Acoustic features analysis

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This script explores the acoustic features in the expanded corpus, specifically:

- correlations between features
- correlations between individual feature differences and similarity between originals and covers
- PCA to find low-dimensional representation that best captures variability, both on absolute features and scaled feature differences

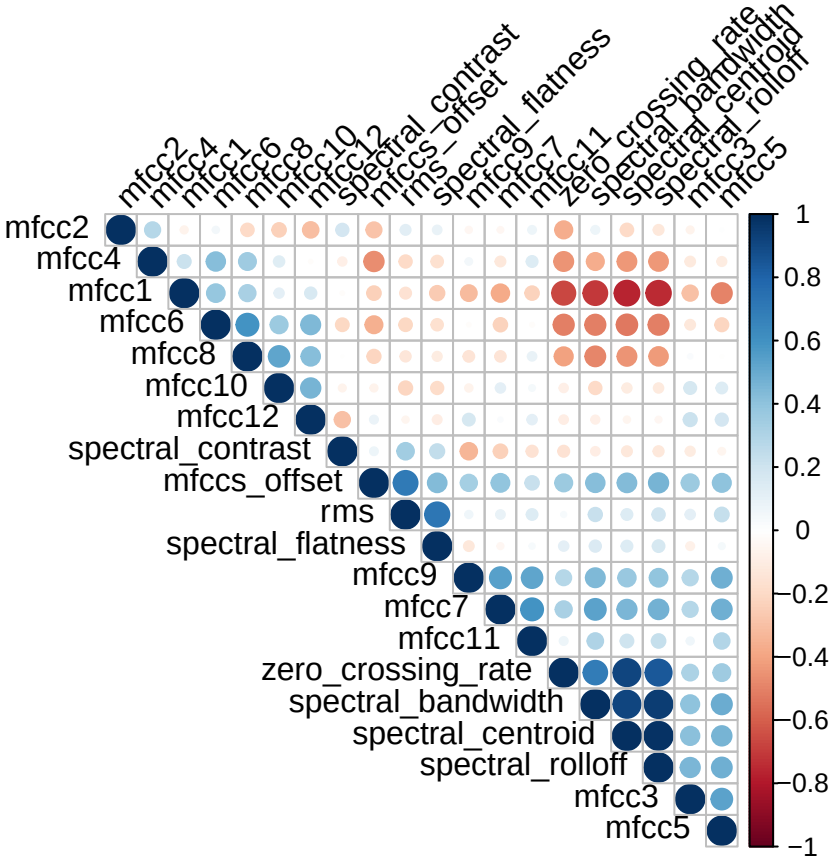
First, load the features and feature differences (unscaled).

Select only columns with acoustic features.

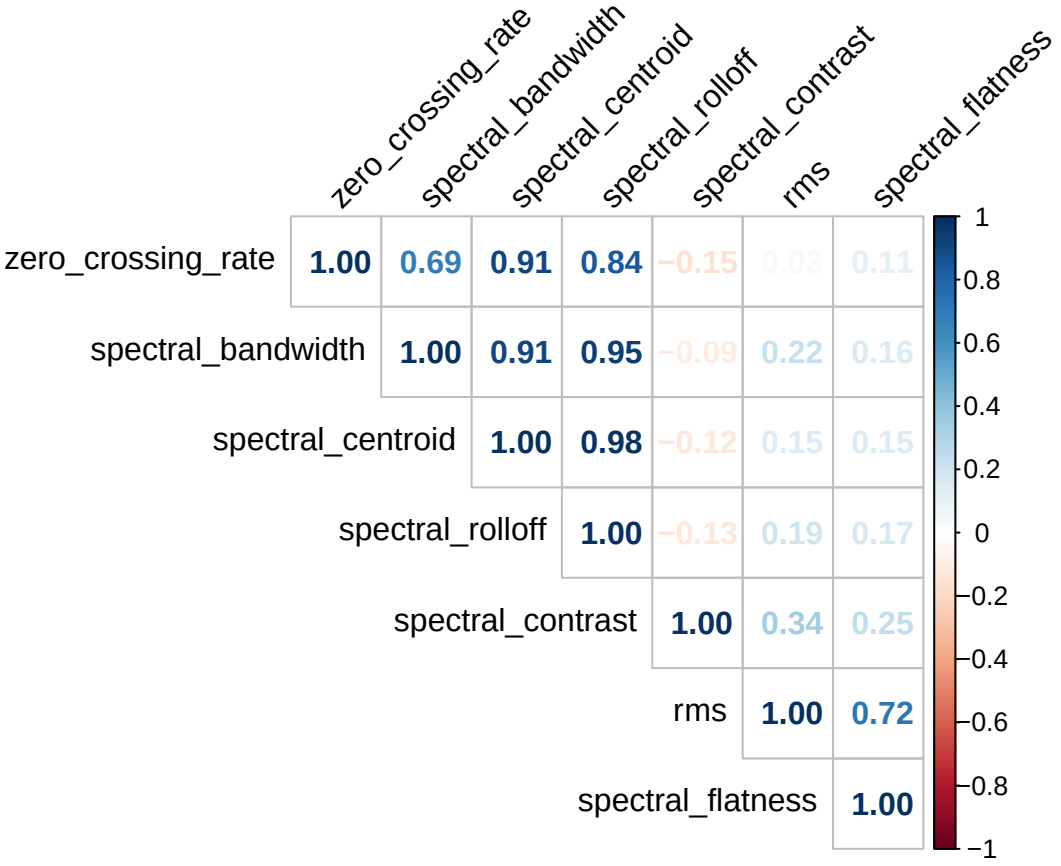
Correlation between features

Features

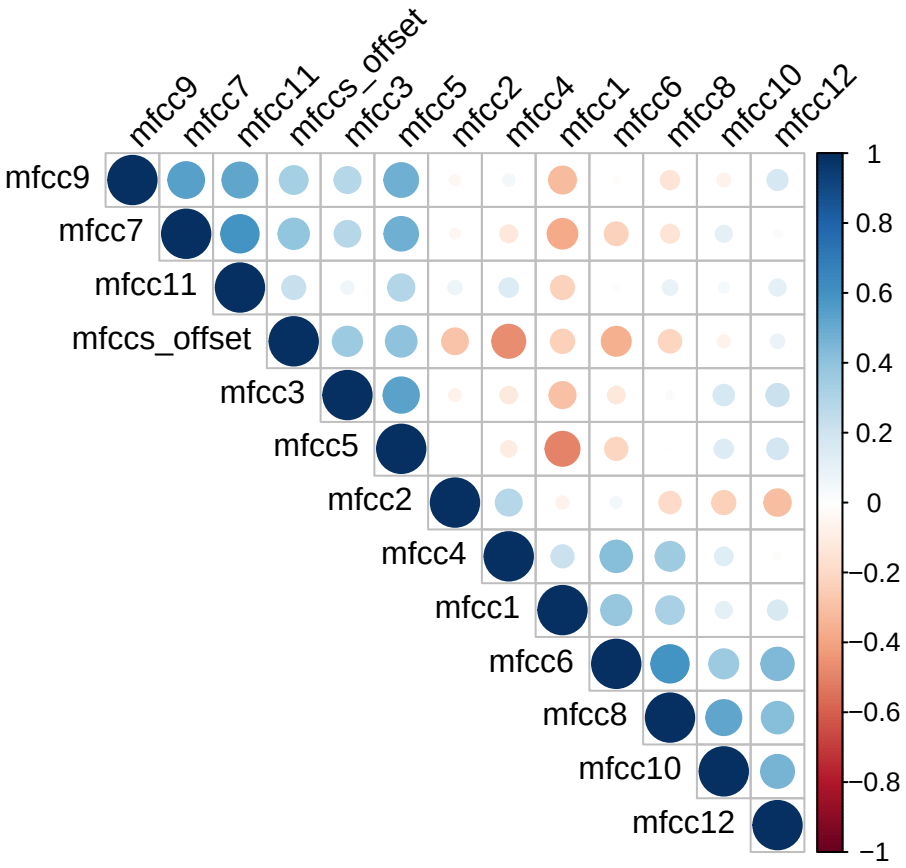
Compute the correlation matrix.



Without MFCCs.

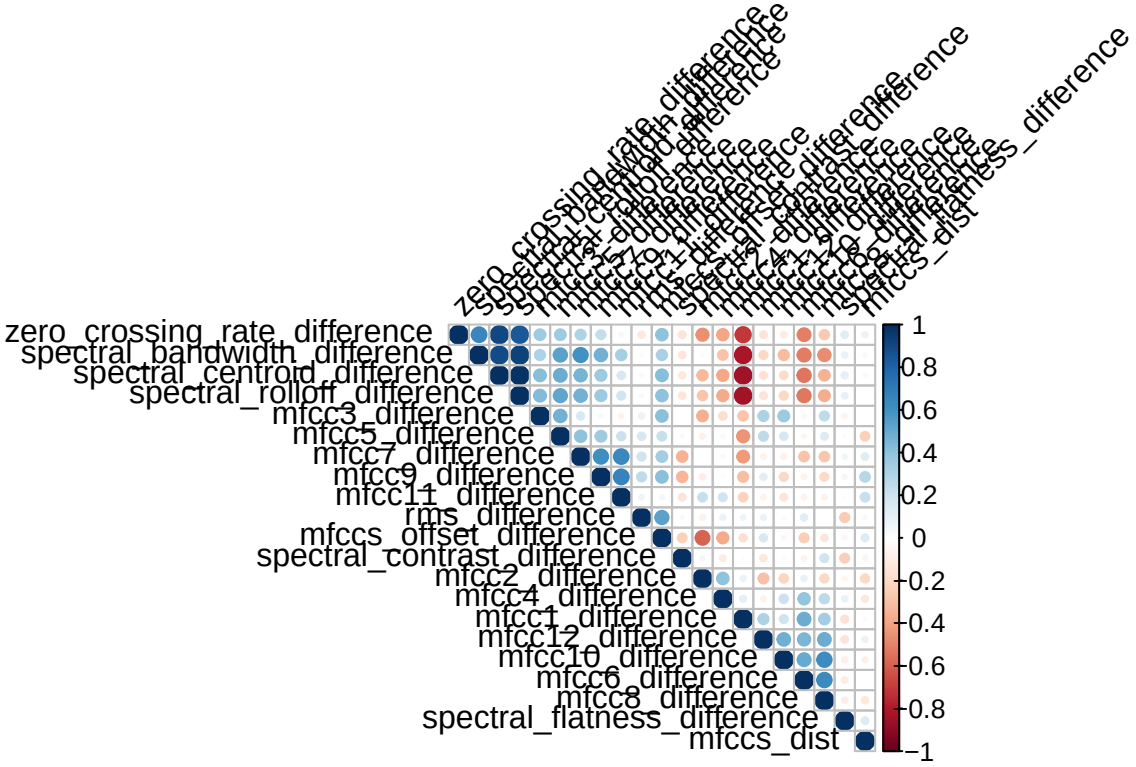


Now just look at MFCCs.

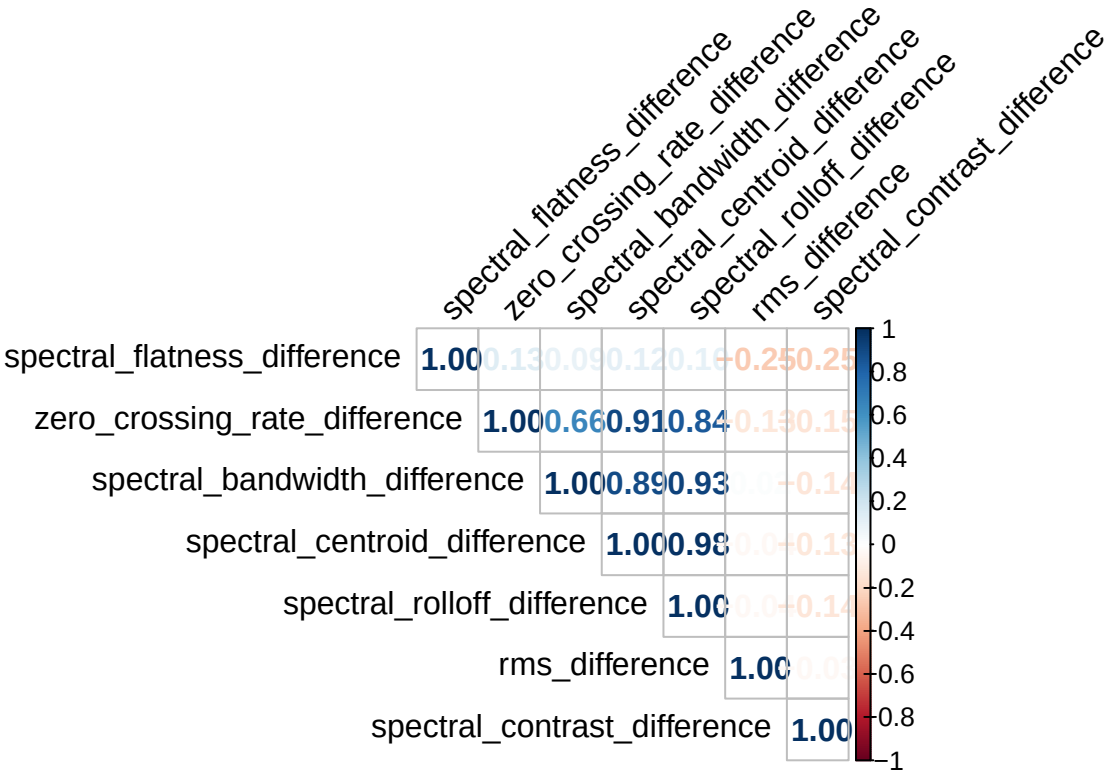


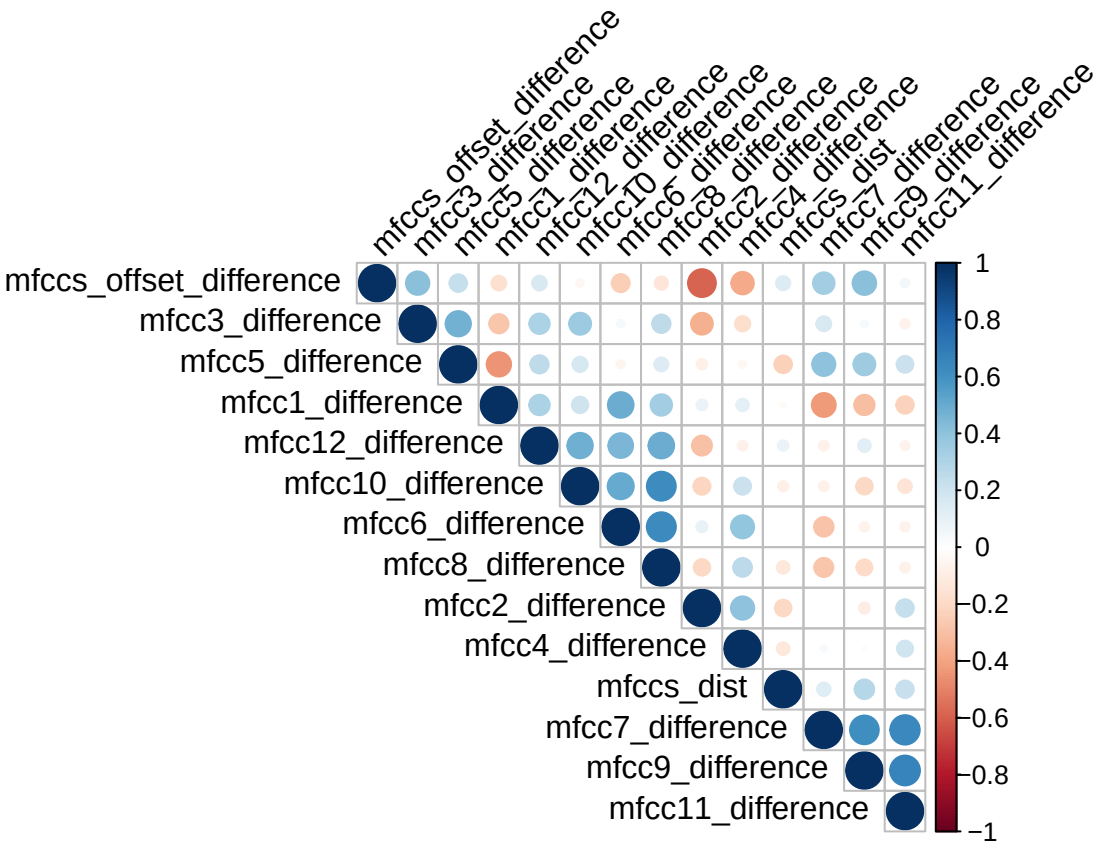
Feature differences

Are there correlations between feature differences?



Yes, there seem to be similar systematic differences.


spectral_flatness_difference
zero_crossing_rate_difference
spectral_bandwidth_difference
spectral_centroid_difference
spectral_rolloff_difference
rms_difference
spectral_contrast_difference
1.00
0.13
0.09
0.12
0.16
−0.25
0.25
1.00
0.66
0.91
0.84
0.13
0.15
1.00
0.89
0.93
0.0
−0.14
1.00
0.98
0.0
−0.13
1.00
0.0
−0.14
1.00
0.0
1.00
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1


mfccs_offset_difference
mfcc3_difference
mfcc5_difference
mfcc1_difference
mfcc12_difference
mfcc10_difference
mfcc6_difference
mfcc8_difference
mfcc2_difference
mfcc4_difference
mfccs_dist
mfcc7_difference
mfcc9_difference
mfcc11_difference
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1

Correlations between individual feature differences and similarity

How well do individual features predict similarity? Take these results with a grain of salt because we're running A LOT of models.

```
##
## Call:
## lm(formula = mean_sim ~ rms_difference, data = acoustic_diffs)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.23814 -0.96684 -0.01565  0.95759  2.49644
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.256      0.139  30.616   <2e-16 ***
## rms_difference   -7.119      4.516  -1.576     0.12
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.158 on 68 degrees of freedom
## Multiple R-squared:  0.03525,    Adjusted R-squared:  0.02106
## F-statistic: 2.485 on 1 and 68 DF,  p-value: 0.1196
```

```
##
## Call:
## lm(formula = mean_sim ~ spectral_bandwidth_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0667 -0.9447 -0.1820  1.0103  2.5149
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    4.243e+00  1.429e-01   29.68   <2e-16 ***
## spectral_bandwidth_difference -5.772e-05  1.859e-04   -0.31    0.757
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.178 on 68 degrees of freedom
## Multiple R-squared:  0.001415,   Adjusted R-squared:  -0.01327
## F-statistic: 0.09637 on 1 and 68 DF,  p-value: 0.7572
```

```
##
## Call:
## lm(formula = mean_sim ~ spectral_centroid_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1924 -0.9075 -0.1660  0.9871  2.4997
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   4.2607773  0.1428367  29.830   <2e-16 ***
## spectral_centroid_difference -0.0001237  0.0001367  -0.904    0.369
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.172 on 68 degrees of freedom
## Multiple R-squared:  0.01189,    Adjusted R-squared:  -0.002645
## F-statistic: 0.8179 on 1 and 68 DF,  p-value: 0.369

##
## Call:
## lm(formula = mean_sim ~ spectral_contrast_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0265 -0.9704 -0.1865  1.0250  2.3520
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    4.1943     0.1448  28.975   <2e-16 ***
## spectral_contrast_difference  -0.1237     0.1138  -1.087    0.281
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.169 on 68 degrees of freedom
## Multiple R-squared:  0.01708,    Adjusted R-squared:  0.002621
## F-statistic: 1.181 on 1 and 68 DF,  p-value: 0.2809

##
## Call:
## lm(formula = mean_sim ~ spectral_flatness_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9927 -0.9783 -0.1326  1.0445  2.5312
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    4.2380     0.1413  29.990   <2e-16 ***
## spectral_flatness_difference   7.7803    35.0024   0.222    0.825
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.179 on 68 degrees of freedom
## Multiple R-squared:  0.0007261,  Adjusted R-squared:  -0.01397
## F-statistic: 0.04941 on 1 and 68 DF,  p-value: 0.8248

##
## Call:
## lm(formula = mean_sim ~ spectral_rolloff_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1413 -0.8955 -0.1747  0.9794  2.4955
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  4.257e+00  1.425e-01  29.869   <2e-16 ***
```

```
## spectral_rolloff_difference -4.876e-05  5.813e-05  -0.839    0.404
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.173 on 68 degrees of freedom
## Multiple R-squared:  0.01024,    Adjusted R-squared:  -0.004313
## F-statistic: 0.7037 on 1 and 68 DF,  p-value: 0.4045
```

```
##
## Call:
## lm(formula = mean_sim ~ zero_crossing_rate_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1744 -0.9399 -0.1356  0.9680  2.4901
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     4.2493     0.1411  30.121   <2e-16 ***
## zero_crossing_rate_difference  -4.0915     4.7630  -0.859    0.393
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.173 on 68 degrees of freedom
## Multiple R-squared:  0.01074,    Adjusted R-squared:  -0.003813
## F-statistic: 0.7379 on 1 and 68 DF,  p-value: 0.3933
```

```
##
## Call:
## lm(formula = mean_sim ~ mfccs_offset_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1637 -0.9044 -0.1086  0.9264  2.7177
##
## Coefficients:
##                           Estimate Std. Error t value Pr(>|t|)
## (Intercept)               4.259940   0.145869  29.204   <2e-16 ***
## mfccs_offset_difference -0.001218   0.001952  -0.624    0.535
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.176 on 68 degrees of freedom
## Multiple R-squared:  0.005696,   Adjusted R-squared:  -0.008926
## F-statistic: 0.3896 on 1 and 68 DF,  p-value: 0.5346
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc1_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0424 -0.9007 -0.1982  1.0090  2.5513
##
## Coefficients:
```

```
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)      4.233732   0.140178  30.203   <2e-16 ***
## mfcc1_difference 0.003771   0.004409   0.855    0.395
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.173 on 68 degrees of freedom
## Multiple R-squared:  0.01064,    Adjusted R-squared:  -0.003907
## F-statistic: 0.7315 on 1 and 68 DF,  p-value: 0.3954
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc2_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.4176 -0.9267 -0.1235  1.0195  2.5311
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)      4.259999   0.141947  30.011   <2e-16 ***
## mfcc2_difference 0.004924   0.004866   1.012    0.315
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.17 on 68 degrees of freedom
## Multiple R-squared:  0.01483,    Adjusted R-squared:  0.0003442
## F-statistic: 1.024 on 1 and 68 DF,  p-value: 0.3152
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc3_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0488 -0.9153 -0.1339  0.8372  2.6795
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.246272   0.139554  30.428   <2e-16 ***
## mfcc3_difference -0.011073   0.008773  -1.262    0.211
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.165 on 68 degrees of freedom
## Multiple R-squared:  0.02289,    Adjusted R-squared:  0.008522
## F-statistic: 1.593 on 1 and 68 DF,  p-value: 0.2112
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc4_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9438 -0.9212 -0.1677  1.0649  2.5564
```

```
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.231862   0.140806  30.055   <2e-16 ***
## mfcc4_difference -0.004774   0.009151  -0.522    0.604
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.177 on 68 degrees of freedom
## Multiple R-squared:  0.003986,   Adjusted R-squared:  -0.01066
## F-statistic: 0.2722 on 1 and 68 DF,  p-value: 0.6036
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc5_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1688 -0.8915 -0.2031  0.9032  2.5468
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.24902    0.14074  30.190   <2e-16 ***
## mfcc5_difference -0.01176    0.01249  -0.941     0.35
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.171 on 68 degrees of freedom
## Multiple R-squared:  0.01285,    Adjusted R-squared:  -0.001666
## F-statistic: 0.8852 on 1 and 68 DF,  p-value: 0.3501
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc6_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9775 -0.9968 -0.1497  1.0512  2.5066
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.237671   0.140877  30.081   <2e-16 ***
## mfcc6_difference -0.004757   0.012404  -0.384    0.703
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.178 on 68 degrees of freedom
## Multiple R-squared:  0.002158,   Adjusted R-squared:  -0.01252
## F-statistic: 0.1471 on 1 and 68 DF,  p-value: 0.7025
```

```
##
## Call:
## lm(formula = mean_sim ~ mfcc7_difference, data = acoustic_diffs)
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -2.3672 -0.8261 -0.1251  0.9640  2.4309
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.26437    0.14133  30.173   <2e-16 ***
## mfcc7_difference -0.01277    0.01038  -1.231    0.223
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.166 on 68 degrees of freedom
## Multiple R-squared:  0.02179,    Adjusted R-squared:  0.007408
## F-statistic: 1.515 on 1 and 68 DF,  p-value: 0.2226

##
## Call:
## lm(formula = mean_sim ~ mfcc8_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1744 -0.9018 -0.2792  0.9927  2.6105
##
## Coefficients:
##                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.26561    0.14113  30.225   <2e-16 ***
## mfcc8_difference -0.01901    0.01466  -1.296    0.199
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.165 on 68 degrees of freedom
## Multiple R-squared:  0.02411,    Adjusted R-squared:  0.009762
## F-statistic:  1.68 on 1 and 68 DF,  p-value: 0.1993

##
## Call:
## lm(formula = mean_sim ~ mfcc9_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0083 -0.9756 -0.1518  1.0026  2.5333
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.2368759  0.1436478  29.495   <2e-16 ***
## mfcc9_difference -0.0005832  0.0117845  -0.049    0.961
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.179 on 68 degrees of freedom
## Multiple R-squared:  3.601e-05,  Adjusted R-squared:  -0.01467
## F-statistic: 0.002449 on 1 and 68 DF,  p-value: 0.9607

##
## Call:
## lm(formula = mean_sim ~ mfcc10_difference, data = acoustic_diffs)
```

```
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1328 -0.8258 -0.2191  1.0090  2.5707
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)        4.24807    0.13887  30.591   <2e-16 ***
## mfcc10_difference -0.02659    0.01763  -1.508    0.136
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.16 on 68 degrees of freedom
## Multiple R-squared:  0.03235,    Adjusted R-squared:  0.01812
## F-statistic: 2.274 on 1 and 68 DF,  p-value: 0.1362

##
## Call:
## lm(formula = mean_sim ~ mfcc11_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1765 -0.8132 -0.1523  0.9409  2.4839
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)        4.27940    0.14378  29.763   <2e-16 ***
## mfcc11_difference -0.01796    0.01449  -1.239    0.219
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.166 on 68 degrees of freedom
## Multiple R-squared:  0.02209,    Adjusted R-squared:  0.007712
## F-statistic: 1.536 on 1 and 68 DF,  p-value: 0.2194

##
## Call:
## lm(formula = mean_sim ~ mfcc12_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0614 -0.9399 -0.1190  0.9695  2.6164
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)        4.253591   0.147134  28.910   <2e-16 ***
## mfcc12_difference -0.007562   0.017940  -0.421    0.675
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.177 on 68 degrees of freedom
## Multiple R-squared:  0.002606,   Adjusted R-squared:  -0.01206
## F-statistic: 0.1777 on 1 and 68 DF,  p-value: 0.6747

##
```

```
## Call:
## lm(formula = mean_sim ~ mfccs_dist, data = acoustic_diffs)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.24269 -0.93145  0.03411  1.03036  2.04433
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)  5.103839   0.362037  14.098   <2e-16 ***
## mfccs_dist  -0.016376   0.006339  -2.583   0.0119 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.125 on 68 degrees of freedom
## Multiple R-squared:  0.08937,    Adjusted R-squared:  0.07598
## F-statistic: 6.673 on 1 and 68 DF,  p-value: 0.01194
```

Well, none of the acoustic features individually predict similarity except MFCCs distance. This is not super surprising.

Predicting similarity with all acoustic features

Run the full and subset models just to get a sense...

```
##
## Call:
## lm(formula = mean_sim ~ rms_difference + spectral_bandwidth_difference +
##     spectral_centroid_difference + spectral_contrast_difference +
##     spectral_flatness_difference + spectral_rolloff_difference +
##     zero_crossing_rate_difference, data = acoustic_diffs)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.06418 -0.99084 -0.00887  0.86472  2.37159
##
## Coefficients:
##                                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    4.250e+00  1.607e-01  26.445   <2e-16 ***
## rms_difference                -8.438e+00  5.079e+00  -1.661    0.102
## spectral_bandwidth_difference  9.835e-04  7.340e-04   1.340    0.185
## spectral_centroid_difference  -4.421e-04  1.621e-03  -0.273    0.786
## spectral_contrast_difference  -1.417e-01  1.244e-01  -1.139    0.259
## spectral_flatness_difference  -1.707e+01  3.767e+01  -0.453    0.652
## spectral_rolloff_difference   -2.593e-04  4.690e-04  -0.553    0.582
## zero_crossing_rate_difference  9.481e+00  2.290e+01   0.414    0.680
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.166 on 62 degrees of freedom
## Multiple R-squared:  0.1077, Adjusted R-squared:  0.006961
## F-statistic: 1.069 on 7 and 62 DF,  p-value: 0.3939
```

```
##
## Call:
## lm(formula = mean_sim ~ mfccs_offset_difference + mfcc1_difference +
##     mfcc2_difference + mfcc3_difference + mfcc4_difference +
##     mfcc5_difference + mfcc6_difference + mfcc7_difference +
##     mfcc8_difference + mfcc9_difference + mfcc10_difference +
##     mfcc11_difference + mfcc12_difference, data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.6133 -0.6749 -0.2938  0.7882  2.6601
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)               4.351e+00  1.642e-01  26.492   <2e-16 ***
## mfccs_offset_difference -1.736e-03  3.322e-03  -0.523    0.603
## mfcc1_difference         5.230e-03  7.150e-03   0.731    0.468
## mfcc2_difference         6.614e-03  8.149e-03   0.812    0.420
## mfcc3_difference         1.030e-03  1.331e-02   0.077    0.939
## mfcc4_difference        -4.449e-03  1.248e-02  -0.356    0.723
## mfcc5_difference        -2.866e-03  1.917e-02  -0.150    0.882
## mfcc6_difference        -9.760e-03  2.157e-02  -0.452    0.653
## mfcc7_difference        -7.439e-03  1.852e-02  -0.402    0.689
```

```
## mfcc8_difference        -5.805e-03  2.750e-02  -0.211    0.834
## mfcc9_difference         3.374e-02  2.359e-02   1.431    0.158
## mfcc10_difference       -1.003e-02  2.824e-02  -0.355    0.724
## mfcc11_difference       -3.926e-02  2.724e-02  -1.441    0.155
## mfcc12_difference       -2.466e-05  2.738e-02  -0.001    0.999
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.211 on 56 degrees of freedom
## Multiple R-squared:  0.1304, Adjusted R-squared:  -0.07144
## F-statistic: 0.6461 on 13 and 56 DF,  p-value: 0.8046
```

```
##
## Call:
## lm(formula = mean_sim ~ rms_difference + spectral_bandwidth_difference +
##     spectral_centroid_difference + spectral_contrast_difference +
##     spectral_flatness_difference + spectral_rolloff_difference +
##     zero_crossing_rate_difference + mfccs_offset_difference +
##     mfcc1_difference + mfcc2_difference + mfcc3_difference +
##     mfcc4_difference + mfcc5_difference + mfcc6_difference +
##     mfcc7_difference + mfcc8_difference + mfcc9_difference +
##     mfcc10_difference + mfcc11_difference + mfcc12_difference,
##     data = acoustic_diffs)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.9582 -0.7419 -0.2127  0.9139  2.0576
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   4.301e+00  1.915e-01  22.462   <2e-16 ***
## rms_difference               -1.289e+01  7.976e+00  -1.616    0.113
## spectral_bandwidth_difference  1.497e-03  1.310e-03   1.142    0.259
## spectral_centroid_difference  -2.696e-04  1.992e-03  -0.135    0.893
## spectral_contrast_difference  -1.967e-01  1.633e-01  -1.204    0.234
## spectral_flatness_difference  -2.641e+01  4.083e+01  -0.647    0.521
## spectral_rolloff_difference   -4.871e-04  5.401e-04  -0.902    0.372
## zero_crossing_rate_difference  5.759e+00  2.789e+01   0.206    0.837
## mfccs_offset_difference        2.762e-03  4.529e-03   0.610    0.545
## mfcc1_difference               4.307e-04  1.120e-02   0.038    0.969
## mfcc2_difference              -4.564e-04  1.070e-02  -0.043    0.966
## mfcc3_difference               2.048e-03  1.450e-02   0.141    0.888
## mfcc4_difference              -1.465e-03  1.425e-02  -0.103    0.919
## mfcc5_difference               8.949e-03  2.121e-02   0.422    0.675
## mfcc6_difference              -4.752e-03  2.349e-02  -0.202    0.841
## mfcc7_difference              -2.388e-02  2.229e-02  -1.071    0.289
## mfcc8_difference              -1.655e-03  2.904e-02  -0.057    0.955
## mfcc9_difference               1.964e-02  2.461e-02   0.798    0.429
## mfcc10_difference             -1.282e-02  2.970e-02  -0.432    0.668
## mfcc11_difference             -2.955e-02  2.824e-02  -1.046    0.301
## mfcc12_difference             -1.301e-02  2.861e-02  -0.455    0.651
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 1.211 on 49 degrees of freedom
## Multiple R-squared:  0.2393, Adjusted R-squared:  -0.07123
## F-statistic: 0.7706 on 20 and 49 DF,  p-value: 0.7334
```

Cool, so NOTHING is significant.

Principal components

(Actual PCA performed in `acoustic_PCA.ipynb`, just analyzed here...)

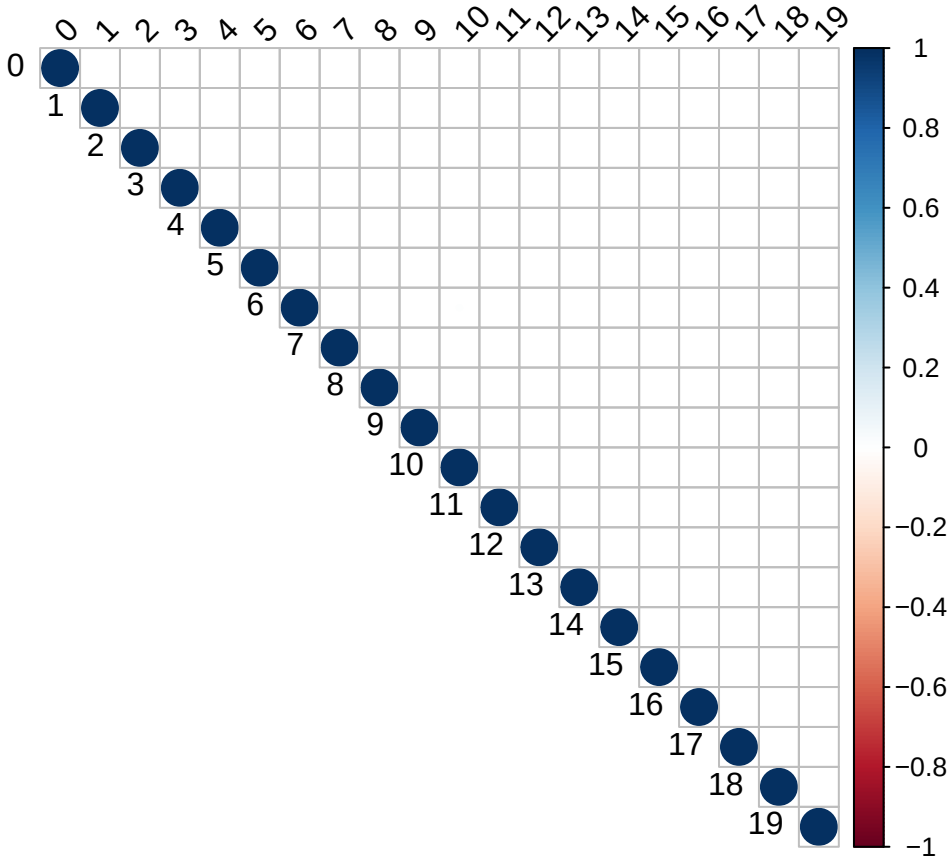
Load the PCs for analysis.

The first 6 PCs explains about 80% of the variance in the acoustic features.

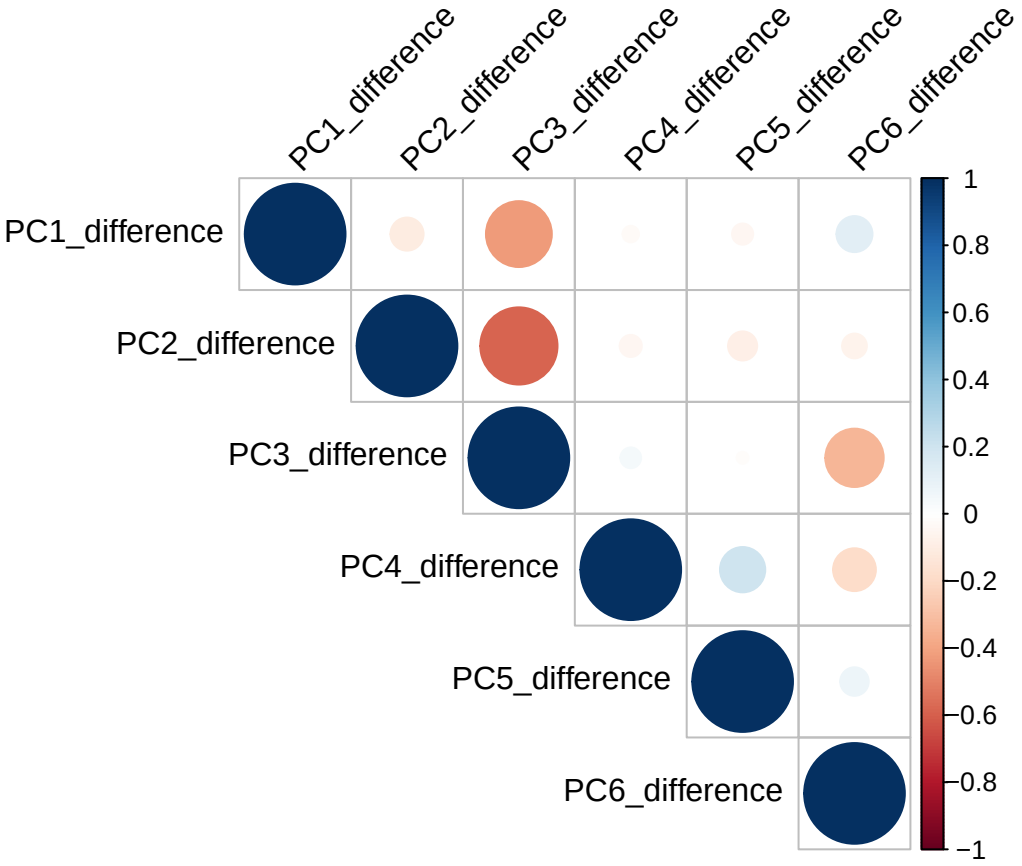
Pivot the data wider and calculate differences in the first 6 PCs.

Save this dataframe.

The PCs themselves should be uncorrelated (which they are).



But the differences might be correlated?



Try to predict similarity with all 6 PCs individually.

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC1_difference), data = pcs_diff_sim)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8738 -0.9415 -0.1002  1.0818  2.3394
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)          4.45994    0.22515  19.809   <2e-16 ***
## abs(PC1_difference) -0.08804    0.06939  -1.269    0.209
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.165 on 68 degrees of freedom
## Multiple R-squared:  0.02312,    Adjusted R-squared:  0.008759
## F-statistic:  1.61 on 1 and 68 DF,  p-value: 0.2089
```

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC2_difference), data = pcs_diff_sim)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.05806 -0.89944 -0.08702  0.96011  2.55704
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.4748     0.2233   20.04   <2e-16 ***
## abs(PC2_difference)  -0.1539     0.1123   -1.37    0.175
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.163 on 68 degrees of freedom
## Multiple R-squared:  0.02685,    Adjusted R-squared:  0.01254
## F-statistic: 1.876 on 1 and 68 DF,  p-value: 0.1753
```

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC3_difference), data = pcs_diff_sim)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.1044 -0.9052 -0.1301  1.0500  2.5921
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.4095     0.2183  20.201   <2e-16 ***
## abs(PC3_difference)  -0.1826     0.1759  -1.038    0.303
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 1.17 on 68 degrees of freedom
## Multiple R-squared:  0.0156, Adjusted R-squared:  0.001128
## F-statistic: 1.078 on 1 and 68 DF,  p-value: 0.3028
```

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC4_difference), data = pcs_diff_sim)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.06446 -0.86158  0.01036  0.81438  2.48396
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.44740    0.20421  21.778   <2e-16 ***
## abs(PC4_difference) -0.14128    0.09982  -1.415    0.162
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.162 on 68 degrees of freedom
## Multiple R-squared:  0.02862,    Adjusted R-squared:  0.01433
## F-statistic: 2.003 on 1 and 68 DF,  p-value: 0.1615
```

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC5_difference), data = pcs_diff_sim)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.8991 -1.0530 -0.1553  0.9774  2.4213
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.4383     0.2362  18.789   <2e-16 ***
## abs(PC5_difference)  -0.1624     0.1524  -1.065    0.291
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.169 on 68 degrees of freedom
## Multiple R-squared:  0.01641,    Adjusted R-squared:  0.001945
## F-statistic: 1.134 on 1 and 68 DF,  p-value: 0.2906
```

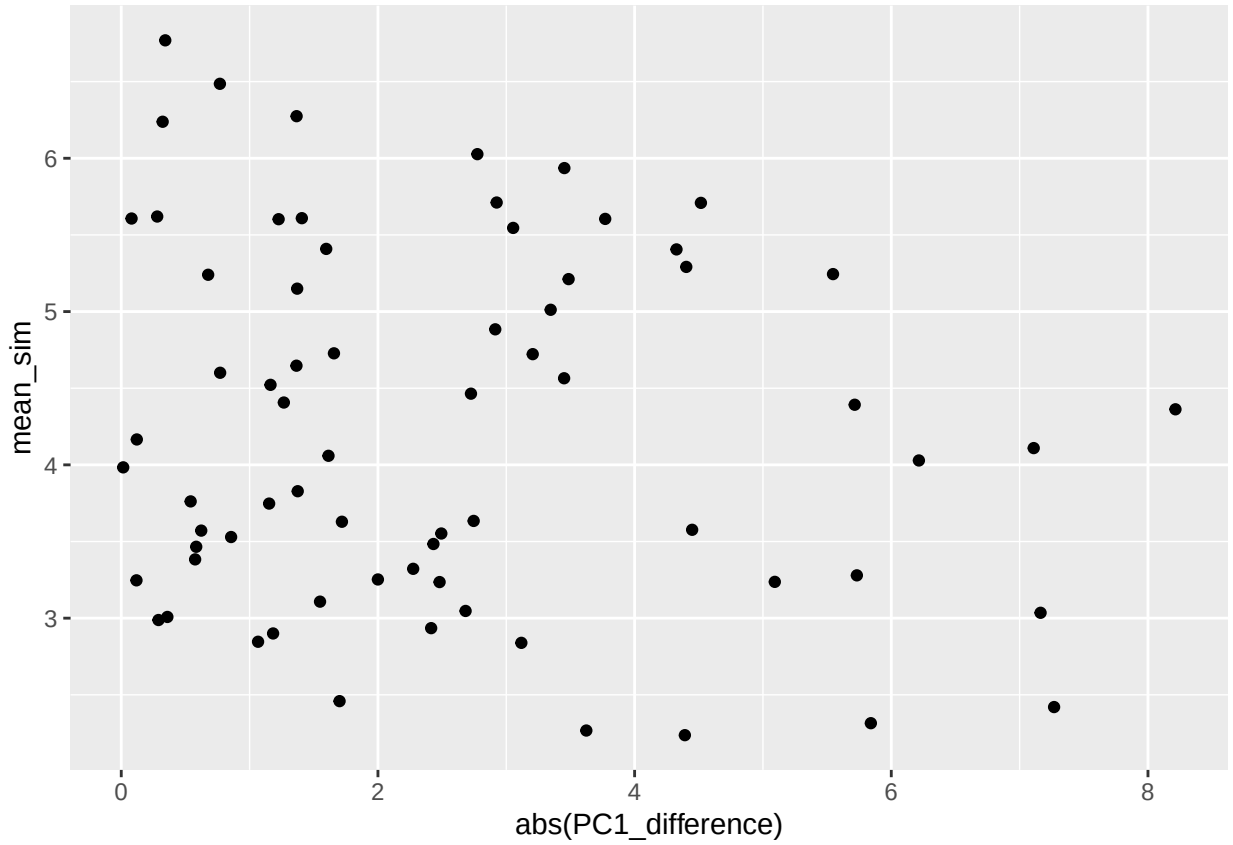
```
##
## Call:
## lm(formula = mean_sim ~ abs(PC6_difference), data = pcs_diff_sim)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.0464 -0.8854 -0.1373  1.0331  2.4949
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.3679     0.2177  20.066   <2e-16 ***
## abs(PC6_difference)  -0.1761     0.2214  -0.795    0.429
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.174 on 68 degrees of freedom
## Multiple R-squared:  0.009214,   Adjusted R-squared:  -0.005356
## F-statistic: 0.6324 on 1 and 68 DF,  p-value: 0.4293
```

And together.

```
##
## Call:
## lm(formula = mean_sim ~ abs(PC1_difference) + abs(PC2_difference) +
##     abs(PC3_difference) + abs(PC4_difference) + abs(PC5_difference) +
##     abs(PC6_difference), data = pcs_diff_sim)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.00959 -0.97933 -0.02268  1.05092  2.28018
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)           4.94359    0.35616  13.880   <2e-16 ***
## abs(PC1_difference) -0.06718    0.07299  -0.920    0.361
## abs(PC2_difference) -0.15147    0.12865  -1.177    0.243
## abs(PC3_difference)  0.04424    0.21139   0.209    0.835
## abs(PC4_difference) -0.12491    0.11551  -1.081    0.284
## abs(PC5_difference) -0.07505    0.16790  -0.447    0.656
## abs(PC6_difference) -0.08285    0.22928  -0.361    0.719
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.176 on 63 degrees of freedom
## Multiple R-squared:  0.07752,    Adjusted R-squared:  -0.01033
## F-statistic: 0.8824 on 6 and 63 DF,  p-value: 0.5131
```

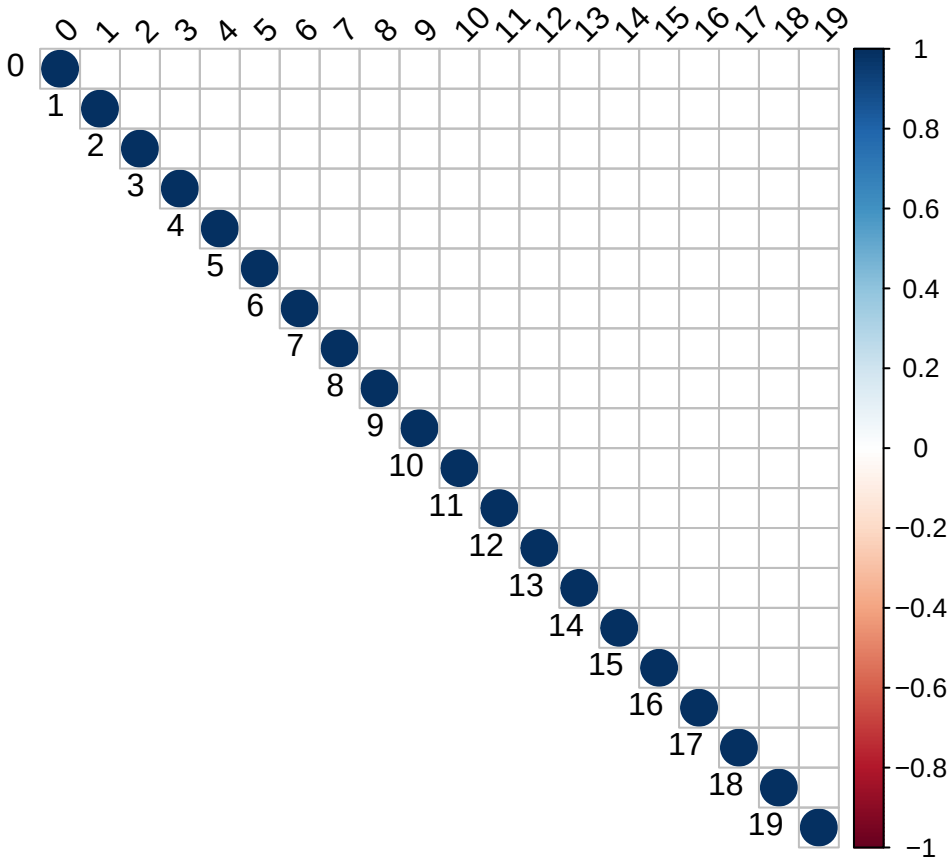
Visualize just the first PC.



PCA on scaled feature differences

Load the PCs of the scaled feature differences.

The PCs themselves should be uncorrelated (which they are).



Load mean similarity ratings.

Run models for each PC individually (using `broom`).

```
## # A tibble: 40 x 6
##    column term         estimate std.error statistic p.value
##    <chr>  <chr>           <dbl>     <dbl>     <dbl>   <dbl>
##  1 0      (Intercept) -4.09e-16    0.118  -3.48e-15  1.00
##  2 0      value       -9.50e- 2    0.0528 -1.80e+ 0  0.0764
##  3 1      (Intercept) -4.12e-16    0.120  -3.42e-15  1.00
##  4 1      value        2.16e- 2    0.0750  2.89e- 1  0.774
##  5 2      (Intercept) -4.20e-16    0.117  -3.58e-15  1.00
##  6 2      value       -1.65e- 1    0.0854 -1.93e+ 0  0.0577
##  7 3      (Intercept) -4.12e-16    0.120  -3.43e-15  1.00
##  8 3      value       -2.70e- 2    0.0922 -2.93e- 1  0.771
##  9 4      (Intercept) -4.15e-16    0.120  -3.45e-15  1.00
## 10 4      value        6.69e- 2    0.0989  6.76e- 1  0.501
## # i 30 more rows
```

PCs 1, 3, 8, and 17 have marginally significant p-values in their individual models (between 0.05 and 0.10). However, we're running 20 separate models so those p-values probably would not survive multiple comparisons corrections.

Run one model with all 20 PCs.

```
##
## Call:
## lm(formula = mean_sim ~ ., data = .)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.09151 -0.62786  0.05887  0.60041  1.55449
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -4.654e-16  1.159e-01   0.000   1.0000
## `0`         -9.500e-02  5.203e-02  -1.826   0.0740 .
## `1`          2.165e-02  7.229e-02   0.299   0.7659
## `2`         -1.648e-01  8.442e-02  -1.952   0.0567 .
## `3`         -2.698e-02  8.880e-02  -0.304   0.7625
## `4`          6.686e-02  9.558e-02   0.700   0.4875
## `5`          1.462e-01  1.130e-01   1.294   0.2019
## `6`          5.140e-02  1.229e-01   0.418   0.6775
## `7`         -2.206e-01  1.262e-01  -1.749   0.0866 .
## `8`          1.359e-01  1.320e-01   1.029   0.3085
## `9`         -1.353e-03  1.446e-01  -0.009   0.9926
## `10`         4.549e-02  1.563e-01   0.291   0.7722
## `11`         2.173e-01  1.683e-01   1.291   0.2028
## `12`         3.054e-02  1.725e-01   0.177   0.8602
## `13`        -1.574e-01  1.924e-01  -0.818   0.4171
## `14`         2.558e-01  2.115e-01   1.210   0.2323
## `15`         2.789e-01  2.220e-01   1.257   0.2149
## `16`        -4.415e-01  2.432e-01  -1.816   0.0756 .
## `17`        -1.087e-03  2.577e-01  -0.004   0.9967
## `18`         2.693e-01  4.755e-01   0.566   0.5737
## `19`        -1.382e+00  1.154e+00  -1.197   0.2369
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##
## Residual standard error: 0.9701 on 49 degrees of freedom
## Multiple R-squared:  0.3317, Adjusted R-squared:  0.05899
## F-statistic: 1.216 on 20 and 49 DF,  p-value: 0.2819
```

This gives the same results as the individual models (unsurprisingly). The adjusted R^2 (0.059) is quite a bit lower than R^2 (0.332) suggesting that we might benefit from reducing the number of predictors in the model.

We know that 12 PCs explain 90% of the variance in the acoustic feature differences, so what if we try to predict mean similarity using the first 12 PCs only?

```
##
## Call:
## lm(formula = mean_sim ~ ., data = .)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.51514 -0.73389 -0.07226  0.66381  1.82597
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -4.219e-16  1.167e-01   0.000   1.0000
## `0`         -9.500e-02  5.240e-02  -1.813   0.0751 .
## `1`          2.165e-02  7.279e-02   0.297   0.7673
## `2`         -1.648e-01  8.501e-02  -1.939   0.0575 .
## `3`         -2.698e-02  8.942e-02  -0.302   0.7640
## `4`          6.686e-02  9.624e-02   0.695   0.4901
## `5`          1.462e-01  1.138e-01   1.285   0.2041
## `6`          5.140e-02  1.237e-01   0.415   0.6794
## `7`         -2.206e-01  1.271e-01  -1.737   0.0879 .
## `8`          1.359e-01  1.329e-01   1.022   0.3111
## `9`         -1.353e-03  1.456e-01  -0.009   0.9926
## `10`         4.549e-02  1.573e-01   0.289   0.7735
## `11`         2.173e-01  1.695e-01   1.282   0.2050
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9768 on 57 degrees of freedom
## Multiple R-squared:  0.2118, Adjusted R-squared:  0.04588
## F-statistic: 1.277 on 12 and 57 DF,  p-value: 0.2576
```

Same thing - the PCs that were marginally significant are still marginally significant (without correction). I don't have an intuition for how interactions between PCs would improve prediction (if at all).