Tunes Over Time

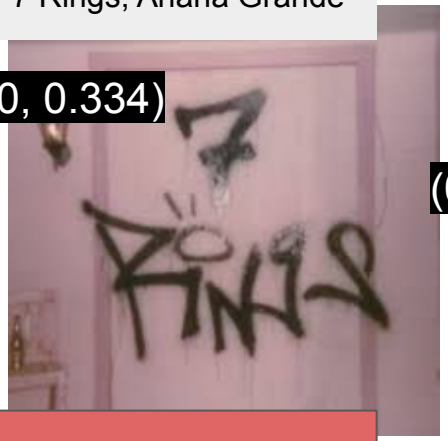
CS1951A | Summer 2021 | SMAK

Sophia Liu, **M**andy He, **A**nnabeth Stokely, **K**iera Walsh

What are We Doing?

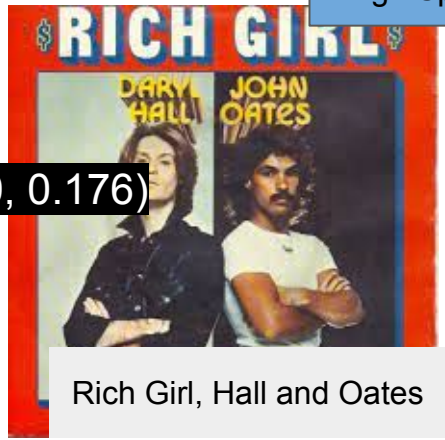

```
{
    "audio_features": [
        {
            "danceability": 0.808,
            "energy": 0.626,
            "key": 7,
            "loudness": -12.733,
            "mode": 1,
            "speechiness": 0.168,
            "acousticness": 0.00187,
            "instrumentalness": 0.159,
            "liveness": 0.376,
            "valence": 0.369,
            "tempo": 123.99,
            "type": "audio_features",
            "id": "4JpKVNYnVcJ8tuMKjAj50A",
```

7 Rings, Ariana Grande



(0, 0.334)

High Speechiness



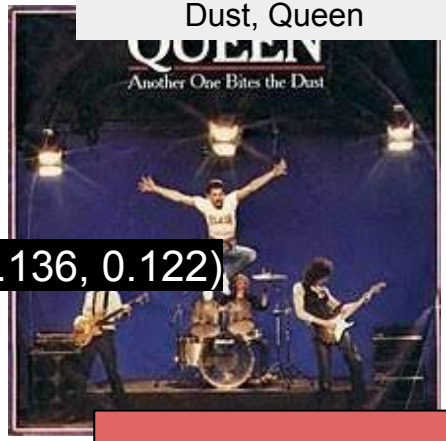
(0, 0.176)

Rich Girl, Hall and Oates

(0.128, 0.156)

Turn Down for What, DJ Snake and Lil Jon

Another One Bites the Dust, Queen



(0.136, 0.122)

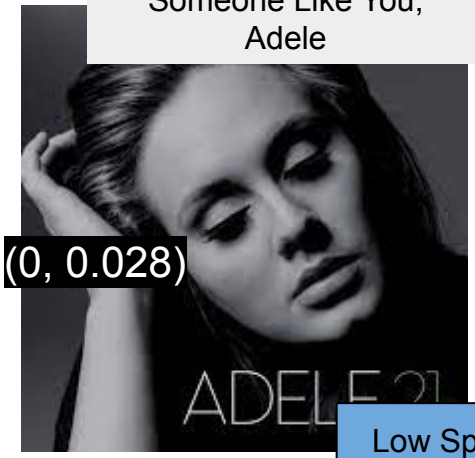
Low Instrumentalness

High Instrumentalness

(0, 0.025)

Hey Jude, The Beatles

Someone Like You, Adele



(0, 0.028)

Low Speechiness

Pumped Up Kicks, Foster and the People

(.155, .029)

(.0181, .023)

Don’t You (Forget About Me), Simple Minds

Hypothesis

Popular songs from 1990s-2010s have a higher speechiness and a lower instrumentalness than popular songs from 1960s-1990s

We collected data from two sources:

Kaggle and Spotify

1) Kaggle Dataset

Billboard "The Hot 100" Songs
Dhruvil Dave

# rank	song	artist	# last-week	# peak-rank
1	Butter	BTS	1	1
2	Good 4 U	Olivia Rodrigo	2	1
3	Levitating	Dua Lipa Featuring DaBaby	4	2
4	Kiss Me More	Doja Cat Featuring SZA	3	3
5	Montero (Call Me By Your Name)	Lil Nas X	8	1
6	Bad Habits	Ed Sheeran	5	5
7	Leave The Door Open	Silk Sonic (Bruno Mars & Anderson .Paak)	6	1

2) Spotify API


```
{
    "audio_features": [
        {
            "danceability": 0.808,
            "energy": 0.626,
            "key": 7,
            "loudness": -12.733,
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            "valence": 0.369,
            "tempo": 123.99,
            "type": "audio_features",
            "id": "4JpKVNYnVcJ8tuMKjAj50A",
```
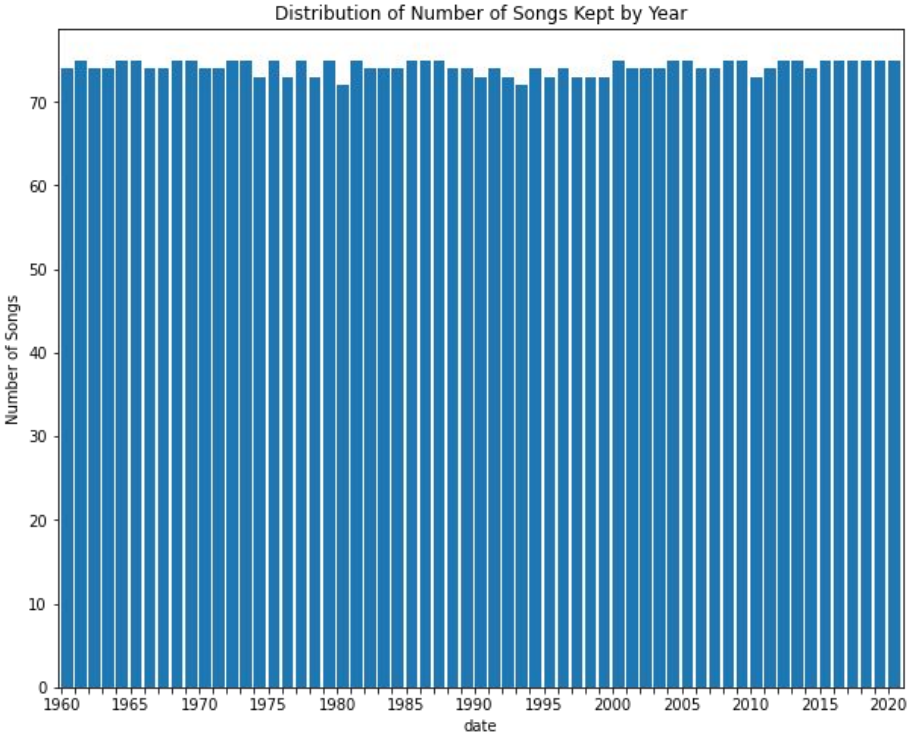
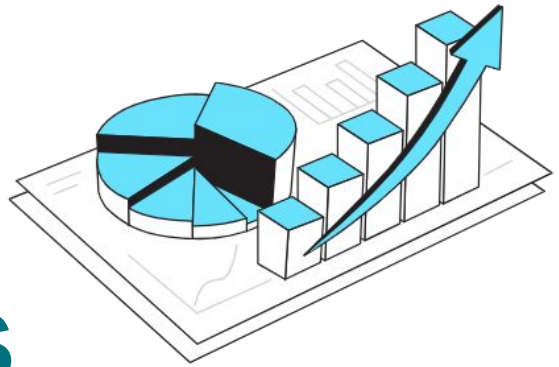

Assumptions/Limitations

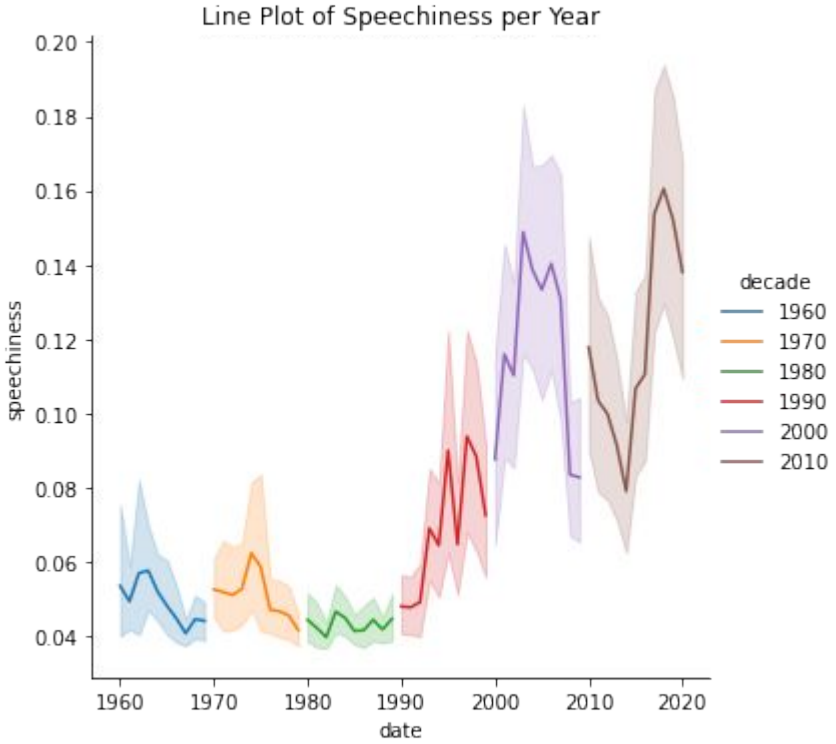
- Only popular songs in the USA
- Only analyzing songs on Spotify
  - 56 out of 4,725 songs removed
    - <= 3 songs removed per year
    - No artist removed an abnormal amount of times
- Determining popularity
  - Not accounting for popularity on other platforms

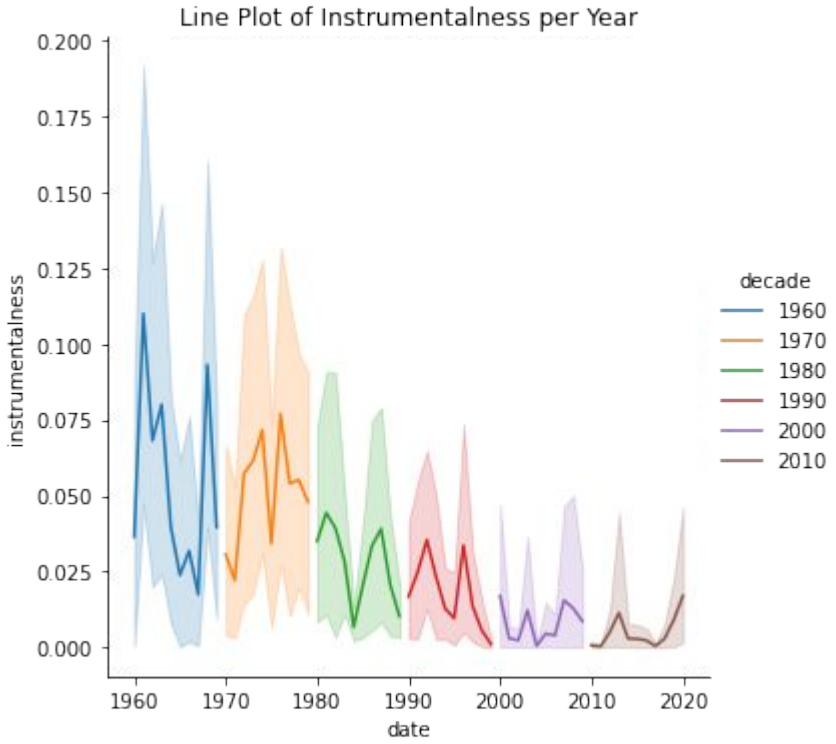


Visualizing the Trends of Speechiness + Instrumentalness



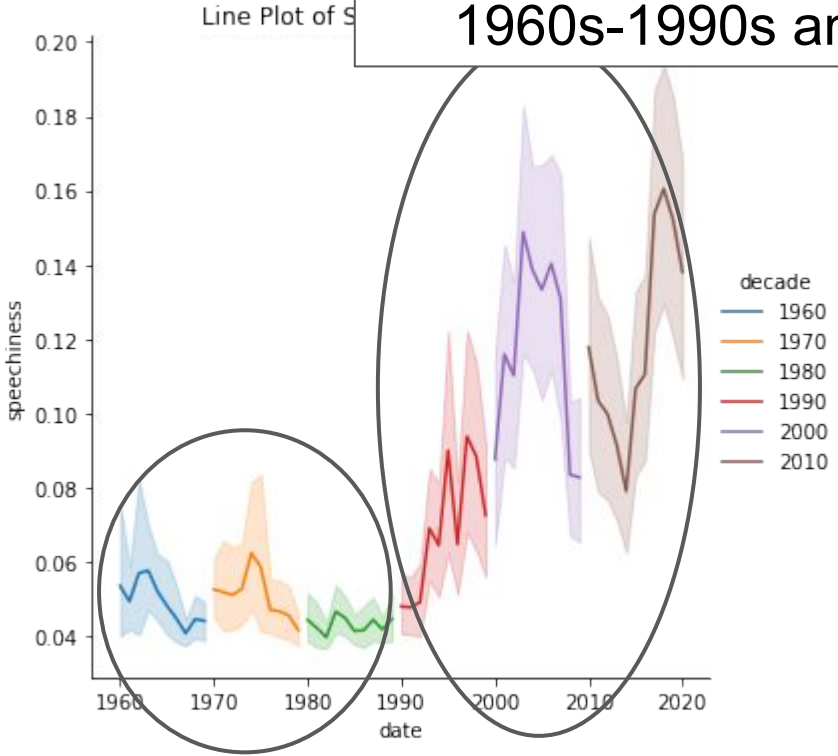
Are there differences between decades in terms of speechiness and instrumentalness of songs?

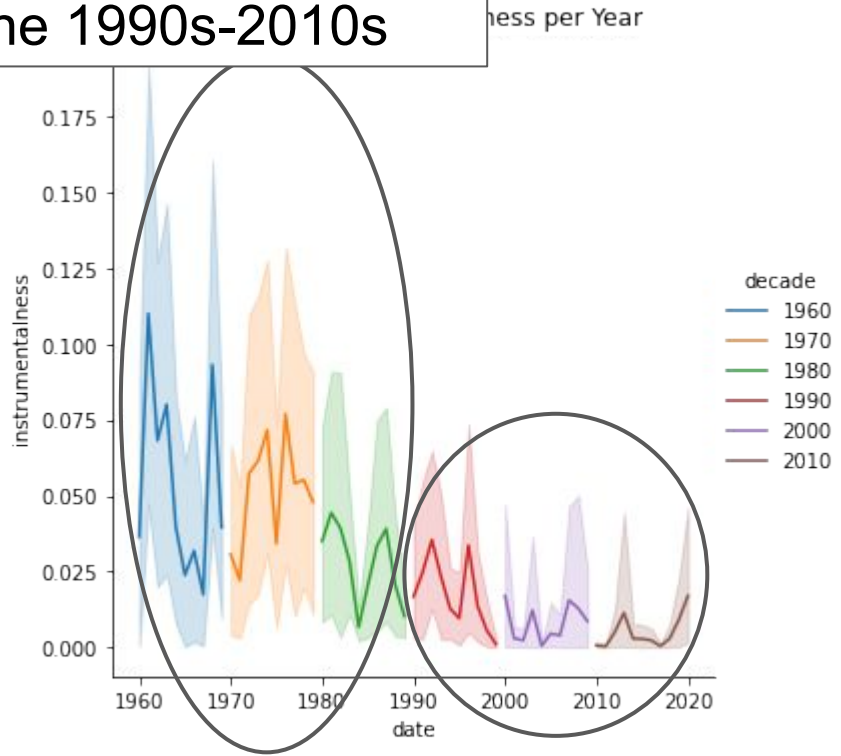




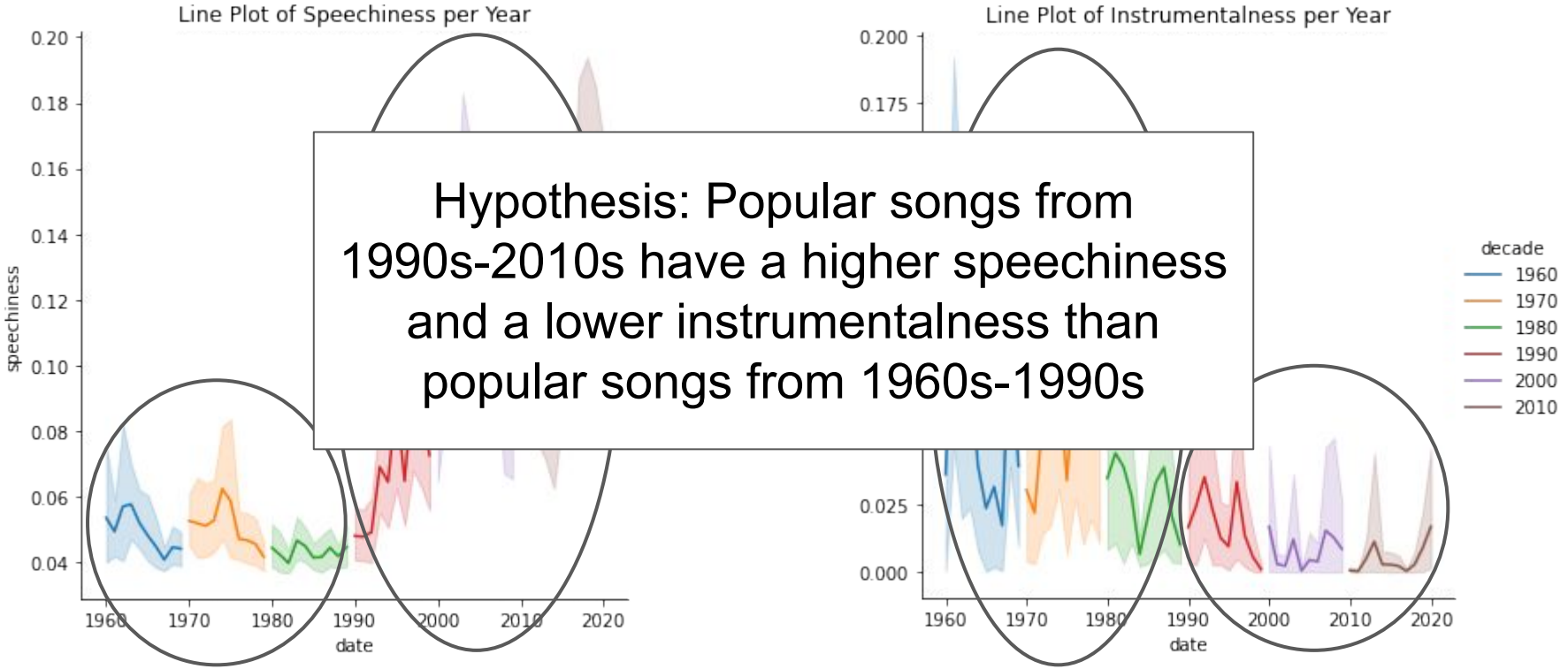
Are the … erms of spee … ngs?

Takeaway: There are differences. Specifically, there seems to be a difference between songs from the 1960s-1990s and the 1990s-2010s





Are there differences between decades in terms of speechiness and instrumentalness of songs?



Hypothesis: Popular songs from 1990s-2010s have a higher speechiness and a lower instrumentalness than popular songs from 1960s-1990s

Now on to …

Hypothesis Testing

T-test Time!

- We conducted two unpaired two-sample t-tests using an alpha of 0.05 to see if there is a difference in:
  - Mean speechiness of songs from 1960-1990 and songs from 1990-2020
  - Mean instrumentalness of songs from 1960-1990 and songs from 1990-2020

- We chose a t-test because we wanted to specifically test if the two time periods had different, sustained results from each other, with 1990 as a turning point for these metrics.

Two-Sample t-test for Speechiness

- Null hypothesis: There is no significant difference in mean speechiness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean speechiness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$

Two-Sample t-test for Speechiness

- Null hypothesis: There is no significant difference in mean speechiness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean s
  between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$

That's a really small number

This p-value says that the probability of observing a difference as great as we did if the null hypothesis were true is $8.34 * 10^{-90}$

Two-Sample t-test for Speechiness

- Null hypothesis: There is no significant difference in mean speechiness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean speechiness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$

Conclusion: Based on our low p-value, we can **reject the null hypothesis**. There is enough evidence to conclude that there is a significant difference between the two decade groups in terms of speechiness in popular songs.

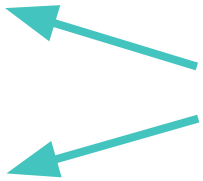
Two-Sample t-test for Speechiness

- Null hypothesis: There is no significant difference in mean speechiness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean speechiness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$
- Using our test data:
  - Test statistic of -8.93
  - p-value of $3.57 * 10^{-18}$

We replicated the t-test using our held-out test data, and also observed a small p-value for which we can reject the null hypothesis.

Two-Sample t-test for Speechiness

- Null hypothesis: There is no significant difference in mean speechiness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean speechiness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$
- Using our test data:
  - Test statistic of -8.93
  - p-value of $3.57 * 10^{-18}$



There is still a significant difference, but the effect is not as large in our t-test using the test data as with the train data.

Two-Sample T-test for Instrumentalness

- Null hypothesis: There is no significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of 8.271
  - p-value of 2.21×10^{-16}

Two-Sample T-test for Instrumentalness

- Null hypothesis: There is no significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of 8.271
  - p-value of 2.21×10^{-16}

Conclusion: Based on our low p-value, we can **reject the null hypothesis**. There is enough evidence to conclude that there is a significant difference between the two decade groups in terms of instrumentalness of popular songs.

Two-Sample T-test for Instrumentalness

- Null hypothesis: There is no significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Alternative hypothesis: There is a significant difference in mean instrumentalness between 1960-1990 and 1990-2020
- Using our train data:
  - Test statistic of 8.271
  - p-value of 2.21×10^{-16}
- Using our test data:
  - Test statistic of 2.097
  - p-value of 0.0363

We replicated the t-test using our held-out test data, and also observed a small p-value for which we can reject the null hypothesis.

Instrumentalness

- Using our train data:
  - Test statistic of 8.271
  - p-value of 2.21×10^{-16}
- Using our test data:
  - Test statistic of 2.097
  - p-value of 0.0363

$$t = 8.271 > 0$$

$$\bar{x}_{1960\text{-}1990} > \bar{x}_{1990\text{-}2020}$$

Speechiness

- Using our train data:
  - Test statistic of -20.974
  - p-value of $8.34 * 10^{-90}$
- Using our test data:
  - Test statistic of -8.93
  - p-value of $3.57 * 10^{-18}$

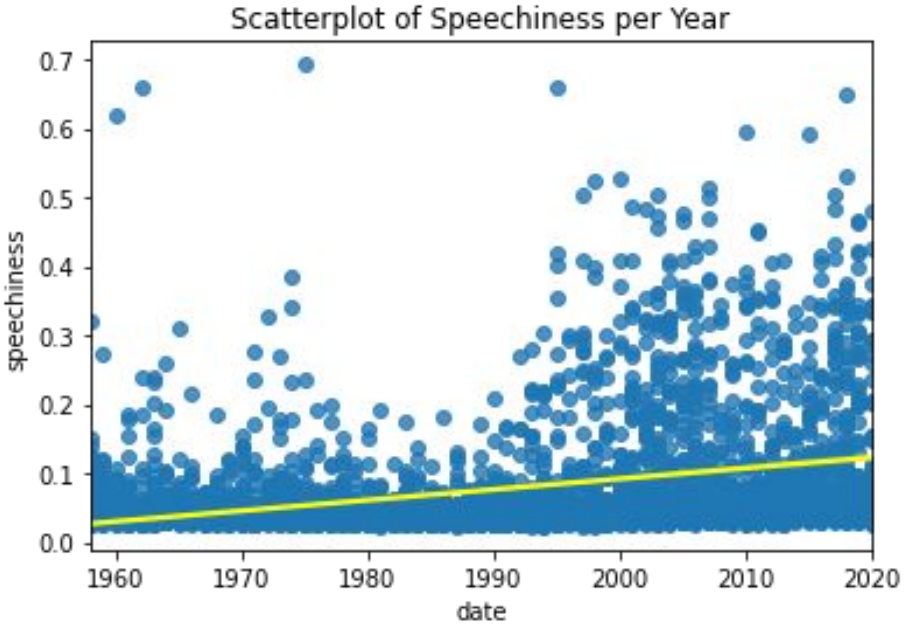
$$t = -20.974 < 0$$

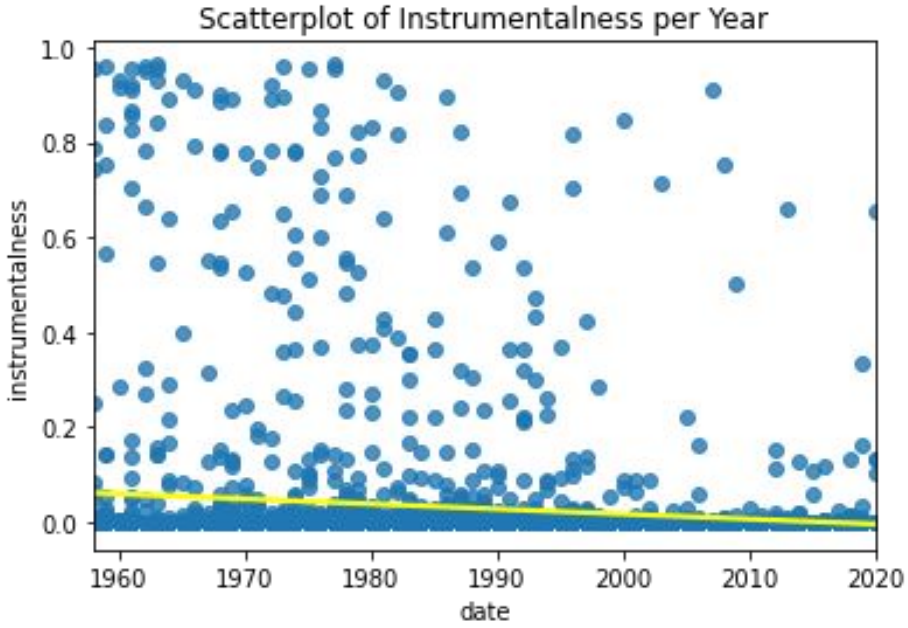
$$\bar{x}_{1960\text{-}1990} < \bar{x}_{1990\text{-}2020}$$

Linear Regression

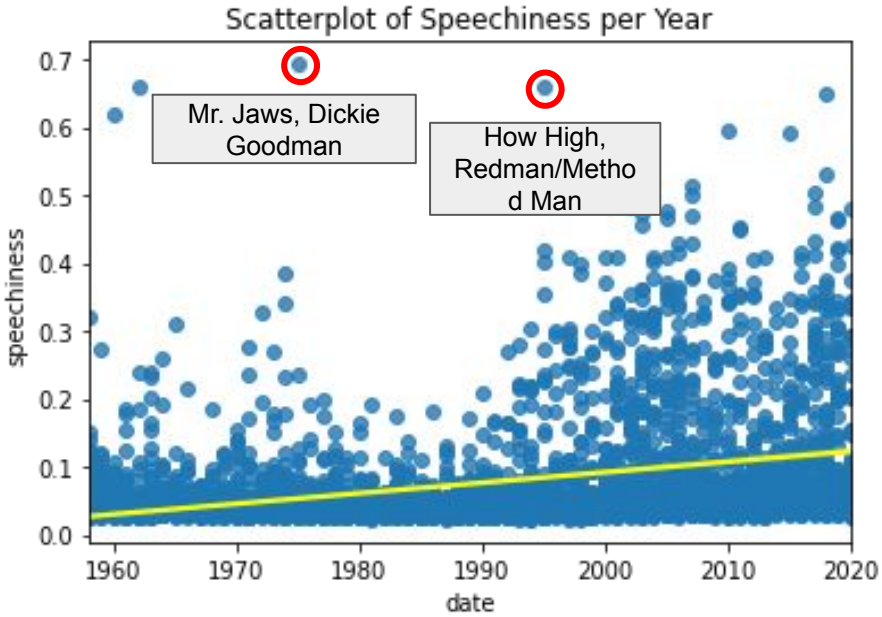
Time vs Speechiness and Instrumentalness

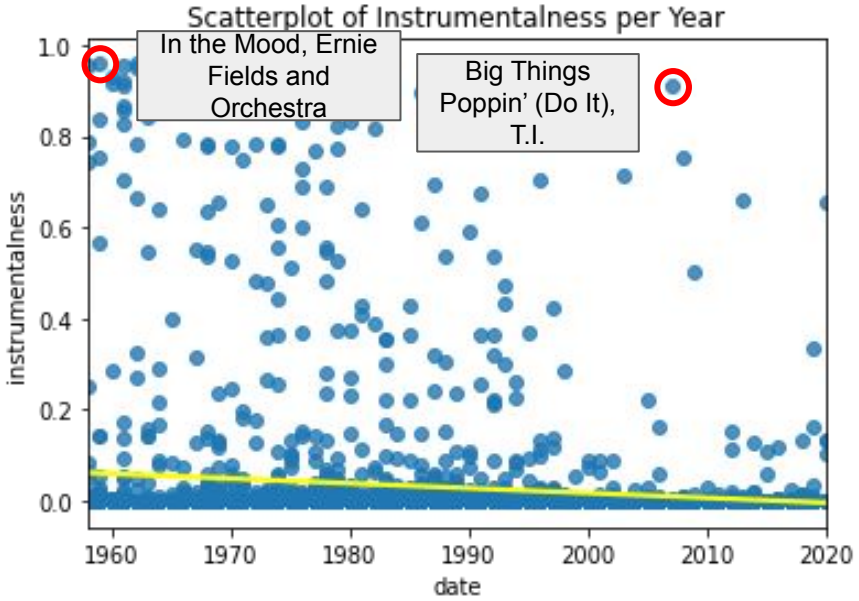
Regression Plots





Regression Plots





Speechiness

OLS Regression Results

Dep. Variable:	speechiness	R-squared:	0.115
Model:	OLS	Adj. R-squared:	0.115
Method:	Least Squares	F-statistic:	483.2
Date:	Fri, 06 Aug 2021	Prob (F-statistic):	8.60e-101
Time:	18:14:17	Log-Likelihood:	4207.3
No. Observations:	3724	AIC:	-8411.
Df Residuals:	3722	BIC:	-8398.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	-3.0043	0.140	-21.446	0.000	-3.279	-2.730
date	0.0015	7.04e-05	21.982	0.000	0.001	0.002

Omnibus:	2227.874	Durbin-Watson:	1.847
Prob(Omnibus):	0.000	Jarque-Bera (JB):	21436.603
Skew:	2.759	Prob(JB):	0.00
Kurtosis:	13.378	Cond. No.	2.17e+05

Instrumentalness

OLS Regression Results

Dep. Variable:	instrumentalness	R-squared:	0.023
Model:	OLS	Adj. R-squared:	0.023
Method:	Least Squares	F-statistic:	87.59
Date:	Fri, 06 Aug 2021	Prob (F-statistic):	1.36e-20
Time:	16:03:44	Log-Likelihood:	2432.3
No. Observations:	3724	AIC:	-4861.
Df Residuals:	3722	BIC:	-4848.
Df Model:	1		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	2.1394	0.226	9.482	0.000	1.697	2.582
date	-0.0011	0.000	-9.359	0.000	-0.001	-0.001

Omnibus:	3875.462	Durbin-Watson:	2.007
Prob(Omnibus):	0.000	Jarque-Bera (JB):	162335.361
Skew:	5.409	Prob(JB):	0.00
Kurtosis:	33.482	Cond. No.	2.17e+05

Speechiness

	coef
const	-3.0043
date	0.0015

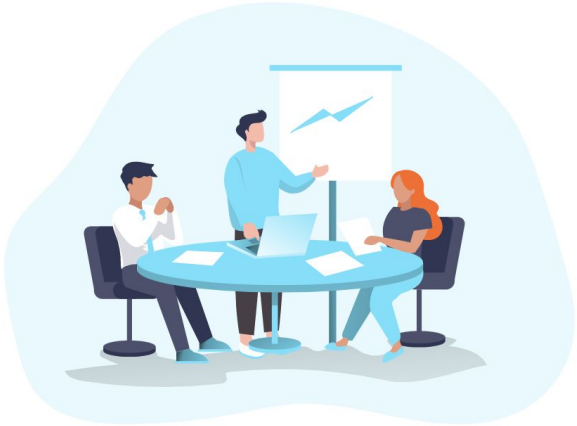
Instrumentalness

	coef
const	2.1394
date	-0.0011

Supports our hypothesis!

Recap…

Conclusions



WE CAN REJECT OUR NULL HYPOTHESIS!!!

Recap

- T-test Results:
  - The difference between speechiness and instrumentalness was statistically significant
  - Reject the null hypothesis

- Linear Regression
  - Date had a statistically significant effect on the speechiness and instrumentalness of a song
  - Our coefficients indicate that songs released earlier had higher instrumentalness and lower speechiness; the opposite for later songs.

- Conclusion: songs from 1960-1990 had a higher instrumentalness and a lower speechiness than songs from 1990-2020

Conclusions

Original Goal: Investigate the influence of rap music on popular songs in America.

- Goal somewhat reached!
- Next steps: Find genres for our songs and specifically test rap music vs. other genres.

Further investigation questions:

- What topics and groups feature prominently in pop music?
- What trends does this reflect in our culture?

Thanks for Watching!

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Annabeth Stokely, Mandy He, Kiera Walsh, Sophia Liu