated the relationships among the songs based on their proximity.

The final stage was cluster validation, where the agglomerative coefficient was calculated for each clustering result to assess the compactness of the clusters. The method with the highest coefficient value was chosen as the most suitable clustering solution. Both the hierarchical clustering analysis and the cluster validation, including the calculation of agglomerative coefficients, were executed using RStudio. The overall research workflow is visually represented in Figure 1.

Hierarchical clustering is conducted using an agglomerative approach to group objects based on their distances. At the start of the clustering process, each object is treated as an individual cluster. The distance between pairs of objects is calculated using the Euclidean distance formula (see Equation (1)), where the distance between two objects, x and y , is denoted as $d(x, y)$. Then, i is the index of each data, n is the total sum of data, x_{ik} is the center of the cluster, and y_{jk} is the to- jk data (Khikmah & Sofro, 2021).

$$d(x, y) = \sqrt{\sum_{i=1}^n (x_{ik} - y_{jk})^2} \quad (1)$$

A symmetrical matrix representing distances, denoted as $D = \{d_{ij}\}$, is created, where each element indicates the distance between objects. According to Khikmah & Sofro (2021) and Mulyaningrum et al. (2020), the clustering process consists of four main stages.

In the initial stage, all objects are treated as a single cluster, forming an N -cluster based on the distance matrix D . Next, pairs of clusters with the smallest distance (d_{uv}) are selected for merging. After the merge, the distance between the newly formed cluster and the remaining clusters is recalculated using specific linkage methods. In this research, the linkage methods employed include single linkage, complete linkage, and average linkage. Each of these methods produces a distinct hierarchical structure, represented in the form of a dendrogram. The clustering process continues iteratively until all objects are combined into one large cluster.

In single linkage clustering, the distance between two clusters is determined by the shortest distance between any two objects, one from each cluster (U and V), as shown in Equation (2). In contrast, complete linkage clustering calculates the distance based on the

longest distance between objects in clusters U and V , as illustrated in Equation (3).

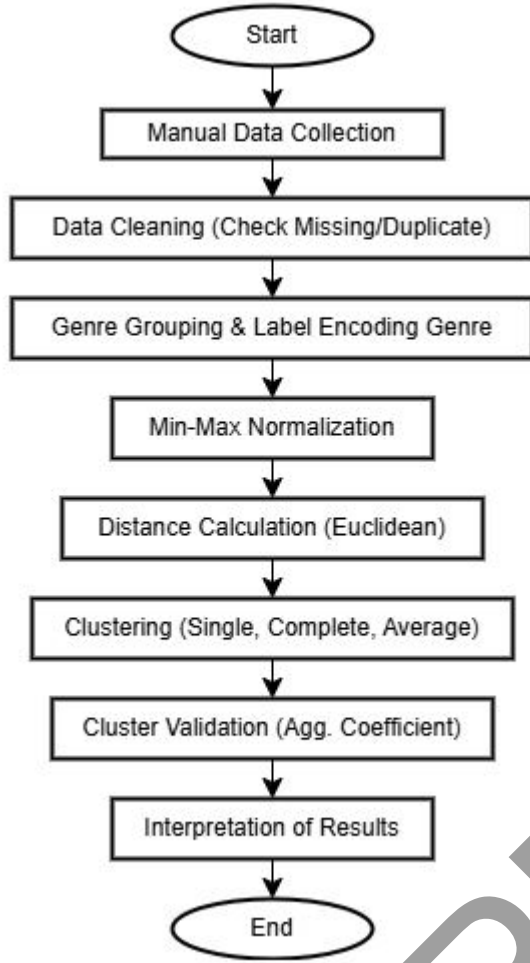


Figure 1 Research Methodology Flowchart

Equations (2) and (3) show $d_{(UV)W}$ is the distance between the new cluster UV and the cluster W . Additionally, d_{UW} denotes the distance between objects in cluster U and cluster W . In contrast, d_{VW} is the distance between the objects in the cluster V and the cluster W (Choudhury & Ashraf, 2022).

$$d_{(UV)W} = \min\{d_{UW}, d_{VW}\} \quad (2)$$

$$d_{(UV)W} = \max\{d_{UW}, d_{VW}\} \quad (3)$$

In average linkage, the distance between clusters is determined by calculating the average distance between all objects in the combined cluster, as illustrated in Equation (4). In this Equation, d_{ik} is the distance between the object to- i in the cluster (UV) and the object to- k in the cluster W , $N(UV)$ is the number of objects in the cluster (UV) , and $N(W)$ is the number of objects in the cluster W (Choudhury & Ashraf, 2022).

$$d_{(UV)W} = \frac{\sum_i \sum_k d_{ik}}{N_{UV} N_W} \quad (4)$$

Music elements such as genre, tempo, danceability, energy, and happiness are essential components for analyzing song characteristics. Genre refers to a category of music that can significantly influence a person's mood and personality. Tempo, which is measured as the speed of the beat, also plays a crucial role in determining the mood and energy of a song. According to information from Tunebat, danceability is assessed based on how well a song lends itself to dancing, considering factors like beat strength, rhythm stability, and tempo.

The energy of a song is measured by its intensity and activity, taking into account elements such as sound variation, pitch speed, vocal characteristics, volume level, and dynamic range. Additionally, the happiness of a song can be evaluated based on the overall cheerful atmosphere it conveys. Each of these elements is rated on a scale from 0 to 100. These five elements have a significant relationship with popularity indicators, such as the number of streams and views. Overall, these components of music play a vital role in enhancing a song's appeal and ultimately influencing its popularity on streaming platforms.

The Min-Max normalization method scales data into a specific range, such as $[0,1]$ or $[-1,1]$, to eliminate the influence of other variables. Variables with different ranges can lead to unbalanced weights in similarity measurements, making normalization essential for equalizing the weights of variables. By applying Min-Max normalization, all variables exert equal influence on decision-making, thus preventing bias toward variables with a larger range of values (Ali, 2022). The normalization process can be calculated using Equation (5), where x represents the data of each column, \min represents the minimum value of the data in that column, and \max indicates the maximum value of the data in the same column.

$$x' = \frac{x - \min}{\max - \min} \quad (5)$$

In this research, the Min-Max normalization technique was manually applied to all numerical variables using Microsoft Excel. These variables include the genre (which was first labeled on a scale of 0 to 5), tempo (in beats per minute, or BPM), danceability, energy, and happiness (on a scale of 0 to 100), as well as YouTube views and Spotify streams. The genre categories were converted into numeric codes based on six aggregated categories described in the Results section. All variables were then scaled to a standard range between 0 and 1 to ensure equal weighting during the clustering process.

The agglomerative coefficient is a measure used to assess the strength of the cluster structure in hierarchical cluster analysis. It is calculated based on the inequality of an object relative to the first cluster it joins, divided by the inequality present at the final merger during the clustering process. These values are then averaged across all objects in the dataset (Novaldi & Wijayanto, 2023; Ni'matuzzahroh et al., 2022).

According to Widodo et al. (2021), the agglomerative coefficient serves as a metric to evaluate the quality of clustering results. A coefficient value close to 1 indicates that the resulting groupings are improving and becoming more robust. This suggests that the objects within the cluster exhibit a high degree of similarity, resulting in a more cohesive and well-defined structure. The agglomerative coefficient (AC) is mathematically represented in Equation (6), where "i" represents each object and "l(i)" denotes the length of the range.

$$AC = \sum_i l(i) \quad (6)$$

III. RESULTS AND DISCUSSIONS

The dataset comprises 57 songs nominated for the MAMA 2024 Song of the Year award. It includes information such as release dates, musical elements, and popularity indicators recorded as of November 28, 2024. This data is presented in Table 1 (see Appendices). Data normalization was performed on seven variables using the Min-Max method. The genre variable, which includes 27 specific genre labels from the 57 songs, was manually grouped into six broader categories based on similarities in musical style.

Each category encompasses several closely related sub-genres. For example, Dance Pop, Folk-Pop, Rock-Pop, Funk-Pop, Indie Pop, Pop-Funk, Pop-Rock, City Pop, Alternative Pop, Dramatic Pop, and Pop-Rock are all grouped under the umbrella of Contemporary Pop. This classification aims to reduce data sparsity and enhance the interpretability of the clustering process. While these categories are not based on an official taxonomy, such as Billboard or

Spotify, they reflect patterns consistently observed across the dataset. The six genres identified include Contemporary Pop (including Dance Pop, Folk-Pop, Rock-Pop, Funk-Pop, Indie Pop, Pop-Funk, Pop-Rock, City Pop, Alternative Pop, Dramatic Pop, and Pop-Rock); Hip-Hop Music (including Hip-Hop Dance, Trap/Hip-Hop, Pluggnb, Hip-Hop, and Phonk); R&B and Soul (including R&B, Funk-Pop, Soul Funk, and R&B Dance); Electronic Music (including EDM, House Music, and Dance Pop House); Variative Rock (including Soft Rock, Quirk-Rock, Pop-Punk, and Indie/Brit Rock); and Ballad. Following the genre encoding process, the data underwent Min-Max normalization. The normalized results are presented in Table 2 (see Appendices).

Before clustering, an exploratory analysis was performed using RStudio to understand the distribution and relationships between the variables. The boxplot in Figure 2 illustrates that the genre variable has the broadest range because of the numerical encoding of various genre labels. In contrast, the tempo and danceability variables exhibit relatively symmetric distributions. The energy and happiness levels are moderately concentrated toward the higher end, indicating that upbeat songs are prevalent in the dataset.

In contrast, YouTube views and Spotify streams are significantly right-skewed, with several outliers representing songs that have achieved remarkable global popularity. The correlation matrix presented in Figure 3 shows a strong positive relationship between danceability and happiness ($r = 0.64$), as well as between danceability and energy ($r = 0.47$). This correlation indicates that more energetic songs are both more danceable and emotionally uplifting. Popularity indicators show a moderate correlation with

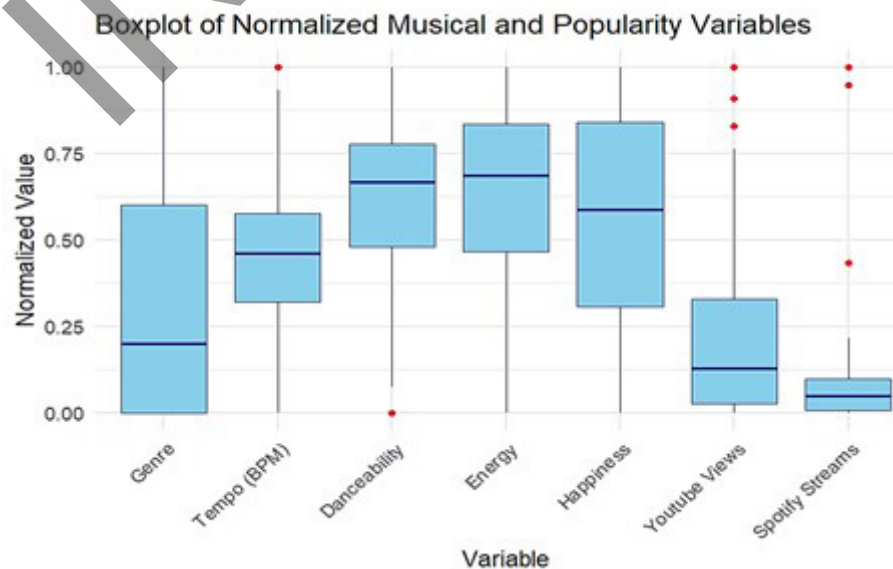


Figure 2 Boxplot Among Normalized Musical and Popularity Attributes

one another ($r = 0.56$) but exhibit weak correlations with musical elements (all below $r = 0.36$). This indicator highlights the distinct influence of popularity metrics. These patterns confirm that musical features and popularity indicators capture complementary aspects of the songs, supporting their combined use in clustering to uncover richer grouping structures.

The clustering process utilized Euclidean distances calculated from all normalized variables, which included both musical elements and indicators of popularity. The Euclidean distance, determined using the formula in Equation (1), measures the straight-line dissimilarity between each pair of songs, resulting in a square, symmetrical distance matrix. With a dataset of 57 songs, the resulting matrix is 57×57 , as shown in Table 3 (see Appendices). This matrix serves as the foundation for hierarchical grouping.

Clustering was conducted using three linkage methods: single, complete, and average linkage. Single linkage combines clusters based on the smallest distance between two objects, which is calculated using the Euclidean distance formula presented in Equation (2). Complete linkage, on the other hand, measures the farthest distance between objects within a cluster, as computed in Equation (3). In contrast, average linkage determines the merging of clusters by calculating the average distance between them, as shown in Equation (4). These three linkage methods are applied iteratively until the target number of clusters, which is seven, is achieved. The results of the clustering process are presented in Tables 4, 5, and 6. Additionally, the visualization of the dendrograms in Figures 4, 5, and 6 illustrates the division of the clusters using these methods.

The clustering results presented in the dendrogram reveal that the single, complete, and average linkage methods produce varying patterns. The height of the dendrogram indicates the dissimilarity between songs based on music elements such as genre, tempo, danceability, energy, and happiness. Additionally, it takes into account popularity indicators such as YouTube views and Spotify streams, which highlight differences in both musical characteristics and levels of popularity. For example, songs with high dissimilarity, such as Jimin's "Who" and Jungkook's "Standing Next to You" in the single linkage clustering, along with LUCY's "The knight who can't die and the silk cradle" in the average and complete linkage clustering, display unique characteristics in both music elements and popularity indicators. This distinctiveness causes them to merge into their respective clusters at the final stage of the clustering process.

Although these songs have high height scores, they do not exhibit a consistent pattern when compared to other songs. In contrast, songs with low height values tend to share more similarities, both in their musical elements and popularity, allowing them to cluster together more quickly. Therefore, the height in the dendrogram reflects the similarity of the songs from a combined perspective of musical features and popularity indicators.

Validation of clustering results using three methods — single, complete, and average linkage — was carried out based on agglomerative coefficient values. The agglomerative coefficient is an internal clustering evaluation measure that quantifies cluster cohesion, with values closer to 1 indicating more

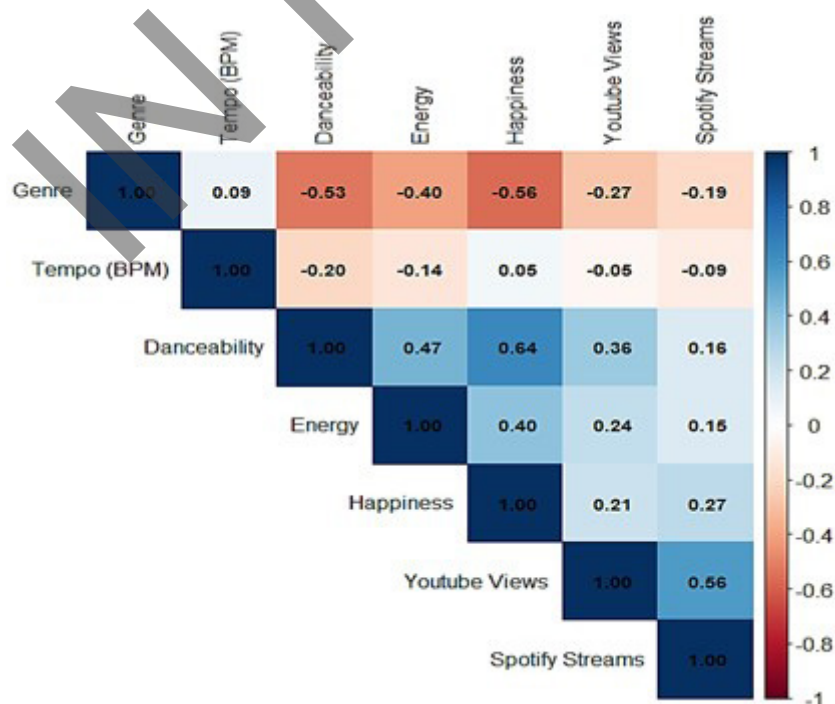


Figure 3 Pearson Correlation Matrix Among Normalized Musical and Popularity Attributes

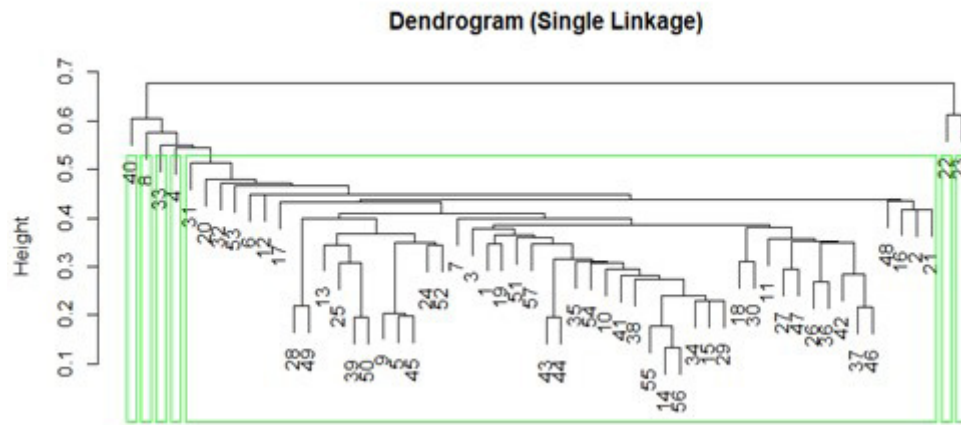


Figure 4 Visualization of Single Linkage with the Smallest Distance Using Cluster Dendrogram

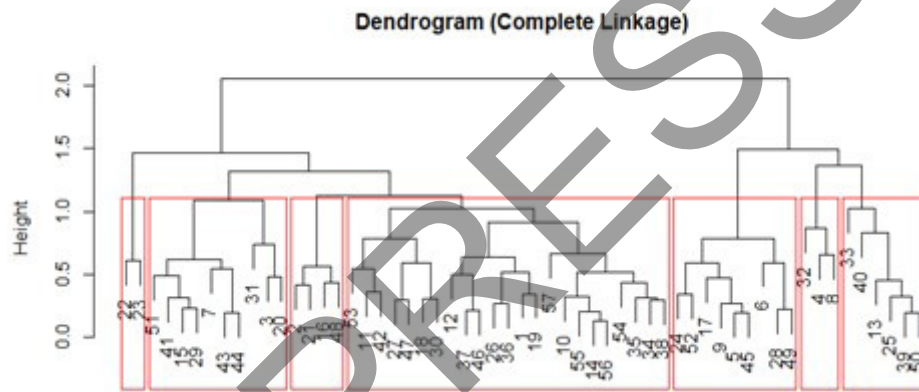


Figure 5 Visualization of Complete Linkage with the Farthest Distance Using Cluster Dendrogram

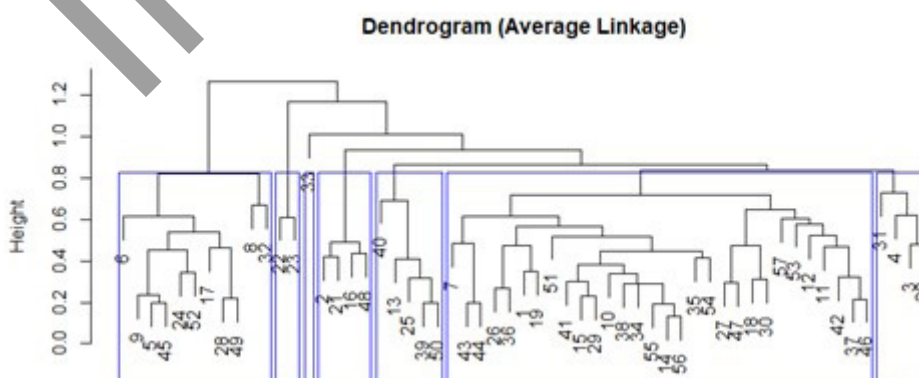


Figure 6 Visualization of Average Linkage with the Average Distance Using Cluster Dendrogram

compact and meaningful groupings (Widodo et al., 2021). The calculation was carried out using RStudio, yielding values of 0.4749 for single linkage, 0.8167 for average linkage, and 0.7193 for complete linkage. These results demonstrate that, according to this evaluation metric, average linkage produces the tightest and strongest clustering performance among the three methods.

In comparison with similar studies, Wijaya and Oetama (2021) reported a Silhouette Score of 0.55 using the K-Means algorithm on a dataset of 20 K-Pop songs. In contrast, Al-Beitawi et al. (2020) achieved a Silhouette Score of only about 0.15 on their silhouette chart for 100 Spotify tracks. Although these studies utilized different clustering algorithms and evaluation metrics, the agglomerative coefficient in this research—0.8167—indicates stronger cluster cohesion under hierarchical linkage. The differences in scores can be attributed to variations in algorithms, evaluation methods, and the characteristics of the datasets used.

The average linkage method not only achieved the highest agglomerative coefficient, but it also produced more balanced clusters and effectively handled moderate outliers. Unlike single linkage, which tends to group most songs into one large cluster, or complete linkage, which sometimes clusters dissimilar songs together, average linkage generated clearer and more interpretable groupings. For example, LUCY's experimental song was identified as an outlier in Cluster 5, while mainstream songs formed a cohesive group in Cluster 2. This suggests that average linkage offers better separation and stability in datasets with diverse musical styles and popularity levels.

By selecting the best clustering results based on the highest agglomerative coefficient, explicitly using the average linkage method, researchers can derive meaningful insights. According to Table 6, 57 songs have been categorized into seven main clusters. In Cluster 1, four songs seamlessly blend R&B and hip-hop styles, characterized by intense energy and a variety of rhythms. Notably, "Boys Like Girls" and "Taxi Blurr" feature a moderate tempo and a suitable level of danceability, appealing to a specific audience with their unique rhythm. Cluster 2, the largest of the clusters, consists of 30 songs that span a range of genres, including pop, hip-hop, and dance-pop. This group features popular artists such as IVE, SEVENTEEN, and aespa. The songs in this cluster showcase high energy and danceability, reflecting their broad appeal and substantial streaming numbers. As a result, these tracks dominate both YouTube and Spotify, highlighting their popularity in the mainstream music scene.

Cluster 3 comprises five songs that explore experimental and indie genres, including indie pop and house music. This group features artists like GroovyRoom and Sunmi. These songs blend moderate energy with a danceable appeal, appealing to alternative audiences. In Cluster 4, there are four high-energy tracks with dynamic rhythms, such as

"LALALALA" by Stray Kids and "Magnetic" by ILLIT. Additionally, Cluster 5 includes one unique outlier: LUCY's "The knight who can't die and the silk cradle," notable for its experimental style. Cluster 6 features two songs dominated by BTS members Jimin and Jungkook. The group blends funk and R&B styles, and these songs have gained a global fan base along with impressive streaming success, with Spotify streams surpassing one billion. Lastly, Cluster 7 comprises 11 songs, including original soundtrack (OST) ballads and emotional tracks from artists such as IU and Davichi. The songs in this group typically have lower tempos and energy levels, as well as lower happiness scores. These songs make them appealing to listeners who prefer deep, emotional themes and songs that touch the heart.

IV. CONCLUSIONS

Among the three clustering methods evaluated, the average linkage method yielded the best results, with an agglomerative coefficient of 0.8167. This method produces higher coefficients than the complete linkage method (0.7193) and the single linkage method (0.4749). These findings suggest that the average linkage method provides stronger cluster cohesion, enabling a more meaningful interpretation of the groupings based on musical attributes and popularity. The analysis of 57 songs nominated for the MAMA 2024 Song of the Year identified seven distinct clusters, each reflecting different patterns in musical elements and streaming popularity.

The results of the grouping analysis were divided into seven clusters. Cluster 1 features R&B and hip-hop styles characterized by diverse energy levels and rhythms, appealing to listeners who appreciate unique beats and rhythms. Cluster 2 is the largest group, comprising pop, hip-hop, and dance-pop songs that dominate streaming platforms due to their high-energy characteristics, making them particularly appealing to dance music enthusiasts. Cluster 3 encompasses experimental and indie genres, including indie pop and house music, catering to audiences seeking alternative sounds. Cluster 4 focuses on songs with dynamic rhythms and high energy, excelling in live performances. Cluster 5 stands out as a unique outlier, characterized by its experimental nature. Cluster 6 showcases its global appeal through R&B and funk songs by BTS members, such as Jimin and Jungkook, which have achieved remarkable streaming success in international markets. Cluster 7 consists of low-tempo ballads and emotionally charged soundtracks (OSTs), appealing to listeners who prefer introspective themes.

These findings have important implications for the music industry. By understanding the relationship between musical elements and song popularity, music labels, industry professionals, and artists can create works that align with market preferences, ultimately enhancing their chances of success. Furthermore, this research offers valuable insights into the evolving trends within the music industry, serving as a data-

driven strategy guide for producing music that resonates with modern audiences.

However, several limitations should be acknowledged. This research only included hit songs nominated at a single award show, limiting its generalizability. Expanding the dataset to include songs from different genres and periods could provide a more comprehensive representation of the music market. Additionally, the research focused on musical elements but did not consider other influential factors such as song lyrics, duration, or artist branding, which may also contribute to a song's success. Additionally, since MAMA primarily features popular genres such as K-pop, hip-hop, and OSTs, this dataset may exhibit genre bias and may not fully represent other types of music.

Future research should incorporate additional variables to gain a deeper understanding of the factors that influence song popularity. Additionally, researchers may explore alternative clustering methods, such as the Ward and centroid techniques, along with other agglomerative approaches, including the Manhattan distance. By broadening the scope of research, researchers can gain more refined insights into the dynamics of K-pop music success and identify broader trends within the music industry.

AUTHOR CONTRIBUTIONS

Conceived and designed the analysis; Collected the data; Contributed data or analysis tools; Performed the analysis; and Wrote the paper, L. A. H.; Provided academic supervision and guidance during the research project A. S.

DATA AVAILABILITY

The data that support the findings of the research are available from the corresponding author, L. A. H., upon reasonable request. The data were manually collected from public sources including YouTube, Spotify, Tunebat, and Soompi. Summary data are presented in the appendix.

REFERENCES

- Al-Beitawi, Z., Salehan, M., & Zhang, S. (2020). Cluster analysis of musical attributes for top trending songs. *53rd Hawaii International Conference on System Sciences*, 129–135.
- Ali, P. J. (2022). Investigating the impact of Min-Max data normalization on the regression performance of K-Nearest Neighbor with different similarity measurements. *Aro-the Scientific Journal of Koya University*, 10(1), 85–91. <https://doi.org/10.14500/aro.10955>
- Billboard. (2022). *Psy's 'Gangnam Style' turns 10: How its video became the first member of YouTube's billion views club*. [https://www.billboard.com/music/pop/psy-gangnam-style-10th-anniversary-youtube-](https://www.billboard.com/music/pop/psy-gangnam-style-10th-anniversary-youtube-billion-views-club-1235115043/)
- billion-views-club-1235115043/
- Cho, K. (2016). *A study on the current status and future development of K-pop: K-pop advancement strategies to America and Europe based on the success stories of K-pop in Japan and China*. Master's thesis, Kyunghee University Graduate School, Post Modern Music Major.
- Choudhury, J., & Ashraf, F. Bin. (2022). An analysis of different Distance-Linkage methods for clustering gene expression data and observing pleiotropy: Empirical study. *JMIR Bioinformatics and Biotechnology*, 3(1). <https://doi.org/10.2196/30890>
- Hibatullah, A. I., Sulistyani, H. D., & Rahardjo, T. (2024). *Pemaknaan fanbase terhadap isu-isu politik dalam lagu bergenre Indie Rock*. 12(2), 259–274. <https://ejournal3.undip.ac.id/index.php/interaksi-online/article/view/43795>
- K-pop Blueprint: Drawing Inspiration from South Korea's Creative Industries*. (2024). UN Trade & Development. <https://unctad.org/news/k-pop-blueprint-drawing-inspiration-south-koreas-creative-industries>
- Khikmah, K. N., & Sofro, A. (2021). Clustering regency and city in East Java based on population density and cumulative confirmed COVID-19 cases. *ComTech: Computer, Mathematics and Engineering Applications*, 12(2), 111–121. <https://doi.org/10.21512/comtech.v12i2.6891>
- Kim, D. (2024). *2024 MAMA Awards Announce Nominees + Fans' Choice Voting Begins*. <https://www.soompi.com/article/1694893wpp/2024-mama-awards-announces-nominees-fans-choice-voting-begins>
- Mulyaningrum, D., Nusrang, M., & Sudarmin. (2020). *Analisis cluster pendekatan metode Hierarchical Clustering terhadap pertumbuhan ekonomi di provinsi Sulawesi Selatan*. Bachelor's thesis, Makassar State University.
- Ni'matuzzahroh, L., Dani, A. T. R., & Adrianingsih, N. Y. (2022). Clustering regencies/cities in Kalimantan Island based on poverty indicators using Agglomerative Hierarchical Clustering (AHC). *Jurnal Matematika, Statistika, Dan Komputasi*, 19(1), 79–89. <https://doi.org/10.20956/j.v19i1.20882>
- Novaldi, J., & Wijayanto, A. W. (2023). Analisis cluster kualitas pemuda di Indonesia pada tahun 2022 dengan Agglomerative Hierarchical dan K-Means. *Komputika : Jurnal Sistem Komputer*, 12(2), 211–219. <https://doi.org/10.34010/komputika.v12i2.10348>
- Park, J. (2023). From cultural export to economic engine : Examining the role of K-pop in the growth of the South Korean economy. *Open Journal of Business and Management*, 11, 2198–2214. <https://doi.org/10.4236/ojbm.2023.115121>
- Widodo, E., Ermayani, P., Laila, L. N., & Madani, A. T. (2021). Pengelompokan provinsi di Indonesia berdasarkan tingkat kemiskinan menggunakan analisis Hierarchical Agglomerative Clustering. *Seminar Nasional Official Statistics*, 1, 557–566.

<https://doi.org/10.34123/semnasoffstat.v2021i1.971>

Wijaya, H., & Oetama, R. S. (2021). Song similarity analysis with clustering method on Korean pop song. *6th International Conference on New Media Studies (CONMEDIA), Tangerang, Indonesia*, 66–71. <https://doi.org/10.1109/CONMEDIA53104.2021.9617204>

IN PRESS

APPENDICES

Table 1 Data of Songs and Artists Nominated for Song of the Year MAMA 2024
with Music Element Attributes and Song Popularity Data (up to November 28, 2024)

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
1	aespa – “Armageddon”	May 27, 2024	Hip-Hop Dance	92	70	79	47	101,241,699	170,514,389
2	aespa – “Supernova”	May 13, 2024	Dance Pop	120	74	75	37	152,692,727	222,729,846
3	AKMU – “Hero”	Jun 3, 2024	Folk-Pop	136	66	43	66	4,495,677	3,188,960
4	BIBI – “Bam Yang Gang”	Feb 13, 2024	R&B	178	46	41	74	26,351,856	49,150,177
5	Crush – “Love You With All My Heart” (“Queen of Tears” OST)	Mar 24, 2024	Ballad	134	46	33	21	33,843,839	59,396,853
6	Davichi – “A very personal story”	Nov 15, 2023	Ballad	80	64	53	50	1,436,298	444,529
7	DAY6 – “Welcome to the Show”	Mar 18, 2024	Rock-Pop	132	60	76	38	12,537,701	13,716,188
8	DEAN – “DIE 4 YOU”	Nov 18, 2023	R&B	154	43	36	29	4,622,161	33,279,859
9	ECLIPSE – “Sudden Shower” (“Lovely Runner” OST)	Apr 8, 2024	Ballad	133	47	51	22	14,717,564	75,362,955
10	ENHYPEN – “Sweet Venom”	Nov 17 2023	Funk-Pop	115	84	67	91	65,143,188	123,582,711
11	(G)I-DLE – “Fate”	Jan 29, 2024	Pop-Punk	115	87	73	81	61,571,040	51,368,820
12	(G)I-DLE – “Super Lady”	Jan 29, 2024	EDM	122	80	87	53	115,112,126	86,333,642
13	GroovyRoom – “Yes or No (Feat. Huh Yunjin, Crush)”	Jan 17, 2024	R&B	131	67	93	47	4,818,597	17,891,951
14	Hwasa – “NA”	Sep 19, 2024	Dance Pop	127	80	74	79	34,182,346	5,363,597
15	Hyukoh, Sunset Rollercoaster – “Young Man”	Jul 3, 2024	Indie Pop	111	66	73	72	1,633,607	3,026,516
16	ILLIT – “Magnetic”	Mar 25, 2024	Pluggnb	131	80	67	69	175,641,617	473,657,192
17	IU – “Love wins all”	Jan 24, 2024	Ballad	101	50	45	32	83,198,809	86,637,058
18	IVE – “Baddie”	Oct 13, 2023	Trap/Hip-Hop	160	74	68	76	55,157,381	119,174,888
19	IVE – “HEYA”	Apr 29, 2024	Hip-Hop Dance	92	70	84	69	71,369,792	68,875,950
20	Jay Park – “Taxi Blurr (Feat. Natty)”	May 28, 2024	R&B	144	61	57	56	5,629,697	9,942,000
21	Jennie – “You & Me”	Oct 6, 2023	Dance Pop	112	79	57	56	192,332,437	235,736,634
22	Jimin – “Who”	Jul 19, 2024	R&B	116	66	76	84	70,765,446	1,095,538,464
23	Jungkook – “Standing Next to You”	Nov 3, 2023	Pop-Funk	106	71	81	82	161,845,747	1,039,027,393

Table 1 Data of Songs and Artists Nominated for Song of the Year MAMA 2024
with Music Element Attributes and Song Popularity Data (up to November 28, 2024)
(Continued)

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
24	K.will – “No Sad Song For My Broken Heart (Prod. Yoon Sang)”	Jun 20, 2024	Ballad	136	65	55	25	7,005,809	1,983,888
25	Key – “Pleasure Shop”	Sep 23, 2024	House Music	121	72	81	33	8,128,802	2,542,591
26	LE SSERAFIM – “CRAZY”	Aug 30, 2024	Dance Pop	130	80	90	53	94,665,377	129,551,963
27	LE SSERAFIM – “EASY”	Feb 19, 2024	R&B	165	74	70	60	101,338,792	215,470,770
28	Lee Chang Sub – “Heavenly fate” (“A Not So Fairy Tale” OST)	Feb 21, 2024	Ballad	72	44	52	16	18,315,037	2,797,713
29	Lee Mu Jin – “Episode”	Dec 13, 2023	Folk-Pop	118	73	71	59	5,333,217	9,637,854
30	Lee Young Ji – “Small Girl (Feat. D.O.)”	Jun 21, 2024	R&B	170	77	60	88	45,968,245	46,764,420
31	Leellamarz – “Boys Like Girls (Feat. Gist, Jayci Yucca)”	Oct 26, 2023	Hip-Hop	150	89	38	86	1,533,843	1,852,039
32	Lim Young Woong – “Warmth”	May 6, 2024	Ballad	171	35	23	34	14,840,356	11,546,726
33	LUCY – “The knight who can’t die and the silk cradle”	Mar 20, 2024	Rock-Pop	165	39	88	50	3,485,683	1,864,620
34	N.Flying – “Into You”	Jun 25, 2024	Pop-Rock	106	73	84	80	1,826,230	1,789,543
35	Nayeon – “ABCD”	Jun 14, 2024	Dance Pop	106	68	93	86	53,674,846	92,080,712
36	NCT 127 – “Fact Check”	Oct 6, 2023	Hip-Hop Dance	130	76	91	57	63,342,931	80,183,608
37	NewJeans – “How Sweet”	May 24, 2024	R&B	125	80	90	76	46,960,372	146,308,742
38	NewJeans – “Supernatural”	Jun 21, 2024	City Pop	109	70	71	86	42,299,988	106,698,017
39	PLAVE – “WAY 4 LUV”	Feb 26, 2024	Soft Rock	127	67	85	50	11,427,176	8,328,330
40	QWER – “T.B.H”	Apr 1, 2024	Quirk-Rock	178	55	96	68	23,440,790	10,853,025
41	Red Velvet – “Cosmic”	Jun 24, 2024	Dance Pop	106	72	56	65	32,072,547	47,777,901
42	RIIZE – “Impossible”	Apr 18, 2024	Dance Pop House	128	77	81	80	27,435,609	33,215,473
43	RIIZE – “Love 119”	Jan 5, 2024	Dance Pop	99	75	75	42	27,243,149	60,847,711
44	RM – “LOST!”	May 24, 2024	Alternative Pop	88	77	68	34	14,118,554	106,674,346
45	Roy Kim – “Whenever, Wherever” (“My Demon” OST)	Dec 1, 2023	Ballad	126	45	39	26	4,298,334	7,383,122
46	SEVENTEEN – “God of Music”	Oct 23, 2023	Soul Funk	120	73	91	81	77,408,645	94,473,007
47	SEVENTEEN – “MAESTRO”	Apr 29, 2024	R&B Dance	152	68	84	59	83,115,136	82,919,829

Table 1 Data of Songs and Artists Nominated for Song of the Year MAMA 2024
with Music Element Attributes and Song Popularity Data (up to November 28, 2024)
(Continued)

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
48	Stray Kids – “LALALALA”	Nov 10, 2023	Phonk	126	71	85	61	211,331,868	209,336,807
49	Sung Si Kyung, Naul – “Even for a moment”	Oct 19, 2023	Ballad	85	44	46	27	4,169,353	1,267,744
50	Sunmi – “Balloon in Love”	Jun 13, 2024	Indie/Brit Rock	133	62	81	39	2,334,213	3,317,826
51	Taemin – “Guilty”	Oct 30, 2023	Dramatic Pop	82	57	78	67	27,322,096	57,480,407
52	Taeyeon – “Dream” (“Welcome to Samdalri” OST)	Dec 17, 2023	Ballad	112	56	67	33	5,327,062	10,267,859
53	Taeyeon – “To. X”	Nov 27, 2023	R&B	97	84	59	65	28,524,010	58,666,204
54	Taeyong – “TAP”	Feb 26, 2024	Hip-Hop	88	80	87	85	9,160,972	49,562,196
55	TWS – “plot twist”	Jan 22, 2024	Pop-Rock	112	81	71	73	35,852,896	59,774,031
56	Yuqi – “FREAK”	Apr 23, 2024	Dance Pop	120	81	82	81	29,449,143	22,473,771
57	Zico – “SPOT! (Feat. Jennie)”	Apr 26, 2024	Hip-Hop	108	88	78	91	110,380,407	173,433,376

Table 2 The Results of Normalization Data

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
1	aespa – “Armageddon”	May 27, 2024	0.200	0.189	0.648	0.767	0.413	0.476	0.155
2	aespa – “Supernova”	May 13, 2024	0.000	0.453	0.722	0.712	0.280	0.721	0.203
3	AKMU – “Hero”	Jun 3, 2024	0.000	0.604	0.574	0.274	0.667	0.015	0.003
4	BIBI – “Bam Yang Gang”	Feb 13, 2024	0.400	1.000	0.204	0.247	0.773	0.119	0.044
5	Crush – “Love You With All My Heart” (“Queen of Tears” OST)	Mar 24, 2024	1.000	0.585	0.204	0.137	0.067	0.154	0.054
6	Davichi – “A very personal story”	Nov 15, 2023	1.000	0.075	0.537	0.411	0.453	0.000	0.000
7	DAY6 – “Welcome to the Show”	Mar 18, 2024	0.000	0.566	0.463	0.726	0.293	0.053	0.012
8	DEAN – “DIE 4 YOU”	Nov 18, 2023	0.400	0.774	0.148	0.178	0.173	0.015	0.030
9	ECLIPSE – “Sudden Shower” (“Lovely Runner” OST)	Apr 8, 2024	1.000	0.575	0.222	0.384	0.080	0.063	0.068
10	ENHYPEN – “Sweet Venom”	Nov 17 2023	0.000	0.406	0.907	0.603	1.000	0.304	0.112
11	(G)I-DLE – “Fate”	Jan 29, 2024	0.800	0.406	0.963	0.685	0.867	0.286	0.047
12	(G)I-DLE – “Super Lady”	Jan 29, 2024	0.600	0.472	0.833	0.877	0.493	0.542	0.078
13	GroovyRoom – “Yes or No (Feat. Huh Yunjin, Crush)”	Jan 17, 2024	0.400	0.557	0.593	0.959	0.413	0.016	0.016
14	Hwasa – “NA”	Sep 19, 2024	0.000	0.519	0.833	0.699	0.840	0.156	0.004
15	Hyukoh, Sunset Rollercoaster – “Young Man”	Jul 3, 2024	0.000	0.368	0.574	0.685	0.747	0.001	0.002
16	ILLIT – “Magnetic”	Mar 25, 2024	0.200	0.557	0.833	0.603	0.707	0.830	0.432
17	IU – “Love wins all”	Jan 24, 2024	1.000	0.274	0.278	0.301	0.213	0.390	0.079
18	IVE – “Baddie”	Oct 13, 2023	0.200	0.830	0.722	0.616	0.800	0.256	0.108
19	IVE – “HEYA”	Apr 29, 2024	0.200	0.189	0.648	0.836	0.707	0.333	0.062
20	Jay Park – “Taxi Blurr (Feat. Natty)”	May 28, 2024	0.400	0.679	0.481	0.466	0.533	0.020	0.009
21	Jennie – “You & Me”	Oct 6, 2023	0.000	0.377	0.815	0.466	0.533	0.909	0.215
22	Jimin – “Who”	Jul 19, 2024	0.400	0.415	0.574	0.726	0.907	0.330	1.000
23	Jungkook – “Standing Next to You”	Nov 3, 2023	0.000	0.321	0.667	0.795	0.880	0.764	0.948
24	K.will – “No Sad Song For My Broken Heart (Prod. Yoon Sang)”	Jun 20, 2024	1.000	0.604	0.556	0.438	0.120	0.027	0.001

Table 2 The Results of Normalization Data
(Continued)

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
25	Key – “Pleasure Shop”	Sep 23, 2024	0.600	0.462	0.685	0.795	0.227	0.032	0.002
26	LE SSERAFIM – “CRAZY”	Aug 30, 2024	0.000	0.547	0.833	0.918	0.493	0.444	0.118
27	LE SSERAFIM – “EASY”	Feb 19, 2024	0.400	0.877	0.722	0.644	0.587	0.476	0.196
28	Lee Chang Sub – “Heavenly fate” (“A Not So Fairy Tale” OST)	Feb 21, 2024	1.000	0.000	0.167	0.397	0.000	0.080	0.002
29	Lee Mu Jin – “Episode”	Dec 13, 2023	0.000	0.434	0.704	0.658	0.573	0.019	0.008
30	Lee Young Ji – “Small Girl (Feat. D.O.)”	Jun 21, 2024	0.400	0.925	0.778	0.507	0.960	0.212	0.042
31	Leellamarz – “Boys Like Girls (Feat. Gist, Jayci Yucca)”	Oct 26, 2023	0.200	0.736	1.000	0.205	0.933	0.000	0.001
32	Lim Young Woong – “Warmth”	May 6, 2024	1.000	0.934	0.000	0.000	0.240	0.064	0.010
33	LUCY – “The knight who can’t die and the silk cradle”	Mar 20, 2024	0.000	0.877	0.074	0.890	0.453	0.010	0.001
34	N.Flying – “Into You”	Jun 25, 2024	0.000	0.321	0.704	0.836	0.853	0.002	0.001
35	Nayeon – “ABCD”	Jun 14, 2024	0.000	0.321	0.611	0.959	0.933	0.249	0.084
36	NCT 127 – “Fact Check”	Oct 6, 2023	0.200	0.547	0.759	0.932	0.547	0.295	0.073
37	NewJeans – “How Sweet”	May 24, 2024	0.400	0.500	0.833	0.918	0.800	0.217	0.133
38	NewJeans – “Supernatural”	Jun 21, 2024	0.000	0.349	0.648	0.658	0.933	0.195	0.097
39	PLAVE – “WAY 4 LUV”	Feb 26, 2024	0.800	0.519	0.593	0.849	0.453	0.048	0.007
40	QWER – “T.B.H”	Apr 1, 2024	0.800	1.000	0.370	1.000	0.693	0.105	0.010
41	Red Velvet – “Cosmic”	Jun 24, 2024	0.000	0.321	0.685	0.452	0.653	0.146	0.043
42	RIIZE – “Impossible”	Apr 18, 2024	0.600	0.528	0.778	0.795	0.853	0.124	0.030
43	RIIZE – “Love 119”	Jan 5, 2024	0.000	0.255	0.741	0.712	0.347	0.123	0.055
44	RM – “LOST!”	May 24, 2024	0.000	0.151	0.778	0.616	0.240	0.060	0.097
45	Roy Kim – “Whenever, Wherever” (“My Demon” OST)	Dec 1, 2023	1.000	0.509	0.185	0.219	0.133	0.014	0.006
46	SEVENTEEN – “God of Music”	Oct 23, 2023	0.400	0.453	0.704	0.932	0.867	0.362	0.086
47	SEVENTEEN – “MAESTRO”	Apr 29, 2024	0.400	0.755	0.611	0.836	0.573	0.389	0.075
48	Stray Kids – “LALALALA”	Nov 10, 2023	0.200	0.509	0.667	0.849	0.600	1.000	0.191
49	Sung Si Kyung, Naul – “Even for a moment”	Oct 19, 2023	1.000	0.123	0.167	0.315	0.147	0.013	0.001

Table 2 The Results of Normalization Data
(Continued)

No	Artist-Song	Release Date	Genre	Tempo (BPM)	Danceability	Energy	Happiness	YouTube Views	Spotify Streams
50	Sunmi – “Balloon in Love”	Jun 13, 2024	0.800	0.575	0.500	0.795	0.307	0.004	0.003
51	Taemin – “Guilty”	Oct 30, 2023	0.000	0.094	0.407	0.753	0.680	0.123	0.052
52	Taeyeon – “Dream” (“Welcome to Samdalri” OST)	Dec 17, 2023	1.000	0.377	0.389	0.603	0.227	0.019	0.009
53	Taeyeon – “To. X”	Nov 27, 2023	0.400	0.236	0.907	0.493	0.653	0.129	0.053
54	Taeyong – “TAP”	Feb 26, 2024	0.200	0.151	0.833	0.877	0.920	0.037	0.045
55	TWS – “plot twist”	Jan 22, 2024	0.000	0.377	0.852	0.658	0.760	0.164	0.054
56	Yuqi – “FREAK”	Apr 23, 2024	0.000	0.453	0.852	0.808	0.867	0.133	0.020
57	Zico – “SPOT! (Feat. Jennie)”	Apr 26, 2024	0.200	0.340	0.981	0.753	1.000	0.519	0.158

Table 3 Euclidean Distance Matrix

	1	2	3	...	21	...	39	40	...	57
1	0									
2	0.445	0								
3	0.872	0.962	0							
⋮	⋱						
21	0.632	0.418	1.004	...	0					
⋮	⋱				
39	0.828	1.096	1.012	...	1.283	...	0			
40	1.177	1.317	1.172	...	1.492	...	0.604	0		
⋮	⋱	
57	0.693	0.826	0.945	...	0.724	...	1.047	1.232	...	0

Table 4 Member Clusters with Single Linkage Based on Music Element Attributes and Song Popularity Data in the Song of the Year MAMA 2024 Nominations

No	Cluster	Member of the Cluster	Number of Members in Cluster
1	Cluster 1	Jungkook – “Standing Next to You”	1
2	Cluster 2	Jimin – “Who”	1
3	Cluster 3	Leellamarz – “Boys Like Girls (Feat. Gist, Jayci yucca)”, Jay Park – “Taxi Blurr (Feat. Natty)”, Lim Young Woong – “Warmth”, Taeyeon – “To. X”, Davichi – “A very personal story”, (G) I-DLE – “Super Lady”, IU – “Love wins all”, Lee Chang Sub – “Heavenly fate” (“A Not So Fairy Tale” OST), Sung Si Kyung, Naul – “Even for a moment”, GroovyRoom – “Yes or No (Feat. Huh Yunjin, Crush), Key – “Pleasure Shop”, PLAVE – “WAY 4 LUV”, Sunmi – “Balloon in Love”, ECLIPSE – “Sudden Shower” (“Lovely Runner” OST), Crush – “Love You With All My Heart” (“Queen of Tears” OST), Roy Kim – “Whenever, Wherever” (“My Demon” OST), K.will – “No Sad Song For My Broken Heart (Prod. Yoon Sang)”, Taeyeon – “Dream” (“Welcome to Samdalri” OST), DAY6 – “Welcome to the Show”, AKMU – “Hero”, aespa – “Armageddon”, IVE – “HEYA”, Taemin – “Guilty”, Zico – “SPOT! (Feat. Jennie)”, RIIZE – “Love 119”, RM – “LOST!”, Nayeon – “ABCD”, Taeyong – “TAP”, ENHYPEN – “Sweet Venom”, Red Velvet – “Cosmic”, NewJeans – “Supernatural”, TWS – “plot twist”, Hwasa – “NA”, Yuqi – “FREAK”, N.Flying – “Into You”, Hyukoh, Sunset Rollercoaster – “Young Man”, Lee Mu Jin – “Episode”, IVE – “Baddie”, Lee Young Ji – “Small Girl (Feat. D.O.)”, (G) I-DLE – “Fate”, LE SSERAFIM – “EASY”, SEVENTEEN – “MAESTRO”, LE SSERAFIM – “CRAZY”, NCT 127 – “Fact Check”, RIIZE – “Impossible”, NewJeans – “How Sweet”, SEVENTEEN – “God of Music”	51
4	Cluster 4	BIBI – “Bam Yang Gang”	1
5	Cluster 5	LUCY – “The knight who can’t die and the silk cradle”	1
6	Cluster 6	DEAN – “DIE 4 YOU”	1
7	Cluster 7	QWER – “T.B.H”	1
Total			57

Table 5 Member Clusters with Complete Linkage Based on Music Element Attributes and Song Popularity Data in the Song of the Year MAMA 2024 Nominations

No	Cluster	Member of the Cluster	Number of Members in Cluster
1	Cluster 1	LUCY – “The knight who can’t die and the silk cradle”, QWER – “T.B.H”, GroovyRoom – “Yes or No (Feat. Huh Yunjin, Crush), Key – “Pleasure Shop”, PLAVE – “WAY 4 LUV”, Sunmi – “Balloon in Love”	6
2	Cluster 2	Lim Young Woong – “Warmth”, BIBI – “Bam Yang Gang”, DEAN – “DIE 4 YOU”	3
3	Cluster 3	K.will – “No Sad Song For My Broken Heart (Prod. Yoon Sang)”, Taeyeon – “Dream” (“Welcome to Samdalri” OST), IU – “Love wins all”, ECLIPSE – “Sudden Shower” (“Lovely Runner” OST), Crush – “Love You With All My Heart” (“Queen of Tears” OST), Roy Kim – “Whenever, Wherever” (“My Demon” OST), Davichi – “A very personal story”, Lee Chang Sub – “Heavenly fate” (“A Not So Fairy Tale” OST), Sung Si Kyung, Naul – “Even for a moment”	9
4	Cluster 4	Taeyeon – “To. X”, (G)I-DLE – “Fate”, RIIZE – “Impossible”, LE SSERAFIM – “EASY”, SEVENTEEN – “MAESTRO”, IVE – “Baddie”, Lee Young Ji – “Small Girl (Feat. D.O.)”, (G)I-DLE – “Super Lady”, NewJeans – “How Sweet”, SEVENTEEN – “God of Music”, LE SSERAFIM – “CRAZY”, NCT 127 – “Fact Check”, aespa – “Armageddon”, IVE – “HEYA”, Zico – “SPOT! (Feat. Jennie)”, IVE – “HEYA”, TWS – “plot twist”, Hwasa – “NA”, Yuqi – “FREAK”, Taeyong – “TAP”, Nayeon – “ABCD”, N.Flying – “Into You”, NewJeans – “Supernatural”	23
5	Cluster 5	aespa – “Supernova”, Jennie – “You & Me”, ILLIT – “Magnetic”, Stray Kids – “LALALALA”	4
6	Cluster 6	Taemin – “Guilty”, Red Velvet – “Cosmic”, Hyukoh, Sunset Rollercoaster – “Young Man”, Lee Mu Jin – “Episode”, DAY6 – “Welcome to the Show”, RIIZE – “Love 119”, RM – “LOST!”, Leellamarz – “Boys Like Girls (Feat. Gist, Jayci yucca)”, AKMU – “Hero”, Jay Park – “Taxi Blurr (Feat. Natty)”	10
7	Cluster 7	Jimin – “Who”, Jungkook – “Standing Next to You”	2
Total			57

Table 6 Member Clusters with Average Linkage Based on Music Element Attributes and Song Popularity Data in the Song of the Year MAMA 2024 Nominations

No	Cluster	Member of Cluster	Number of Members in Cluster
1	Cluster 1	Leellamarz – “Boys Like Girls (Feat. Gist, Jayci yucca)”, BIBI – “Bam Yang Gang”, AKMU – “Hero”, Jay Park – “Taxi Blurr (Feat. Natty)”	4
2	Cluster 2	DAY6 – “Welcome to the Show”, RIIZE – “Love 119”, RM – “LOST!”, LE SSERAFIM – “CRAZY”, NCT 127 – “Fact Check”, aespa – “Armageddon”, IVE – “HEYA”, Taemin – “Guilty”, Red Velvet – “Cosmic”, Hyukoh, Sunset Rollercoaster – “Young Man”, Lee Mu Jin – “Episode”, ENHYPEN – “Sweet Venom”, NewJeans – “Supernatural”, N.Flying – “Into You”, TWS – “plot twist”, Hwasa – “NA”, Yuqi – “FREAK”, Nayeon – “ABCD”, Taeyong – “TAP”, LE SSERAFIM – “EASY”, SEVENTEEN – “MAESTRO”, IVE – “Baddie”, Lee Young Ji – “Small Girl (Feat. D.O.)”, Zico – “SPOT! (Feat. Jennie)”, Taeyeon – “To. X”, (G)I-DLE – “Super Lady”, (G)I-DLE – “Fate”, RIIZE – “Impossible”, NewJeans – “How Sweet”, SEVENTEEN – “God of Music”	30
3	Cluster 3	QWER – “T.B.H”, GroovyRoom – “Yes or No (Feat. Huh Yunjin, Crush), Key – “Pleasure Shop”, PLAVE – “WAY 4 LUV”, Sunmi – “Balloon in Love”	5
4	Cluster 4	aespa – “Supernova”, Jennie – “You & Me”, ILLIT – “Magnetic”, Stray Kids – “LALALALA”	4
5	Cluster 5	LUCY – “The knight who can’t die and the silk cradle”	1
6	Cluster 6	Jimin – “Who”, Jungkook – “Standing Next to You”	2
7	Cluster 7	Davichi – “A very personal story”, ECLIPSE – “Sudden Shower” (“Lovely Runner” OST), Crush – “Love You With All My Heart” (“Queen of Tears” OST), Roy Kim – “Whenever, Wherever” (“My Demon” OST), K.will – “No Sad Song For My Broken Heart (Prod. Yoon Sang)”, Taeyeon – “Dream” (“Welcome to Samdalri” OST), IU – “Love wins all”, Lee Chang Sub – “Heavenly fate” (“A Not So Fairy Tale” OST), Sung Si Kyung, Naul – “Even for a moment”, DEAN – “DIE 4 YOU”, Lim Young Woong – “Warmth”	11
Total			57