WHAT MAKES SONGS POPULAR NOWADAYS?:
HOW AUDIO FEATURES AFFECT SONG POPULARITY

Soomin Kim | Department of Quantitative Social Science | Dartmouth College

LITERATURE REVIEW

- Chances are high that you've had songs stuck in your head. What makes certain songs more favorable than others?
- With the proliferation of online music streaming services, a novel field of study Music Information Retrieval (MIR) emerged. An active research topic in this field, Hit Song Science, aims to "predict the success of a song before they are release to the market" based on its audio features (Pachet and Sony 2012)
- Drawing on HSS, previous studies have shown optimistic results on the feasibility of predicting popularity based on its audio features (Ni et al. 2011) (Lee and Lee 2015) (Herremans et al. 2014). However, these studies had limited sample size and narrowed focus on chart rankings.
- This project aims to use a large-scale dataset and analyze songs both on- and off-charts to minimize selection bias and gain a more comprehensive understanding on how audio features affect a song's popularity.

DATA

- Dataset was curated from 300+ Spotify playlists (34,355 songs) across various times and genres using the Spotify Web API.
- **Primary Independent Variables (IV) of Interest:**
  - **Danceability:** a measure of the suitability of a track for dancing
  - **Speechiness**: a measure of spoken words in a track
  - **Valence:** a measure of the musical positiveness conveyed by a track
  - **Energy**: a perceptual measure of intensity and activity
  - **Loudness**: the overall loudness of a track in decibels (dB)
  - **Decades:** decade of song release, 1950s-2020s
  - **Key:** the key and mode of the track is in (i.e. C)
  - **Tempo:** a measure of track's beats per minute (BPM) categorized into three levels - slow, medium, fast
- **Dependent Variable (DV):**
  - **Popularity:** a measure of *current* popularity of a track (extracted as of Feb 2020)

QUESTION & HYPOTHESIS

Question
How do song's audio features affect its popularity *nowadays*?

Hypothesis:
- **H1:** The higher the danceability, the greater the popularity
- **H2:** The higher the speechiness, the greater the popularity
- **H3:** The higher the valence, the greater the popularity
- **H4:** The higher the energy, the greater the popularity
- **H5:** The greater the loudness, the greater the popularity
- **H6:** The more recent the songs, the greater the popularity
- **H7:** Songs in C major are most likely to be popular
- **H8:** The faster the tempo, the greater the popularity

METHOD

Multivariate Linear Regression to assess whether the predictor variables (IV) explain the DV, song's popularity:
- IV: Danceability, Speechiness, Valence, Loudness, Energy, Duration, Liveness, Acousticness, Tempo, Decades, Key
  - This combination of IVs gave the highest R-squared value, meaning most variance was explained by this model
- DV: Popularity

Checking Model Assumptions
- Linearity of the data - linear relationship between the DV and each IV observed.
- Normality of residuals - normally distributed.
- The Breusch-Pagan Test to check heteroskedasticity
  - variances were unequal for at least two groups. But statistically significant variables remained the same between heteroskedasticity-consistent SE with original SE. So kept the original SE.
- Tested for multicollinearity across IVs: VIF < 10, so did not exist

RESULTS

	Dependent variable: Change in Pr(Song Popularity)
Danceability	0.274***
	(0.014)
Speechiness	0.190***
	(0.049)
Valence	-0.134***
	(0.009)
Loudness	1.804***
	(0.084)
Energy	-0.117***
	(0.015)
Duration	0.048***
	(0.004)
Slow Tempo	2.528***
	(0.457)
Fast Tempo	1.670***
	(0.413)
2000s	-13.666***
	(2.262)
2010s	-8.690***
	(2.253)
F minor	3.391***
	(1.029)
Constant	46.338***
	(3.032)
Observations	20,547
R2	0.107
Adjusted R2	0.105
Residual Std. Error	23.215 (df = 20506)
F Statistic	61.167*** (df = 40; 20506)
Note:	***p < 0.01

Table 1: Change in Pr(Song Popularity) based on statistically significant audio features (p<0.01). Note: the baselines for factor variables decades, keys, and tempo are the 1950s, C Major, and medium tempo, respectively.

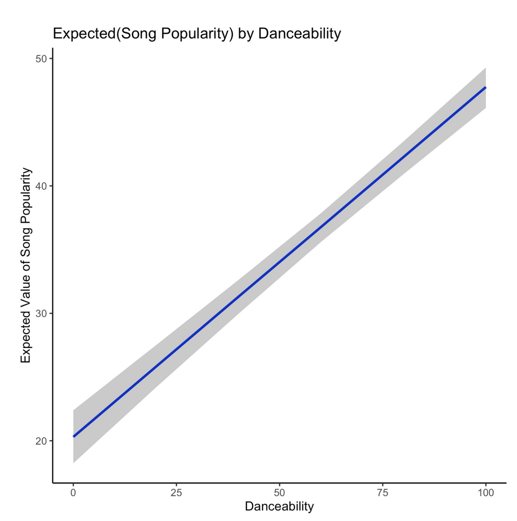

Figure 1: Graph showing the expected values of song popularity by a function of its danceability, including the 95% confidence intervals.

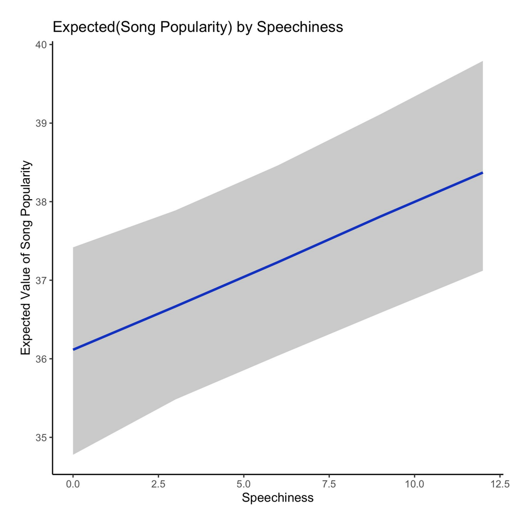

Figure 2: Graph showing the expected values of song popularity by a function of its speechiness, including the 95% confidence intervals.

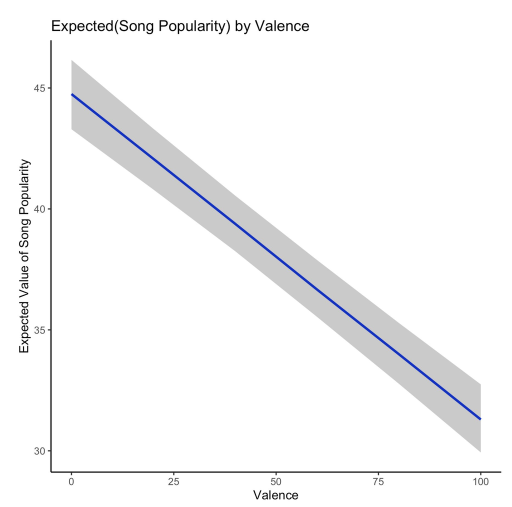

Figure 3: Graph showing the expected values of song popularity by a function of its valence, including the 95% confidence intervals.

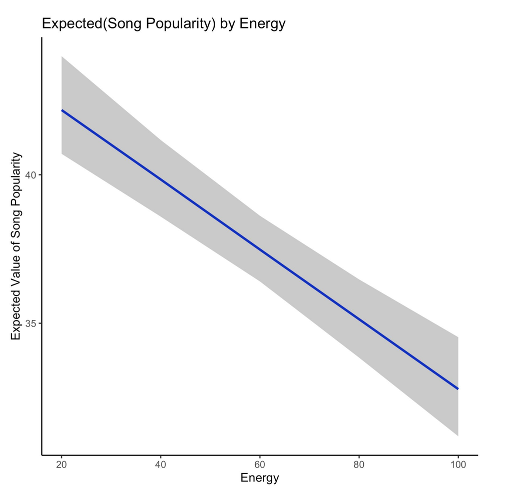

Figure 4: Graph showing the expected values of song popularity by a function of its energy, including the 95% confidence intervals.

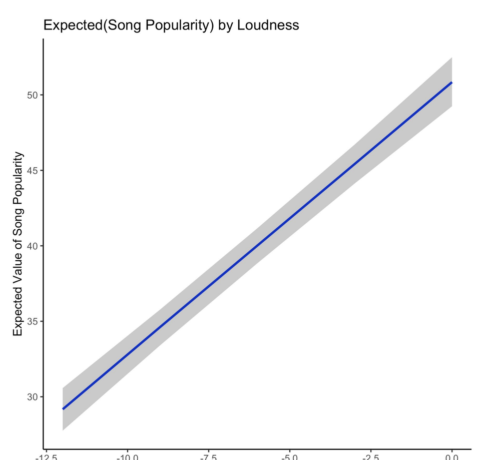

Figure 5: Graph showing the expected values of song popularity by a function of its loudness, including the 95% confidence intervals.

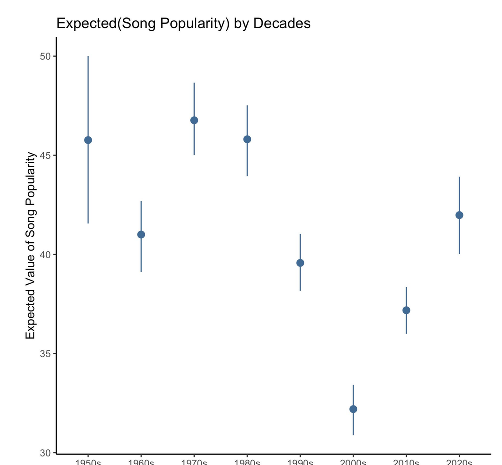

Figure 6: Graph showing the expected values of song popularity at each decade from the 1950s till 2020s, including the 95% confidence intervals.

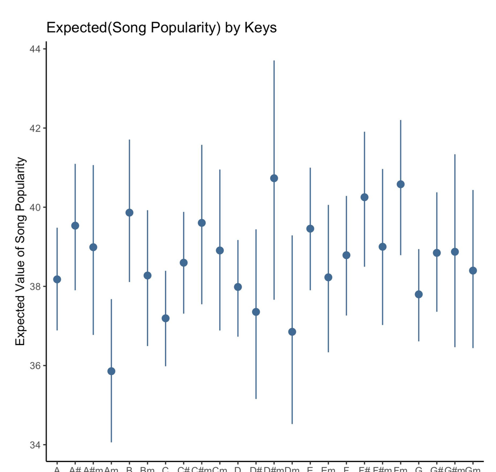

Figure 7: Graph showing the expected values of song popularity by a function of its key, including the 95% confidence intervals. Note: letter 'm' next to key names indicates minor mode.

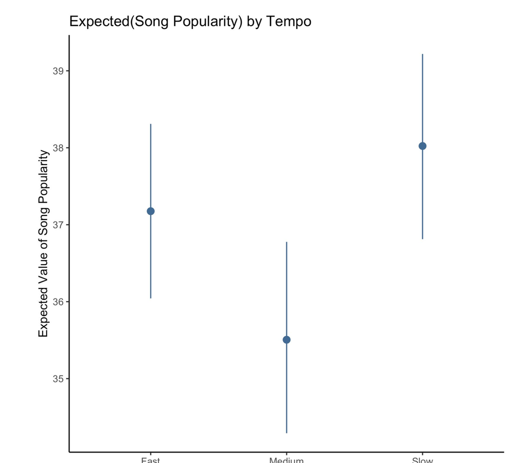

Figure 8: Graph showing the expected values of song popularity by a function of its tempo, including the 95% confidence intervals.

- Statistically significant (p<0.01) *continuous* predictors of song popularity (Table1):
  - (o) danceability, loudness, speechiness, valence, energy, and duration.
  - (x) liveness and acousticness
- Statistically significant (p<0.01) *categorical* predictors of song popularity (Table 1):
  - slow tempo and fast tempo (compared to medium tempo)
  - 2000s and 2010s (compared to 1950s)
  - F minor key (compared to C major)
- Tested hypotheses using the Zelig function (figures 1-6) by specifying quantities of interest (expected values or first differences) for the statistically and substantively significant predictors of popularity:
  - As a song's danceability increases from 0 to 100, its popularity also increases, proving H1 (Figure 1).
  - As a song's speechiness increases from 0 to 12, its popularity increases, proving H2 (Figure 2).
  - As a song's valence increases from 0 to 100, its popularity decreases, disproving H3 (Figure 3).
  - As a song's energy increases from 20 to 100, its popularity decreases, disproving H4 (Figure 4).
  - As a song's loudness increases from -12 to 0 dB, its popularity increases, providing H5 (Figure 5).
  - Song's popularity varies by decade (no observed linear relationship). Though songs released most recently (2020s) show high expected values of song popularity, songs of 1950s, 1970s and 1980s show even greater expected values of popularity, disproving H6 (Figure 6).
  - C major does not have the highest expected value of song popularity, disproving H7 (Figure 7).
  - While fast songs are more likely to be popular than medium tempo songs, they are less likely to be popular than slow songs. This disproves H8 (Figure 8).

CONCLUSION

Popular songs nowadays tend to be:
- More danceable, negatively-oriented, contain more spoken words, loud, low in energy.
- Recently released songs are not necessarily more popular
- Most frequently used key (C major) is not necessarily associated with song popularity
- Fast songs (BPM>120) and slow songs (BPM<102) tend to be more popular than medium tempo songs (102<BPM<121).

Limitations and Further Studies:
- Potential sample bias - though a larger dataset, songs were not equally drawn across different genres, topics, release years. Evident by a few largely skewed IVs, which may not have been representative of its population. Random sampling from an even larger dataset with relatively equal selection of tracks across various factors may lead to more reliable and valid results.
- Tempo variable was re-coded into a category variable based on my own estimation of 'fast', 'medium', and 'slow' tempo based on speculative music theory. Future studies may undergo a more rigorous academic examination on the classification of tempo into distinct categories to ensure a more robust tempo predictor in explaining the popularity of songs.

References
Herremans, Dorien, David Martens and Kenneth Sörensen. 2014. "Dance Hit Song Prediction." ArXiv abs/1905.08076.
Lee, Junghyuk, and Jong-Seok Lee. 2015. "Predicting Music Popularity Patterns Based on Musical Complexity and Early Stage Popularity." Proceedings of the Third Edition Workshop on Speech, Language & Audio in Multimedia.
Pachet, Francois and Sony, CSL. 2012. "Hit song science," Music data mining, pp. 305–26.
Ni, Yizhao, Raúl Santos-Rodriguez, Matt McVicar and Tijl De Bie. 2011. "Hit Song Science Once Again a Science?"
Spotify. "Get Audio Features for a Track." 2020. *Spotify for Developers*.