Bayesian Approach to Inferring a Song's Decade

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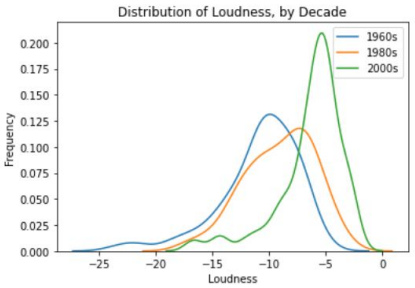
Motivation: Can we infer a song's decade with certainty?

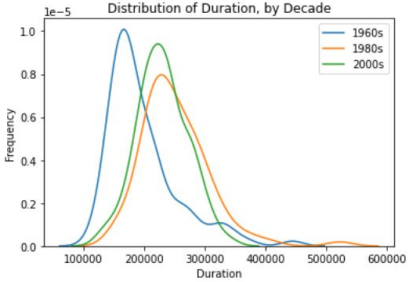
Source: Spotify

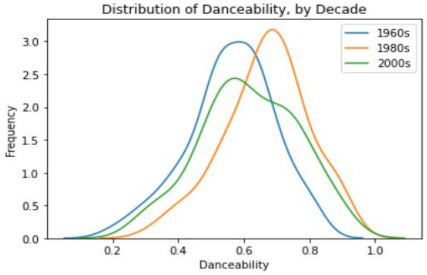
danceability	energy	loudness	speechiness	acousticness	instrumentalness	liveness	valence	tempo	duration_ms
0.437	0.940	-6.946	0.0426	0.05240	0.000573	0.2220	0.480	151.417	212013
0.692	0.422	-10.533	0.0333	0.08110	0.000000	0.0848	0.468	74.375	193120
0.565	0.764	-9.430	0.0351	0.01390	0.004880	0.0790	0.686	100.891	277480
0.851	0.406	-11.631	0.0661	0.21900	0.000006	0.0853	0.792	97.840	226880
0.768	0.829	-5.109	0.0313	0.09640	0.000029	0.0970	0.962	118.773	234333
...	...	...	...	...	...	...	...	...	...
0.642	0.289	-9.918	0.0367	0.66900	0.000000	0.1800	0.407	84.996	258373
0.624	0.819	-4.697	0.0416	0.00575	0.000105	0.2560	0.545	122.064	204773
0.656	0.884	-4.748	0.0372	0.01620	0.000000	0.1440	0.860	105.009	240307
0.681	0.627	-5.456	0.0403	0.49900	0.000001	0.1230	0.494	99.908	164093
0.393	0.633	-4.769	0.0275	0.03390	0.000000	0.1040	0.382	174.022	252440

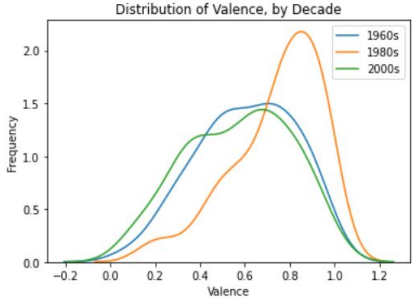
Data accessed via API: https://developer.spotify.com/documentation/web-api/

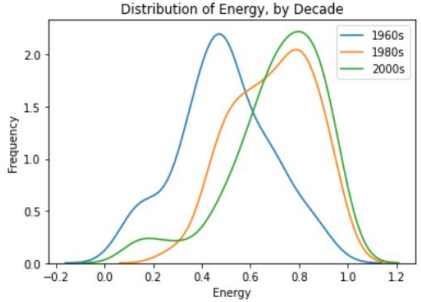
Data Exploration

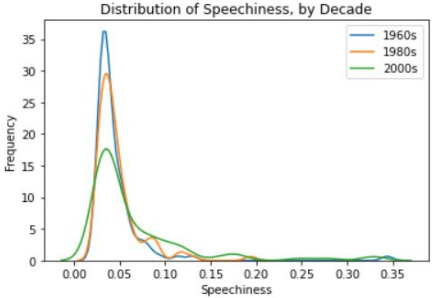


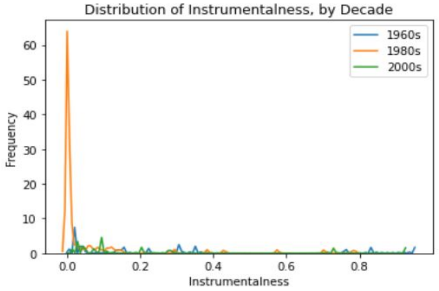


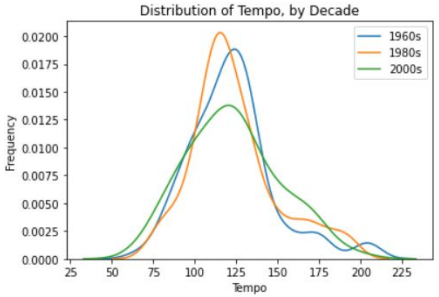


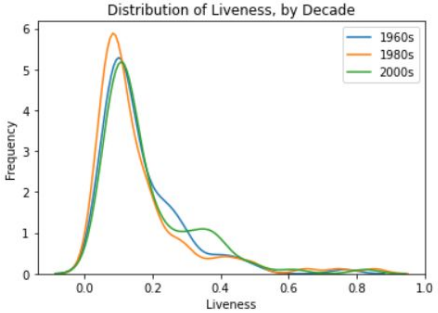


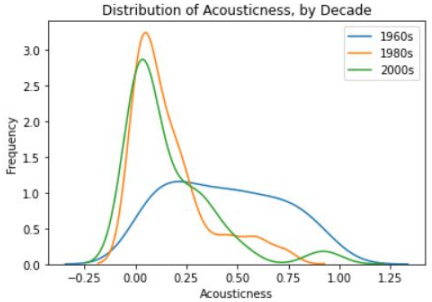












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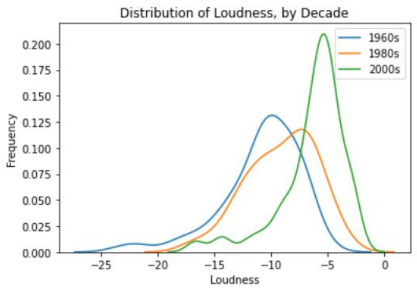

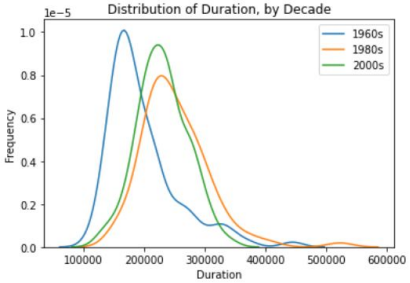

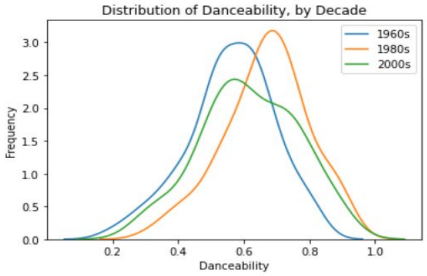

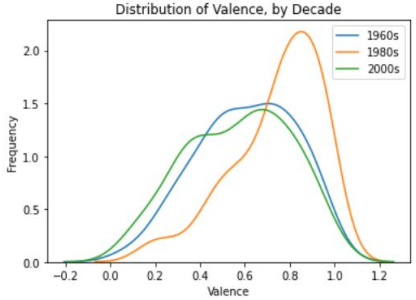

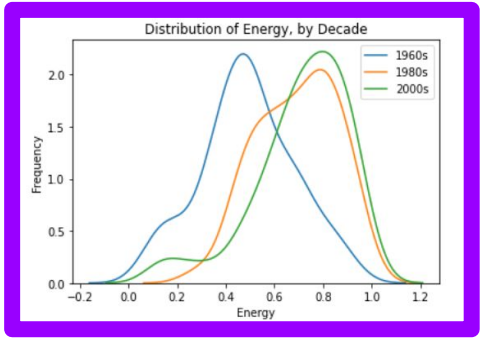

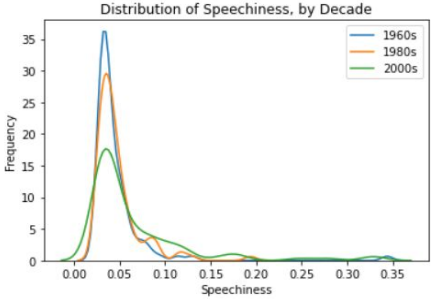

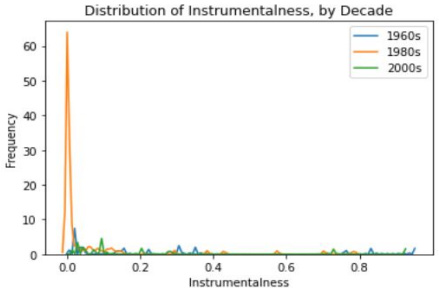

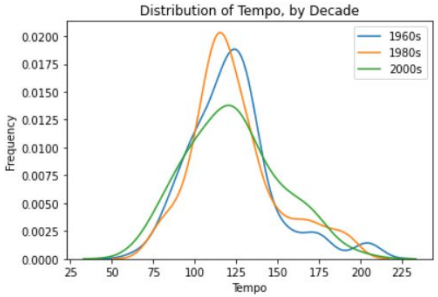

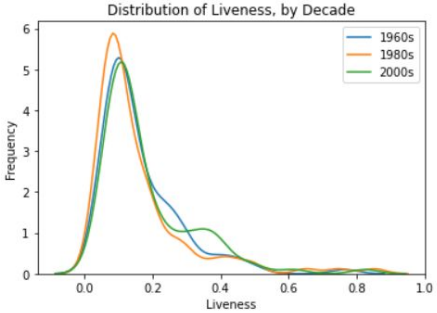

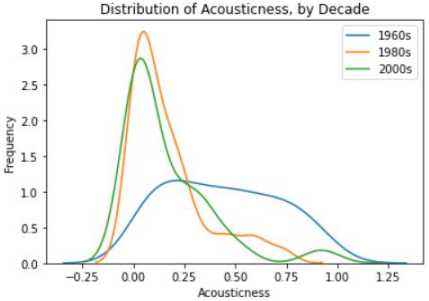

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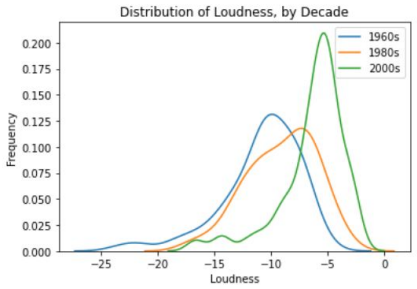

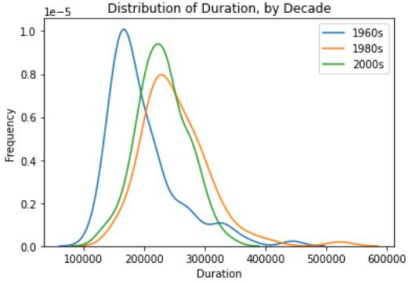

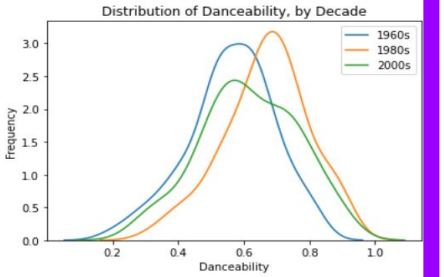

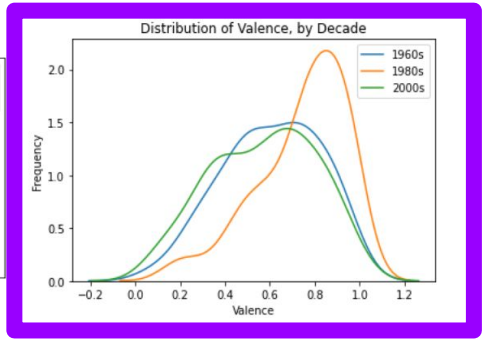

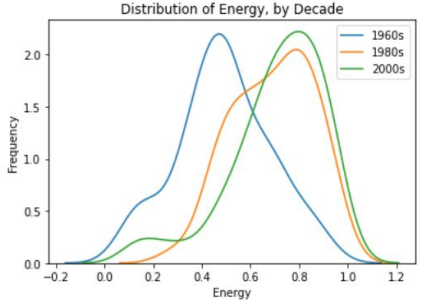

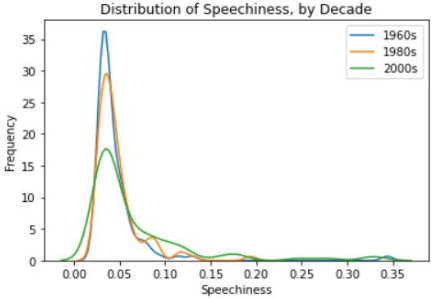

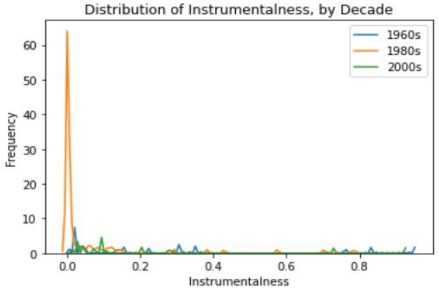

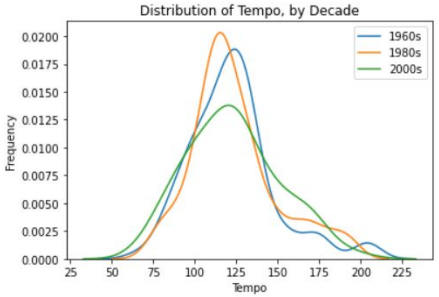

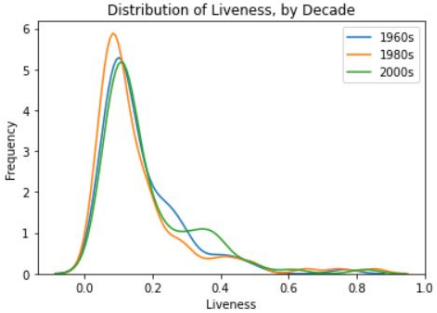

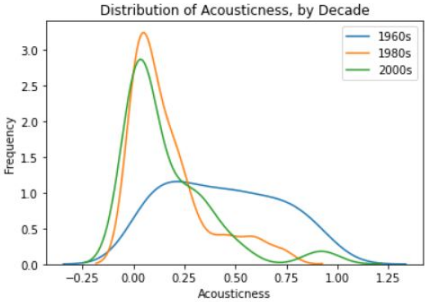

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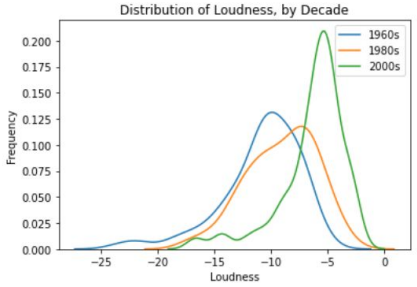
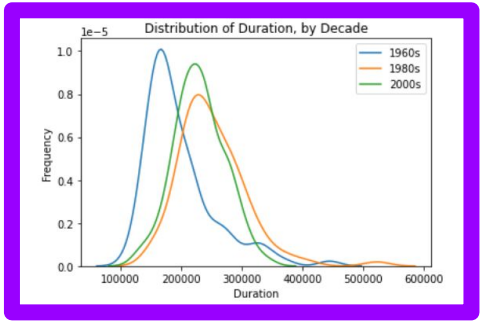
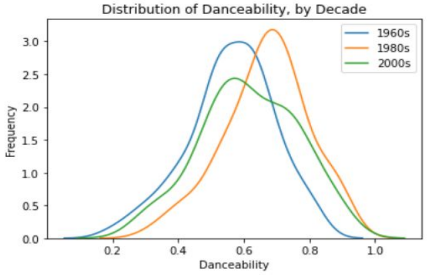
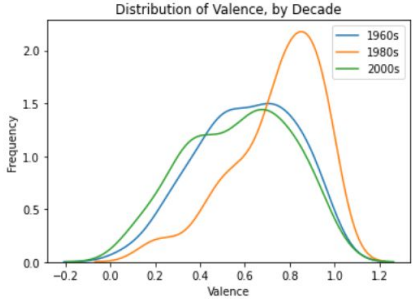
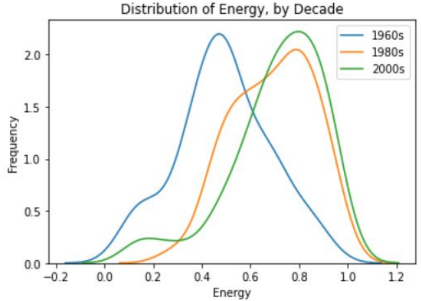
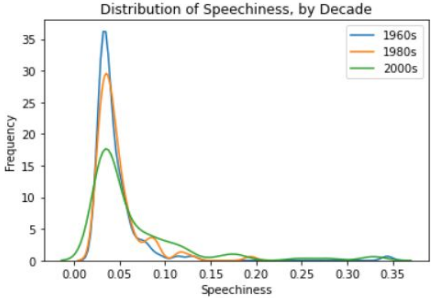


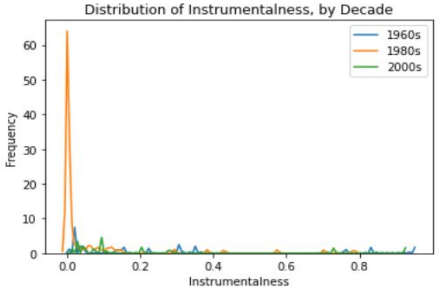


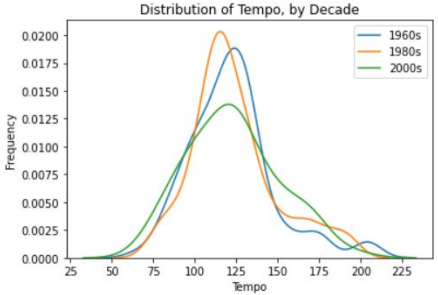


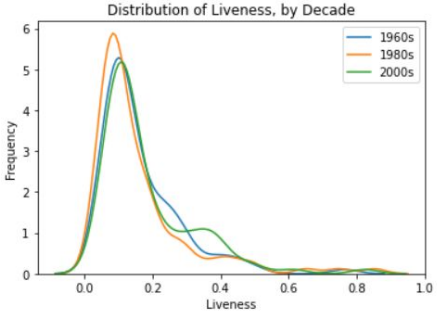


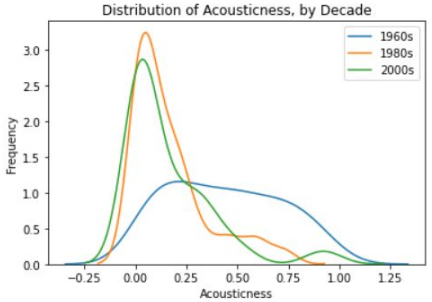






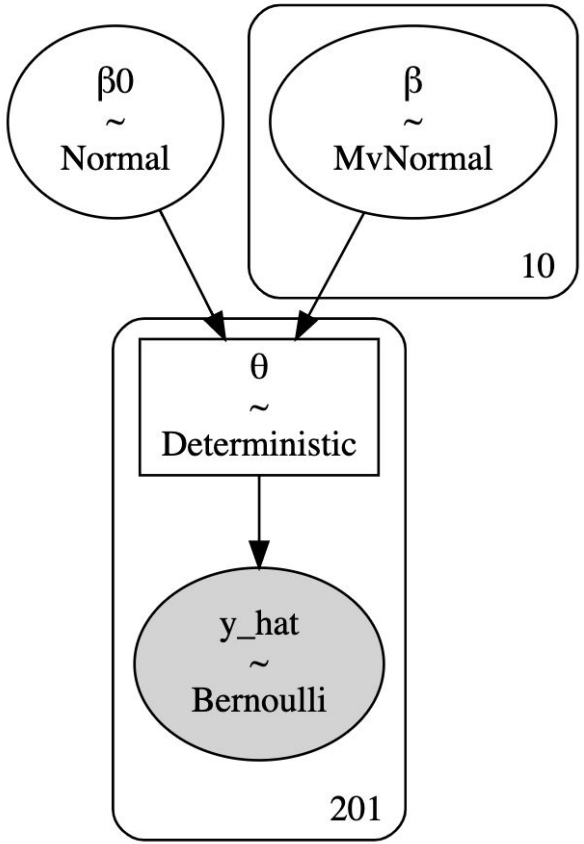






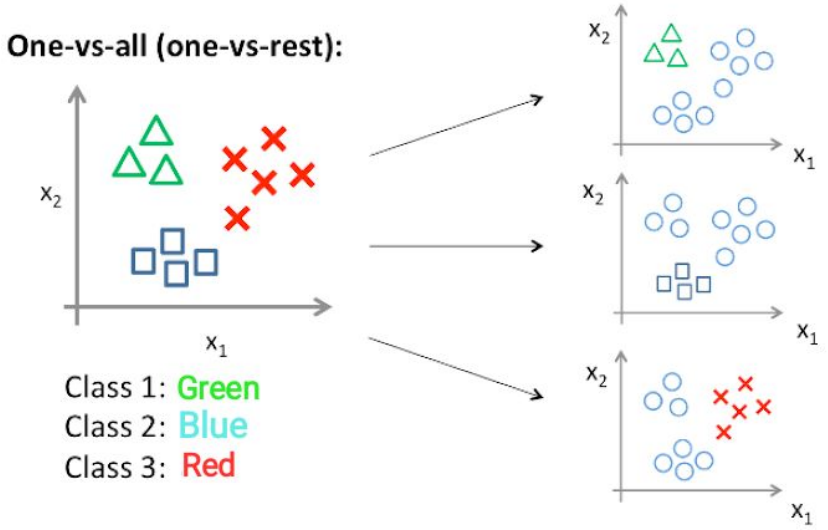
Priors and Sampling

- Gaussian priors on parameters
- Used sampling with PyMC3 to obtain posteriors



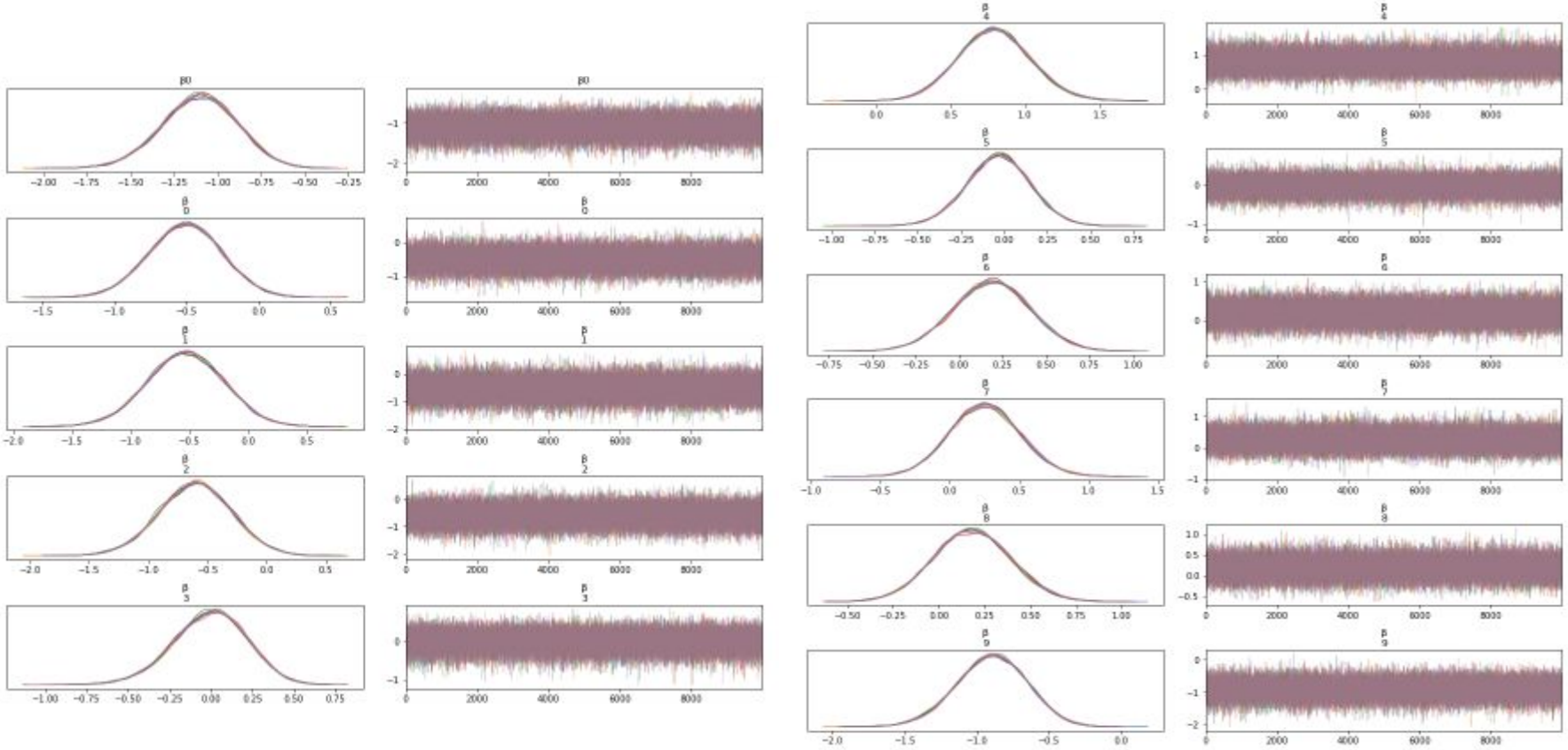
One vs. Rest

- Used logistic regression with One vs. Rest for classification
- Three models: One per decade



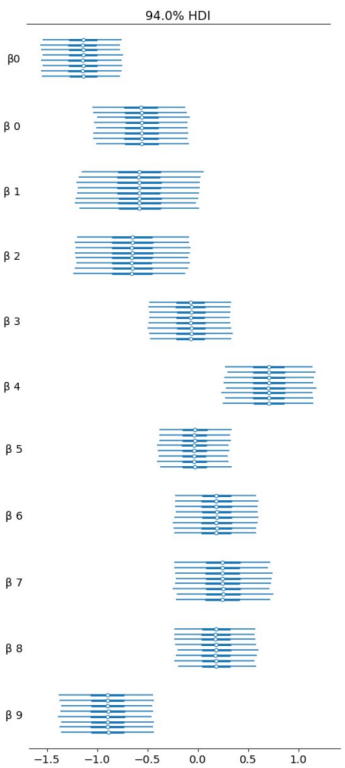
Source: cc.gatech.edu

Convergence of Posterior Distributions

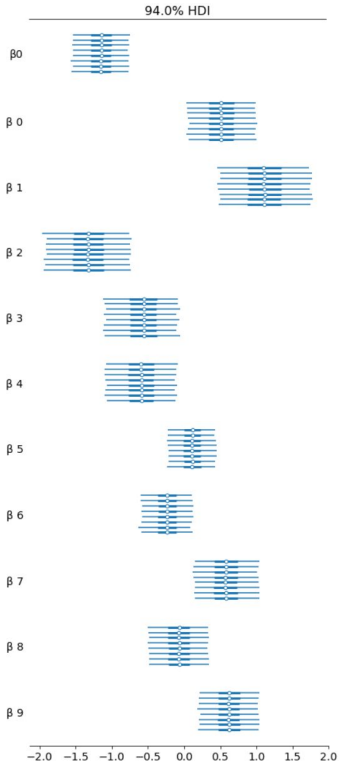


Uncertainty in Predictor Variables

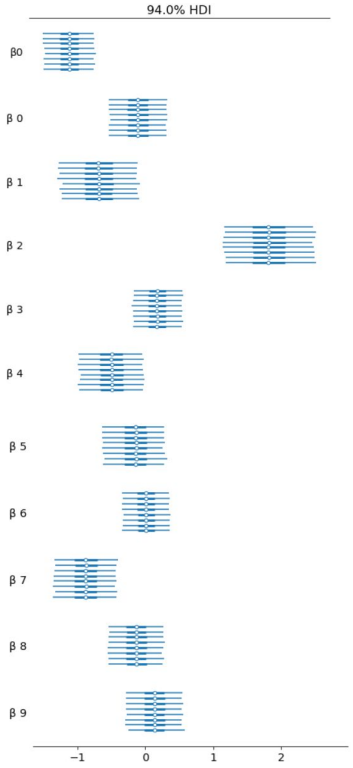
60s Model



80s Model



00s Model



Uncertainty in Predictor Variables

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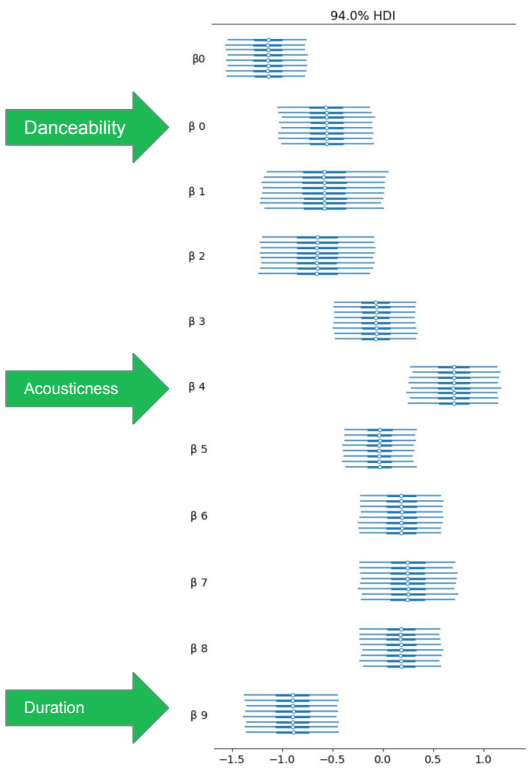

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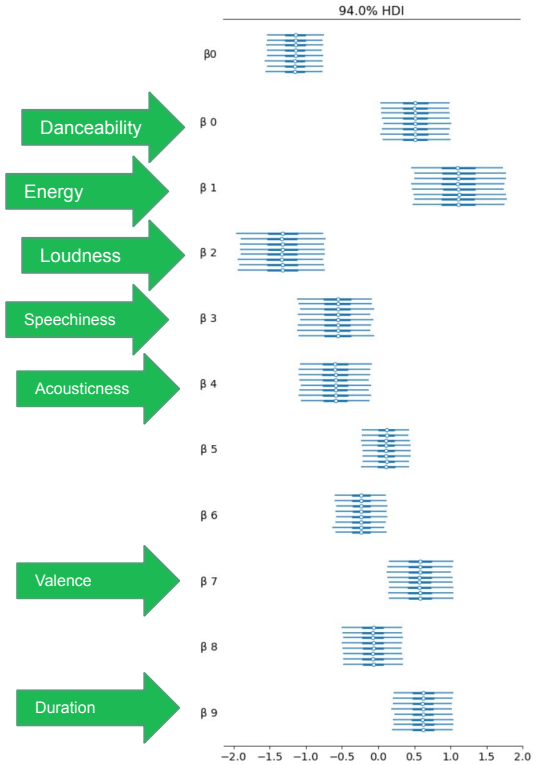
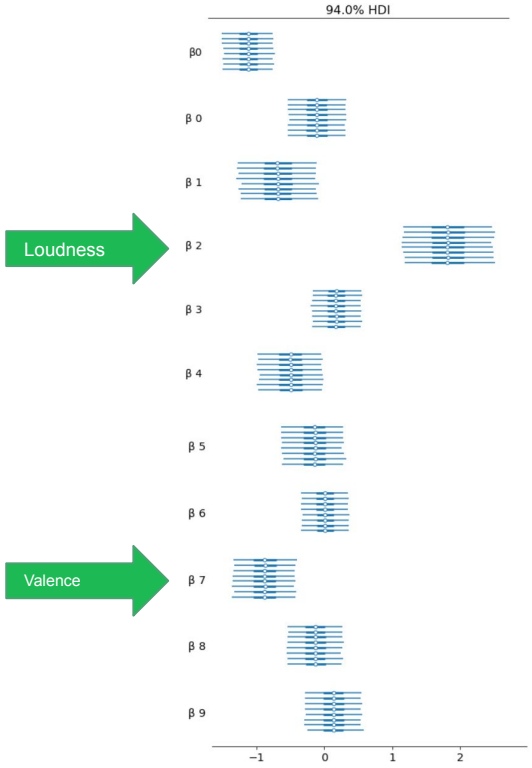


00s Model



Model Results and Conclusions

Predictions based on Bayes Optimal Classifier:

$$\frac{f(X|G=g_i)}{f(X|G=g_j)} > \frac{Pr[G=g_j]}{Pr[G=g_i]}, j \neq i$$

Predicted Decade

True Decade		60s	80s	00s	Recall
	60s	**23**	4	5	71.9%
	80s	5	**28**	5	73.7%
	00s	4	4	**21**	72.4%
	Precision	71.9%	77.8%	67.7%	**72.7%**

Key Findings:

1. Uncertainty and significant variables **depend on the musical trends** for the decade
2. 80s model includes **more significant variables** and has **higher precision**
3. Increasing sample size may **decrease bias**

References:

- https://developer.spotify.com/documentation/web-api/
- https://towardsdatascience.com/multi-class-classification-one-vs-all-one-vs-one-94daed32a87b