Mining Exceptional Genre Patterns on Hit Songs

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Abstract. The music industry has always been complex and competitive. Nowadays, combining different genres has become a common practice to promote new music and reach new audiences. Given the diversity of combinations between all genres, predictive and descriptive analyses are very challenging. Here, our goal is to mine frequent and exceptional patterns in music collaborations that have achieved success in both global and regional markets. We use the Apriori algorithm to mine genre patterns and association rules that reveal how music genres combine with each other in each market. The results show significant differences in the behavior of each market and a strong influence of the regional factor on musical success. In addition, we are able to use such patterns to identify and recommend promising genre combinations for such markets through the association rules.

CCS Concepts: • **Information systems** → **Data mining**; *Music retrieval*; • **Applied computing** → **Sound and music computing**.

Keywords: hit song science, music data mining, music information retrieval, musical genres

1. INTRODUCTION

Music is not only one of the world's most important cultural industries, but also one of the most dynamic. As the music industry is complex and competitive, artists are encouraged to reinvent strategies to maintain their presence in the market and reach new audiences. A few years ago, music consumption was related to radio and physical discs; now, the Internet and the popularization of streaming services enable fans all over the world to access an immense amount of songs from various artists. This new reality has facilitated the insertion of artists and regional genres in the global music scene, enhancing its diversity. Examples include the achievements of the Brazilian singer Anitta, whose song "Envolver" ranked #1 in the Global Spotify Top 200 Chart in 2022, and the establishment of K-pop as a popular genre worldwide.

When studying musical success, a very important issue is how to analyze the music market. Especially, analyzing the global performance is important, but not enough, as *regional markets* have their own features and behaviors regarding success. Previous studies reveal that besides the globally established genres, regional genres are deeply consumed in their countries [Oliveira et al. 2020]. In Brazil, the largest music market in Latin America, the five most listened songs in Spotify[1] include those from *sertanejo* and *funk carioca* – two of the most popular local genres.

Indeed, the genre perspective is essential when analyzing musical success. With so much dynamism in the music industry, artists are no longer linked to one specific genre. Genre-blending has become a common practice in the music industry, and musicians often experiment with the mixture of genres in their songs. For example, Lil Nas X's "Old Town Road" (2019's #1 hit in the Billboard Year-End

[1] https://www.cnnbrasil.com.br/entretenimento/spotify-divulga-retrospectiva-de-2022-marilia-mendonca-e-a-mais-ouvida-no-brasil/

Hot 100) combines hip-hop and country, pop star Ariana Grande raps on her album *Positions*, and Bad Bunny navigates between reggaeton, EDM (electronic dance music), and trap in his songs.

Collaborating with artists from other genres is also a common approach to achieve greater popularity. For example, Lady Gaga's Grammy-nominated album *Chromatica*[2] has collaboration as one of its biggest strengths. The collaboration with Ariana Grande (*pop*), Elton John (*rock*), and Blackpink (*k-pop*) contributed to maintain her among the most prominent pop names nowadays, as well as introducing her to new audiences. More recently, the collaboration between Shakira and Bizarrap, entitled "Music Session Vol.53", took the record for the most-streamed Latin track in a single day in Spotify history in the day of its release in January 2023. It debuted in #1 in the Global chart and in several Spanish-speaking markets, including Argentina, Colombia, Chile, Mexico, and Spain. It also has made it to the top 10 in Luxembourg (#5), the United States (#6), and Switzerland (#7).

The great diversity of genres and the ever-growing tendency to blend them in songs highlights the dynamic and unpredictable nature of the music industry. Given the potential combinations between all such genres, predictive and descriptive analyses over the data available become challenging. As a practical application, record labels may uncover frequent genre combinations that achieve a higher level of success to plan future song releases. In such an interesting, challenging context, we aim to mine exceptional patterns of musical genres in songs that have been successful in both global and regional markets. In other words, we want to verify if there is a relationship between combining different musical genres and success. We do so by answering the following research questions (RQs):

RQ1. Compared to the global scenario, do regional markets present distinct patterns of frequent genre combinations in hit songs?

RQ2. Is it possible to identify and recommend combinations of music genres that are promising and relevant to each market?

Our findings reveal that there is indeed a difference in popular genres across regional markets, and we are able to use such patterns to identify and recommend promising genre combinations for such markets. The remainder of this paper is organized to answer all such questions. We first present relate work in Section 2 and introduce our methodology based on data mining techniques in Section 3. Then, Section 4 details the experimental evaluation and presents the results. Finally, we make our overall considerations on the findings in Section 5.

2. RELATED WORK

Over the years, the number of artists and songs has increased considerably, as have studies on discovering the recipe for turning a song into a hit. Such studies define the area of *Hit Song Science* (HSS), which combines machine learning and data mining techniques with musicology and psychology concepts to verify whether popular songs share similar patterns. The concept of HSS was introduced in 2003 by Polyphonic HMI,[3] and since Dhanaraj and Logan [2005], different studies analyze the impact of acoustic and social characteristics on musical success [Calefato et al. 2018; Cosimato et al. 2019; Silva et al. 2022; Mayerl et al. 2023], some of them including genre information [Abel et al. 2010; Zangerle et al. 2019; Gienapp et al. 2021].

In fact, understanding musical aspects can be genre-dependent, which also reflects in musical success. For example, Ren and Kauffman [2017] aggregate genres in a musical construct vector (MCV) to summarize the acoustic content of a song in a predictive model. Then, Shin and Park [2018] consider genres to understand the life trajectory of songs in Gaon Chart, one of the main Korean music rankings. Furthermore, Ordanini et al. [2018] use genre distance and other variables to demonstrate that artists

[2] *Chromatica* was nominated to Best Pop Vocal Album in the 63rd Grammys (2021).
[3] Polyphonic HMI, Hit Song Science: `http://bit.ly/polyphonic-hmi`

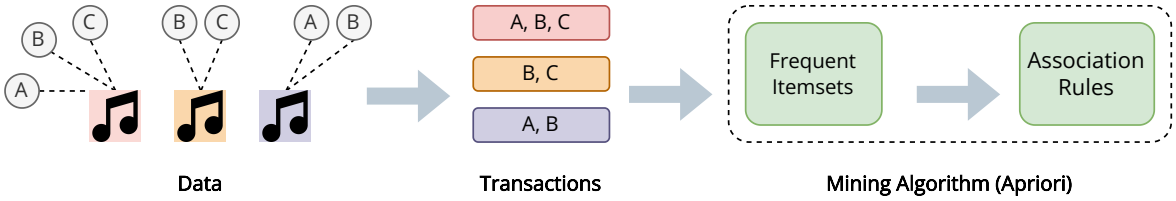

Fig. 1. Methodology used to find frequent and exceptional patterns in hit songs.

who collaborate with artists from other genres are able to achieve a higher level of success in their songs. In addition, data mining techniques have been used in the musical context on recognition of style hierarchies [Iloga et al. 2018] and file indexing by style [Rompré et al. 2017].

Studying musical success from a genre perspective may reveal important information on how artists from different communities try to achieve success. To the best of our knowledge, we are the first to apply data mining techniques to uncover the most frequent and promising genre combinations in hit songs. Considering regional markets makes this work more realistic, as each one behaves in its own distinct way. Thus, our results may enhance further data analysis to guide future song releases.

3. METHODOLOGY

This section presents the methodology used to find both frequent and exceptional patterns in hit songs (Figure 1). We start from a dataset with hit songs of global and regional markets (Section 3.1). Then, we model hit songs as transactions to find frequent itemsets and association rules for each market (Section 3.2). Finally, we present the mining algorithm and the evaluation metrics (Section 3.3).

3.1 Data

In this work, we use the Music Genre Dataset (MGD) [Oliveira et al. 2020] to obtain Spotify success data from 2017 to 2019. Spotify provides a weekly chart of the 200 most streamed songs for each country and territory, as well as an aggregated global chart. This dataset considers the global charts and eight of the top 10 music markets according to IFPI in 2019[4]: United States (#1), Japan (#2), United Kingdom (#3), Germany (#4), France (#5), Canada (#8), Australia (#9), and Brazil (#10).[5] MGD provides the songs that entered in weekly charts for each market and year, as well as acoustic features that describe such songs. In addition, it provides relevant information on the artists who interpret the songs, including the genre list of each one.

Regarding artists' genres, the MGD buiding process contains a preprocessing phase to generate the final genre list. This is because Spotify allows inserting very specific genres for each artist. For example, Shakira is assigned to both *colombian pop* and *pop*, which may be described only by *pop*. Then, the dataset maps all specific genres to more embracing *super-genres*. Overall, MGD contains 1,370 charts from 156 weeks, comprising 13,880 hit songs and 3,612 artists from 896 different music genres mapped into 162 *super-genres*. The dataset is publicly available at Zenodo.[6]

3.2 Modeling Hit Songs as Transactions

In data mining, discovering frequent itemsets and association rules requires a transactional dataset. In such modeling, the dataset instances (i.e., transactions) are composed of a list of items. Here, we

[4]IFPI Global Music Report 2019: `https://gmr.ifpi.org/`
[5]Data from South Korea (#6) and China (#7) was not available as of the collection date.
[6]MGD: `https://doi.org/10.5281/zenodo.4778562`

model an individual transactional dataset for each market and year to find the most frequent genre combinations and association rules. We define each hit song as a single transaction in which the items are the musical genres of the artists who sing it. If a song has more than one artist and they all share a common genre, this genre appears only once in the transaction. Therefore, we are not interested in the number of repeated genres in a song, but in the diversity of different genres that compose it.

For example, consider the remix version of *Despacito* by Luis Fonsi, Daddy Yankee, and Justin Bieber, which spent 16 consecutive weeks in the #1 position on Billboard Hot 100 in 2017. The transaction correspondent to this song comprises the genres of all three artists: *latin*, *tropical*, *pop*, *reggaeton*, and *hip hop*. Besides the fact that *latin* and *tropical* are shared by Fonsi and Yankee and *pop* is shared by Fonsi and Bieber, each genre is counted once. Thus, the final transaction for *Despacito* is represented by the tuple `(hip hop, latin, tropical, pop, reggaeton)`.[7]

3.3 Mining Algorithm and Evaluation Metrics

We focus on finding the most frequent genre combinations by applying a Frequent Itemset Mining (FIM) method from the set of hit songs in each musical market from the Music Genre Dataset (MGD). We do so by running the Python implementation of Apriori,[8] one of the most used state-of-the-art FIM algorithms [Agrawal et al. 1994]. Here, we perform both temporal and regional analyses, running the algorithm separately for each market and year (2017 to 2019). Following the methodology of Section 3.2, we define the transactions of our FIM task as hit songs, whose items are the musical genres of each artist who sing them. As our goal is not to evaluate the period in which each song remained on the charts, they are included only once in the dataset.

Once mined, frequent itemsets can be used to generate Association Rules (AR). An AR is represented by the expression $X \rightarrow Y$ and is composed of an antecedent X and a consequent Y, two disjoint itemsets. It is important to highlight that an AR should not be interpreted as a sign of causality but of co-occurrence between items. Indeed, association rules allow to discover how itemsets are related. To evaluate our frequent itemsets and association rules, we use three classic data mining metrics: relative support, confidence and lift.[9]

Relative Support. It informs the frequency in which an itemset appears on the transactions in a scale from 0 to 1. Then, a relative support of 1 means that an itemset occurs in all transactions.

Confidence. The rule confidence informs the probability of a consequent Y occurring in a transaction given the occurrence of an antecedent X. In other words, it is the frequency in which Y occurs in transactions containing X.

Lift. It is defined as the ratio between the joint probability of X and Y co-occurring and the probability of these sets being independent. It may be used as a measure of surprise within a rule. Therefore, lift shows how much more frequently the consequent Y becomes after the occurrence of the antecedent X. Such a metric is symmetric, and values below 1 mean that the rule occurs less than expected, whereas values above 1 indicate the opposite.

4. RESULTS

This section presents the results and discussions for each analysis carried out to answer our research questions: frequent pattern mining (*RQ1*, Section 4.1) and association rules (*RQ2*, Section 4.2).

[7]Sorted by alphabetical order.
[8]PyFIM: `https://borgelt.net/pyfim.html`
[9]See [Zaki and Meira Jr. 2014] for formal definitions and formulas.

Table I. Top 5 most frequent patterns in global and English-speaking markets (2019).

Market	Pattern	Support	Market	Pattern	Support
Global	('dance pop', 'pop')	0.271	*Australia*	('dance pop', 'pop')	0.294
	('latin', 'reggaeton')	0.173		('rap', 'hip hop')	0.162
	('hip hop', 'trap')	0.172		('electropop', 'pop')	0.145
	('rap', 'hip hop')	0.168		('rap', 'pop rap')	0.145
	('rap', 'trap')	0.151		('pop rap', 'hip hop')	0.131
UK	('dance pop', 'pop')	0.285	*USA*	('hip hop', 'rap')	0.305
	('rap', 'hip hop')	0.159		('trap', 'rap')	0.289
	('tropical house', 'pop')	0.133		('pop rap', 'rap')	0.261
	('tropical house', 'dance pop')	0.127		('trap', 'hip hop')	0.246
	('tropical house', 'dance pop', 'pop')	0.125		('pop rap', 'hip hop')	0.230

4.1 Genre Frequent Patterns

Discovering changes in genre preferences shows the dynamic nature of the music market. As an important cultural artifact, the way music is consumed in different countries may be influenced by language, demographics, and other social aspects. In addition, musicians are naturally venturing into new domains and working outside of the style they had initially emerged from, resulting in a massive variety of new songs and musical tastes. Therefore, in this section, we answer *RQ1* by investigating whether genre combination varies at a country level. That is, we analyze if the association of distinct musical genres in hit songs has specific patterns in global and regional markets.

Overall, as language is crucial for listening to music, we divide our eight regional markets into two distinct groups: English and non-English speaking countries. The former includes Australia, Canada, the United Kingdom, and the United States, while the latter comprises Brazil, France, Germany, and Japan. We then perform our analyses comparing the countries with each other and the patterns found in the global charts, which is an aggregation of all territories in which Spotify is available. Here, we present the results for selected markets and years for readability purposes.

Table I presents the five most frequent genre patterns in hit songs for global and English-speaking markets[10] in 2019. Itemsets are sorted by their relative support value, i.e., their frequency. Regarding the global scenario, there is a strong presence of mainstream genres such as *pop*, *hip hop*, and *rap*. These genres include regional versions of themselves (e.g., *Chicago rap* is within *rap*), which may contribute for their high support values. Besides, the combination of the regional genres *latin* and *reggaeton* appear in 17.3% of all global hit songs, showing their popularization across the world. The latin music expansion began in the early 2000s with artists like Shakira and Ricky Martin, reaching greater popularity in the late 2010s, led by artists such as Bad Bunny, J Balvin, and Karol G.

Analyzing the English-speaking countries individually, we note a high similarity in the popular genre combinations. For instance, the union of *hip hop* and *rap*, which is present in 30.5% of hit songs in the United States, is also relevant in Australia (16.2%), Canada (27.2%) and the United Kingdom (15.9%). All such countries present a strong similarity to the global market, as they share several cultural aspects, including language. Note, English is the most widely spoken language worldwide in terms of number of countries where it is official – 59 countries in all continents.[11]

On the other hand, the analysis of frequent genre patterns for non-English speaking countries reveals a strong regional component in most countries. Table II presents the five most frequent genre associations in 2019 for three countries:[12] Brazil, France, and Japan. All such countries have patterns with regional rhythms, such as *francoton* in France, and *brazilian funk* and *sertanejo* in Brazil. However, Japan stands out in this regard, as all five patterns have regional styles. The main

[10]We do not show data for Canada in Table I since its ranking is similar to the USA. Also, Canada is considered an English-speaking country due to the majority of its population being English speakers, despite its bilingual status.
[11]World Atlas (Access on March 9, 2023): `https://bit.ly/3ePt7CK`
[12]Germany is not shown in Table II as its ranking is similar to Global.

Table II. Top 5 frequent patterns in global and non-English speaking markets (2019).

Market	Pattern	Support	Market	Pattern	Support
Global	('dance pop', 'pop')	0.271	*Brazil*	('brazilian funk', 'pop')	0.177
	('latin', 'reggaeton')	0.173		('electro', 'brazilian funk')	0.102
	('hip hop', 'trap')	0.172		('sertanejo', 'brazilian funk')	0.097
	('rap', 'hip hop')	0.168		('electro', 'pop')	0.080
	('rap', 'trap')	0.151		('trap', 'hip hop')	0.064
France	('hip hop', 'pop')	0.584	*Japan*	('j-rock', 'j-pop')	0.283
	('rap', 'hip hop')	0.449		('other', 'j-pop')	0.140
	('rap', 'pop')	0.423		('anime', 'j-pop')	0.138
	('rap', 'hip hop', 'pop')	0.393		('dance pop', 'pop')	0.133
	('francoton', 'pop')	0.174		('r&b', 'j-pop')	0.108

genres in such a market include *j-pop*, *j-rock* and *anime*. Besides, our results reveal the absence of genres such as *hip hop* and *rap* in Japan, which are present in all other markets. In all four countries, the presence of local genres increased over time, revealing a tendency of the population to value their own culture and consequently promote it globally.

4.2 Recommending Promising Genre Associations

Using the data mining framework offers a wide range of possibilities to perform descriptive analyses in datasets [Fontes et al. 2019; Melo et al. 2021]. For instance, the frequent genre patterns mined in Section 4.1 can be used to uncover association rules, which inform how items (i.e., music genres) are associated with each other. In this section, we answer *RQ2* by using such rules to detect and recommend outstanding genre associations. We define promising rules according to their lift value, and as we aim to find the most promising genre associations, we look for rules with high lift values. Here, we still perform an individual analysis for each music market and year, using the Apriori algorithm to find the relevant rules.

Table III presents the three most promising rules for each market in 2019. We sort the rules by their lift values, but we also present the confidence value to enrich our analyses. The results for the global market reveal the strong association of regional genres such as *latin*, *reggaeton*, and *tropical*. Analyzing the lift value for the first rule, we can affirm that the occurrence of the genre *tropical* when *latin* and *reggaeton* co-occur in a hit song is almost eight times than the expected. Such a result indicates that adding *tropical* in songs containing *latin* and *reggaeton* may increase in up to 7.922 times the chances of reaching the Top 200 chart. Besides, the rule confidence informs that *tropical* is present in 46.8% of the transactions (i.e., hit songs) that contain *latin* and *reggaeton*. Indeed, Latin musical genres had a boom in 2019, following the continuous growing trend observed in the late 2010s. Despite not achieving the #1 position as Luis Fonsi and Daddy Yankee did in 2017 with *Despacito*, artists such as Karol G, Bad Bunny, Ozuna, and J Balvin expressed the power of such genres, as they managed to put two or more songs in the charts.

We also note the presence of local genres in outstanding association rules, mainly in non-English speaking countries. For instance, *francoton* is associated with *rap* and *pop* in France, whereas the probability of *j-rap* occurring is eight times higher given the presence of *r&b* in Japanese hit songs. In Brazil, the genre *pagode baiano* (consequent) appears on 42.5% of the songs containing *brazilian funk* and *pop* (antecedent). In addition, the occurrence of the antecedent of such a rule increases more than five times the chances of the consequent in Brazilian hit songs. Thus, combining such genres increases considerably the chances of a song to reach Brazilian charts. The singer-songwriter Anitta is an example of such an effect, as her music style list includes all three genres aforementioned. She is one of the most popular artists in the country, and her singles *Onda Diferente* (with Ludmilla) and *Combatchy* (with Lexa, Luísa Sonza, and MC Rebecca) contributed to the high relevance of associating such music genres.

Overall, association rules are a powerful tool to understand musical success, as they reveal the level

Table III. Association rules in global and regional markets sorted by lift value (2019).

Market	Rule	Lift	Confidence
Global	('latin', 'reggaeton') → tropical	7.922	0.468
	('latin') → tropical	7.821	0.462
	('reggaeton') → tropical	7.722	0.456
Australia	('tropical house') → house	7.655	0.342
	('tropical house', 'pop') → house	7.173	0.321
	('tropical house', 'pop') → electro	7.111	0.670
Brazil	('hip hop') → trap	6.187	0.434
	('brazilian funk', 'pop') → pagode baiano	5.473	0.425
	('hip hop') → pop rap	5.235	0.303
Canada	('r&b') → soul	7.485	0.226
	('dance pop') → tropical house	3.214	0.243
	('dance pop', 'pop') → tropical house	3.160	0.239
France	('rap', 'pop') → hip hop	1.301	0.900
	('rap', 'pop') → francoton	1.263	0.325
	('hip hop', 'pop') → rap	1.259	0.796
Germany	('dance pop') → tropical house	5.909	0.400
	('dance pop') → electro	5.908	0.338
	('dance pop', 'pop') → tropical house	5.824	0.394
Japan	('r&b') → j-rap	8.067	0.228
	('dance pop') → electro	4.348	0.283
	('dance pop', 'pop') → electro	4.284	0.279
UK	('rock') → indie rock	8.370	0.364
	('rock') → indie	6.216	0.231
	('pop rap', 'hip hop') → trap	5.682	0.660
USA	('pop rap', 'pop', 'rap') → r&b	2.990	0.291
	('pop', 'rap') → r&b	2.888	0.281
	('hip hop', 'pop') → r&b	2.878	0.280

of combination between musical genres in global and regional markets. Similar to the previous sections, local genres play a fundamental role in regional markets, reinforcing their distinct cultural identities. Besides, using lift values to evaluate rules allows recommending promising genre combinations based on their high association level. Such an approach provides considerable benefits to artists, as they can plan their subsequent releases by choosing artists from genres with a high level of association with their own to collaborate. In addition, record labels may use our findings to diversify their set of artists and promote collaborations with high potential of success between them. Indeed, music is a dynamic and unpredictable industry, but this strategy may help guide artists and record labels to develop approaches to achieve success and increase their numbers.

5. CONCLUSION

In this paper, we investigate the relation between the combination of different musical genres and success under a data mining perspective. Using data from the Music Genre Dataset, which contains Spotify chart information from several markets, we perform descriptive analyses to identify frequent genre combinations and exceptional subgroups in genre collaboration networks. We conducted temporal analyses for both global and regional markets, i.e., we run the data mining algorithms individually for each market and year (2017 to 2019). Such an approach is helpful to reveal the evolution of musical tastes over time and show how cultural aspects shape local music markets. We address such an objective by answering two research questions (RQs).

After modeling hit songs as transactions in which the items are their musical genres, our results reveal that there is indeed a difference in popular genre patterns in regional markets, mainly in non-English speaking countries. In addition, we mined association rules to recommend promising genre combinations based on their level of surprise. Again, we found that local genres play a fundamental role in regional markets as they are included in most of the relevant associations.

In conclusion, performing diagnostic analyses is crucial in music, as it allows the understanding of some relevant aspects behind success. Following the findings from previous chapters, our results reinforce the importance of analyzing regional markets, as they behave differently compared to the global scenario or even to the United States (i.e., the biggest music market in the world). For example, in the past few years, the world has seen local genres such as *reggaeton* and *k-pop* becoming extremely popular worldwide. Therefore, our findings provide benefits to artists and record labels, as they serve as a first step in developing strategies to promote their work across the world.

Limitations and Future Work. One limitation of this work is that we do not consider how many times a hit song appears in the charts when building our transactional database. Such a strategy would emphasize the genre frequency but, on the other hand, the distinctness of hit songs would be lost. In addition, we do not use the position in the charts in our analyses. Thus, songs that reached the Top 10 are treated equally to songs from the bottom of the charts. Further experiments must evaluate the impact of such information in genre popularity compared to the analyses already performed here.

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