

Tone Classification

Giang Le and Helen Kim

10/28/2021

Data Import and Preprocessing

Our data contains 12 voice reports from 12 recording sessions.

```
# Read in all the voice reports.
dataFiles <- lapply(Sys.glob("*/channel1/acoustic_measurements_*.csv"), read.csv)

## Add the following categorical predictors.
# Gender: F and M (done)
# Noise type: quiet, 78 or 90 (done)
# Single token or token in a sentence
# Syllable type
# Tone

# Converting to DataFrames

f_1_78 <- as.data.frame(dataFiles[1])
f_1_90 <- as.data.frame(dataFiles[2])
f_1_q <- as.data.frame(dataFiles[3])

m_1_78 <- as.data.frame(dataFiles[4])
m_1_90 <- as.data.frame(dataFiles[5])
m_1_q <- as.data.frame(dataFiles[6])

m_2_78 <- as.data.frame(dataFiles[7])
m_2_90 <- as.data.frame(dataFiles[8])
m_2_q <- as.data.frame(dataFiles[9])

m_3_78 <- as.data.frame(dataFiles[10])
m_3_90 <- as.data.frame(dataFiles[11])
m_3_q <- as.data.frame(dataFiles[12])

# Assigning gender variable (0 for female and 1 for male)
f_1_78$gender = 0
f_1_90$gender = 0
f_1_q$gender = 0

m_1_78$gender = 1
m_1_90$gender = 1
m_1_q$gender = 1

m_2_78$gender = 1
m_2_90$gender = 1
```

```

m_2_q$gender = 1

m_3_78$gender = 1
m_3_90$gender = 1
m_3_q$gender = 1

# Assigning noise level
f_1_78$noise = 78
f_1_90$noise = 90
f_1_q$noise = 0

m_1_78$noise = 78
m_1_90$noise = 90
m_1_q$noise = 0

m_2_78$noise = 78
m_2_90$noise = 90
m_2_q$noise = 0

m_3_78$noise = 78
m_3_90$noise = 90
m_3_q$noise = 0

### Concatenate all dataframes
voice_reports <- rbind(f_1_78, f_1_90, f_1_q,
                      m_1_78, m_1_90, m_1_q,
                      m_2_78, m_2_90, m_2_q,
                      m_3_78, m_3_90, m_3_q)

dim(voice_reports)

## [1] 3786   36

# Assigning if the token is single (1) or not (0).
voice_reports$single <- ifelse(grepl("single", voice_reports$sound.name), 1, 0)

# Assign syllable shapes (do later)

# Assign tone values
voice_reports$tone <- ifelse(grepl("a", voice_reports$sound.name, ignore.case=T), "A1",
                             ifelse(grepl("à", voice_reports$sound.name, ignore.case=T), "A2",
                                     ifelse(grepl("á", voice_reports$sound.name, ignore.case=T), "B1",
                                             ifelse(grepl("â", voice_reports$sound.name, ignore.case=T), "C1",
                                                     ifelse(grepl("ã", voice_reports$sound.name, ignore.case=T), "C2",
                                                         ifelse(grepl("ä", voice_reports$sound.name, ignore.case=T), "B2",
                                                             ifelse(grepl("ê", voice_reports$sound.name, ignore.case=T), "A1",
                                                                 ifelse(grepl("è", voice_reports$sound.name, ignore.case=T), "A2",
                                                                    ifelse(grepl("é", voice_reports$sound.name, ignore.case=T), "B1",
                                                                        ifelse(grepl("ë", voice_reports$sound.name, ignore.case=T), "C1",
                                                                            ifelse(grepl("ẽ", voice_reports$sound.name, ignore.case=T), "C2",
                                                                                ifelse(grepl("ê", voice_reports$sound.name, ignore.case=T), "B2",
                                                                                    ifelse(grepl("u", voice_reports$sound.name, ignore.case=T), "A1",
                                                                                        ifelse(grepl("ù", voice_reports$sound.name, ignore.case=T), "A2",

```

```

        ifelse(grepl("ũ", voice_reports$sound.name, ignore.case=T), "B1",
        ifelse(grepl("ũ", voice_reports$sound.name, ignore.case=T), "C1",
        ifelse(grepl("ũ", voice_reports$sound.name, ignore.case=T), "C2",
        ifelse(grepl("ұ", voice_reports$sound.name, ignore.case=T), "B2",
        ifelse(grepl("õ", voice_reports$sound.name, ignore.case=T), "B2", "NA")))))))

# Assign phonation types
voice_reports$phonation <- ifelse(grepl("A1", voice_reports$tone, ignore.case=T), "modal",
        ifelse(grepl("A2", voice_reports$tone, ignore.case=T), "breathy",
        ifelse(grepl("B1", voice_reports$tone, ignore.case=T), "modal",
        ifelse(grepl("B2", voice_reports$tone, ignore.case=T), "creaky",
        ifelse(grepl("C1", voice_reports$tone, ignore.case=T), "creaky",
        ifelse(grepl("C2", voice_reports$tone, ignore.case=T), "creaky", "NA")))))

# Assign creakiness or not
voice_reports$creaky <- ifelse(grepl("creaky", voice_reports$phonation, ignore.case=T), 1, 0)
head(voice_reports, 20)

```

##	sound.name	total.duration	intensity	spectraltilt	median.F0	mean.F0	sd.F0
## 1	đô	0.229	60.102	-27.852	218.143	200.097	47.803
## 2	đô	0.176	63.003	-27.852	207.166	204.083	6.503
## 3	ẽ	0.444	61.756	-11.698	237.639	187.930	72.74
## 4	ẽ	0.330	59.292	-11.698	223.784	224.516	11.948
## 5	ê	0.430	60.768	-10.194	221.383	220.045	3.625
## 6	ê	0.450	62.075	-10.194	216.449	217.061	4.037
## 7	ệ	0.252	61.200	-11.646	215.220	266.343	134.326
## 8	ệ	0.173	62.570	-11.646	216.202	204.334	31.707
## 9	ẻ	0.469	60.697	-16.422	165.238	162.472	32.743
## 10	ẻ	0.235	60.548	-16.422	167.355	170.803	14.12
## 11	ể	0.419	61.703	-13.377	186.304	203.317	30.96
## 12	ể	0.382	60.027	-13.377	180.660	189.969	17.373
## 13	ề	0.537	61.288	-11.035	178.111	178.156	7.269
## 14	ề	0.450	61.082	-11.035	181.224	180.169	7.256
## 15	TÚT_single	0.175	64.908	-30.200	263.405	262.553	16.382
## 16	TÚT_single	0.183	65.207	-30.200	251.474	253.861	5.784
## 17	TỤT_single	0.194	65.341	-31.444	198.831	195.492	6.208
## 18	TỤT_single	0.229	63.707	-31.444	194.444	195.044	6.422
## 19	thề	0.417	61.015	-18.748	91.309	92.451	5.401
## 20	thề	0.426	62.959	-18.748	174.213	176.461	12.694
##	min.F0	max.F0	number.pulses	number.periods	mean.periods	sd.period	
## 1	73.534	262.563	2	0	--undefined--	--undefined--	
## 2	186.197	210.989	27	26	4.914	0.212	
## 3	104.652	266.835	2	0	--undefined--	--undefined--	
## 4	199.758	241.472	69	68	4.447	0.248	
## 5	205.575	224.446	1	0	--undefined--	--undefined--	
## 6	197.153	222.391	92	91	4.599	0.07	
## 7	193.569	599.754	2	0	--undefined--	--undefined--	
## 8	87.511	218.542	27	25	4.709	0.239	
## 9	68.204	203.482	2	0	--undefined--	--undefined--	
## 10	149.351	194.444	36	35	5.886	0.482	
## 11	171.339	279.908	1	0	--undefined--	--undefined--	
## 12	173.984	236.270	69	68	5.232	0.485	
## 13	166.773	191.322	1	0	--undefined--	--undefined--	

## 14	165.546	190.824	78	77	5.551	0.231
## 15	221.589	341.236	1	0	--undefined--	--undefined--
## 16	248.457	269.794	40	39	3.925	0.106
## 17	185.141	201.616	1	0	--undefined--	--undefined--
## 18	185.762	213.028	40	39	5.146	0.153
## 19	85.531	112.158	1	0	--undefined--	--undefined--
## 20	159.266	216.873	71	70	5.695	0.378
##	fraction.of.locally.unvoiced.frames					
## 1	6.383					
## 2	2.857					
## 3	3.030					
## 4	0.000					
## 5	1.042					
## 6	1.000					
## 7	13.208					
## 8	2.941					
## 9	2.857					
## 10	0.000					
## 11	0.000					
## 12	0.000					
## 13	0.826					
## 14	0.000					
## 15	2.857					
## 16	0.000					
## 17	0.000					
## 18	0.000					
## 19	0.000					
## 20	0.000					
##				fraction number.of.voice.breaks		
## 1	of locally unvoiced frames: 6.383%			(3 / 47)	0	
## 2	of locally unvoiced frames: 2.857%			(1 / 35)	0	
## 3	of locally unvoiced frames: 3.030%			(3 / 99)	0	
## 4	of locally unvoiced frames: 0			(0 / 72)	0	
## 5	of locally unvoiced frames: 1.042%			(1 / 96)	0	
## 6	of locally unvoiced frames: 1.000%			(1 / 100)	0	
## 7	of locally unvoiced frames: 13.208%			(7 / 53)	0	
## 8	of locally unvoiced frames: 2.941%			(1 / 34)	0	
## 9	of locally unvoiced frames: 2.857%			(3 / 105)	0	
## 10	of locally unvoiced frames: 0			(0 / 49)	0	
## 11	of locally unvoiced frames: 0			(0 / 93)	0	
## 12	of locally unvoiced frames: 0			(0 / 84)	0	
## 13	of locally unvoiced frames: 0.826%			(1 / 121)	0	
## 14	of locally unvoiced frames: 0			(0 / 101)	0	
## 15	of locally unvoiced frames: 2.857%			(1 / 35)	0	
## 16	of locally unvoiced frames: 0			(0 / 36)	0	
## 17	of locally unvoiced frames: 0			(0 / 39)	0	
## 18	of locally unvoiced frames: 0			(0 / 47)	0	
## 19	of locally unvoiced frames: 0			(0 / 92)	0	
## 20	of locally unvoiced frames: 0			(0 / 95)	0	
##	degree.of.voice.breaks			degree		
## 1	0 of voice breaks: 0			(0 seconds / 0.229018 seconds)		
## 2	0 of voice breaks: 0			(0 seconds / 0.176274 seconds)		
## 3	0 of voice breaks: 0			(0 seconds / 0.444099 seconds)		
## 4	0 of voice breaks: 0			(0 seconds / 0.330119 seconds)		

```

## 5          0          of voice breaks: 0 (0 seconds / 0 seconds)
## 6          0 of voice breaks: 0 (0 seconds / 0.449857 seconds)
## 7          0 of voice breaks: 0 (0 seconds / 0.251984 seconds)
## 8          0 of voice breaks: 0 (0 seconds / 0.173127 seconds)
## 9          0 of voice breaks: 0 (0 seconds / 0.469197 seconds)
## 10         0 of voice breaks: 0 (0 seconds / 0.234767 seconds)
## 11         0          of voice breaks: 0 (0 seconds / 0 seconds)
## 12         0 of voice breaks: 0 (0 seconds / 0.381955 seconds)
## 13         0          of voice breaks: 0 (0 seconds / 0 seconds)
## 14         0 of voice breaks: 0 (0 seconds / 0.450367 seconds)
## 15         0          of voice breaks: 0 (0 seconds / 0 seconds)
## 16         0 of voice breaks: 0 (0 seconds / 0.182882 seconds)
## 17         0          of voice breaks: 0 (0 seconds / 0 seconds)
## 18         0 of voice breaks: 0 (0 seconds / 0.229112 seconds)
## 19         0          of voice breaks: 0 (0 seconds / 0 seconds)
## 20         0 of voice breaks: 0 (0 seconds / 0.425752 seconds)
##      jitter.local jitter.local.abs      jitter.rap      jitter.ppq5
## 1  --undefined--  --undefined--  --undefined--  --undefined--
## 2          1.74          85.486          0.746          0.376
## 3  --undefined--  --undefined--  --undefined--  --undefined--
## 4          0.626          27.845          0.241          0.253
## 5  --undefined--  --undefined--  --undefined--  --undefined--
## 6          0.448          20.622          0.222          0.175
## 7  --undefined--  --undefined--  --undefined--  --undefined--
## 8          1.247          58.7          0.273          0.435
## 9  --undefined--  --undefined--  --undefined--  --undefined--
## 10         1.81          106.54          0.853          0.923
## 11 --undefined--  --undefined--  --undefined--  --undefined--
## 12         0.59          30.893          0.195          0.248
## 13 --undefined--  --undefined--  --undefined--  --undefined--
## 14         0.498          27.666          0.214          0.226
## 15 --undefined--  --undefined--  --undefined--  --undefined--
## 16         0.977          38.342          0.563          0.605
## 17 --undefined--  --undefined--  --undefined--  --undefined--
## 18         0.42          21.599          0.182          0.166
## 19 --undefined--  --undefined--  --undefined--  --undefined--
## 20         0.75          42.721          0.365          0.315
##      shimmer.local shimmer.local.db      shimmer.apq3      shimmer.apq5
## 1  --undefined--  --undefined--  --undefined--  --undefined--
## 2          4.275          0.442          1.14          1.762
## 3  --undefined--  --undefined--  --undefined--  --undefined--
## 4          1.327          0.117          0.543          0.625
## 5  --undefined--  --undefined--  --undefined--  --undefined--
## 6          1.751          0.163          0.865          0.784
## 7  --undefined--  --undefined--  --undefined--  --undefined--
## 8          2.244          0.195          0.794          1.168
## 9  --undefined--  --undefined--  --undefined--  --undefined--
## 10         4.857          0.634          1.579          1.607
## 11 --undefined--  --undefined--  --undefined--  --undefined--
## 12         1.927          0.175          0.551          0.642
## 13 --undefined--  --undefined--  --undefined--  --undefined--
## 14         2.16          0.214          0.461          0.605
## 15 --undefined--  --undefined--  --undefined--  --undefined--
## 16         2.131          0.196          0.824          1.047

```

```
## 17 --undefined-- --undefined-- --undefined-- --undefined--
## 18      3.799      0.344      2.123      1.871
## 19 --undefined-- --undefined-- --undefined-- --undefined--
## 20      1.68      0.179      0.653      0.665
##      shimmer.apq11 mean.autocorr mean.NHR mean.HNR      F1      F2      F3
## 1  --undefined--      0.878      0.179      12.707      483.544      892.193      3164.547
## 2      4.392      0.962      0.053      18.742      483.544      892.193      3164.547
## 3  --undefined--      0.902      0.140      15.992      579.219      2386.550      3061.336
## 4      1.38      0.979      0.023      20.417      579.219      2386.550      3061.336
## 5  --undefined--      0.974      0.052      25.633      459.312      2321.976      2681.153
## 6      0.979      0.979      0.038      26.296      459.312      2321.976      2681.153
## 7  --undefined--      0.882      0.184      12.837      589.323      2276.287      2893.363
## 8      1.602      0.894      0.156      15.351      589.323      2276.287      2893.363
## 9  --undefined--      0.938      0.079      15.077      492.646      2382.580      2887.993
## 10     2.254      0.966      0.038      16.928      492.646      2382.580      2887.993
## 11  --undefined--      0.975      0.031      19.640      469.019      2381.116      2864.526
## 12     1.09      0.988      0.012      21.111      469.019      2381.116      2864.526
## 13  --undefined--      0.987      0.018      25.883      496.146      2391.518      2735.378
## 14     1.299      0.985      0.022      23.938      496.146      2391.518      2735.378
## 15  --undefined--      0.939      0.105      20.641      428.646      820.776      3166.460
## 16     1.703      0.984      0.018      23.193      428.646      820.776      3166.460
## 17  --undefined--      0.959      0.056      20.837      399.714      935.860      2910.953
## 18     1.922      0.983      0.023      24.161      399.714      935.860      2910.953
## 19  --undefined--      0.975      0.026      18.324      502.106      2248.255      2971.067
## 20     1.156      0.988      0.013      21.172      502.106      2248.255      2971.067
##      F4 gender noise single tone phonation creaky
## 1  3701.005      0      78      0      B2      creaky      1
## 2  3701.005      0      78      0      B2      creaky      1
## 3  4024.072      0      78      0      C2      creaky      1
## 4  4024.072      0      78      0      C2      creaky      1
## 5  3764.261      0      78      0      A1      modal      0
## 6  3764.261      0      78      0      A1      modal      0
## 7  3616.906      0      78      0      B2      creaky      1
## 8  3616.906      0      78      0      B2      creaky      1
## 9  4283.656      0      78      0      C1      creaky      1
## 10 4283.656      0      78      0      C1      creaky      1
## 11 3900.203      0      78      0      B1      modal      0
## 12 3900.203      0      78      0      B1      modal      0
## 13 3869.799      0      78      0      A2      breathy     0
## 14 3869.799      0      78      0      A2      breathy     0
## 15 3803.949      0      78      1      B1      modal      0
## 16 3803.949      0      78      1      B1      modal      0
## 17 3651.814      0      78      1      B2      creaky      1
## 18 3651.814      0      78      1      B2      creaky      1
## 19 4094.997      0      78      0      A2      breathy     0
## 20 4094.997      0      78      0      A2      breathy     0
```

Checking

```
# How many values are of each category
length(voice_reports$tone[voice_reports$tone == "A1"])
```

```
## [1] 574
```

```
## [1] 574
length(voice_reports$tone[voice_reports$tone == "A2"])
```

```
## [1] 575
```

```
## [1] 575
length(voice_reports$tone[voice_reports$tone == "B1"])
```

```
## [1] 719
```

```
## [1] 719
length(voice_reports$tone[voice_reports$tone == "B2"])
```

```
## [1] 768
```

```
## [1] 768
length(voice_reports$tone[voice_reports$tone == "C1"])
```

```
## [1] 575
```

```
## [1] 575
length(voice_reports$tone[voice_reports$tone == "C2"])
```

```
## [1] 575
```

```
## [1] 575
length(voice_reports$tone[voice_reports$tone == "NA"])
```

```
## [1] 0
```

```
## [1] 0
```

Convert categorical values to factors

```
## Not sure if this is necessary for variables already binarily coded.
voice_reports$gender <- as.factor(voice_reports$gender)
voice_reports$noise <- as.factor(voice_reports$noise)
voice_reports$tone <- as.factor(voice_reports$tone)
voice_reports$single <- as.factor(voice_reports$single)
voice_reports$phonation <- as.factor(voice_reports$phonation)
voice_reports$creaky <- as.factor(voice_reports$creaky)
```

Summary of current data

```
summary(voice_reports)
```

```
##  sound.name      total.duration      intensity      spectraltilt
##  Length:3786      Min.   :0.0340      Min.   :46.69      Min.   : -44.880
##  Class :character  1st Qu.:0.2140      1st Qu.:60.91      1st Qu.: -26.676
##  Mode  :character  Median :0.3110      Median :64.94      Median : -17.795
##                      Mean   :0.3208      Mean   :64.74      Mean   : -19.761
##                      3rd Qu.:0.4180      3rd Qu.:69.47      3rd Qu.: -13.379
##                      Max.   :0.7790      Max.   :80.76      Max.   :  2.476
##  median.F0      mean.F0      sd.F0      min.F0
##  Min.   : 64.1      Min.   : 65.06      Length:3786      Min.   : 53.19
##  1st Qu.:118.3      1st Qu.:120.72      Class :character  1st Qu.: 89.42
##  Median :143.2      Median :146.21      Mode  :character  Median :115.19
```

```

## Mean :154.8 Mean :158.63 Mean :123.80
## 3rd Qu.:178.8 3rd Qu.:185.94 3rd Qu.:150.39
## Max. :572.5 Max. :435.42 Max. :299.23
## max.F0 number.pulses number.periods mean.periods
## Min. : 68.75 Min. : 1.00 Min. : 0.00 Length:3786
## 1st Qu.:143.49 1st Qu.: 1.00 1st Qu.: 0.00 Class :character
## Median :172.48 Median : 5.00 Median : 3.50 Mode :character
## Mean :206.09 Mean : 23.35 Mean : 22.10
## 3rd Qu.:234.74 3rd Qu.: 39.00 3rd Qu.: 37.75
## Max. :599.75 Max. :151.00 Max. :150.00
## sd.period fraction.of.locally.unvoiced.frames fraction
## Length:3786 Min. : 0.000 Length:3786
## Class :character 1st Qu.: 0.000 Class :character
## Mode :character Median : 0.000 Mode :character
## Mean : 2.443
## 3rd Qu.: 2.041
## Max. :50.000
## number.of.voice.breaks degree.of.voice.breaks degree
## Min. :0.00000 Min. : 0.000 Length:3786
## 1st Qu.:0.00000 1st Qu.: 0.000 Class :character
## Median :0.00000 Median : 0.000 Mode :character
## Mean :0.08928 Mean : 1.859
## 3rd Qu.:0.00000 3rd Qu.: 0.000
## Max. :3.00000 Max. :62.660
## jitter.local jitter.local.abs jitter.rap jitter.ppq5
## Length:3786 Length:3786 Length:3786 Length:3786
## Class :character Class :character Class :character Class :character
## Mode :character Mode :character Mode :character Mode :character
##
##
## shimmer.local shimmer.local.db shimmer.apq3 shimmer.apq5
## Length:3786 Length:3786 Length:3786 Length:3786
## Class :character Class :character Class :character Class :character
## Mode :character Mode :character Mode :character Mode :character
##
##
## shimmer.apq11 mean.autocorr mean.NHR mean.HNR
## Length:3786 Min. :0.5900 Min. :0.0007 Min. : 1.714
## Class :character 1st Qu.:0.8780 1st Qu.:0.0230 1st Qu.:11.672
## Mode :character Median :0.9480 Median :0.0650 Median :16.133
## Mean :0.9217 Mean :0.1166 Mean :16.232
## 3rd Qu.:0.9790 3rd Qu.:0.1750 3rd Qu.:20.543
## Max. :0.9990 Max. :0.7660 Max. :34.233
## F1 F2 F3 F4 gender
## Min. : 201.0 Min. : 514.6 Min. :1860 Min. :2873 0: 947
## 1st Qu.: 380.1 1st Qu.: 907.9 1st Qu.:2598 1st Qu.:3526 1:2839
## Median : 472.7 Median :1584.1 Median :2722 Median :3695
## Mean : 552.5 Mean :1498.5 Mean :2745 Mean :3734
## 3rd Qu.: 767.6 3rd Qu.:1958.7 3rd Qu.:2866 3rd Qu.:3888
## Max. :1192.0 Max. :2805.6 Max. :3458 Max. :4950
## noise single tone phonation creaky
## 0 :1260 0:1893 A1:574 breathy: 575 0:1868

```



```
## 78:1263 1:1893 A2:575 creaky :1918 1:1918
## 90:1263 B1:719 modal :1293
## B2:768
## C1:575
## C2:575
```

Logistic Regression on Gender

```
head(voice_reports)
```

```
## sound.name total.duration intensity spectraltilt median.F0 mean.F0 sd.F0
## 1 đô 0.229 60.102 -27.852 218.143 200.097 47.803
## 2 đô 0.176 63.003 -27.852 207.166 204.083 6.503
## 3 ẽ 0.444 61.756 -11.698 237.639 187.930 72.74
## 4 ẽ 0.330 59.292 -11.698 223.784 224.516 11.948
## 5 ê 0.430 60.768 -10.194 221.383 220.045 3.625
## 6 ê 0.450 62.075 -10.194 216.449 217.061 4.037
## min.F0 max.F0 number.pulses number.periods mean.periods sd.period
## 1 73.534 262.563 2 0 --undefined-- --undefined--
## 2 186.197 210.989 27 26 4.914 0.212
## 3 104.652 266.835 2 0 --undefined-- --undefined--
## 4 199.758 241.472 69 68 4.447 0.248
## 5 205.575 224.446 1 0 --undefined-- --undefined--
## 6 197.153 222.391 92 91 4.599 0.07
## fraction.of.locally.unvoiced.frames
## 1 6.383
## 2 2.857
## 3 3.030
## 4 0.000
## 5 1.042
## 6 1.000
## fraction number.of.voice.breaks
## 1 of locally unvoiced frames: 6.383% (3 / 47) 0
## 2 of locally unvoiced frames: 2.857% (1 / 35) 0
## 3 of locally unvoiced frames: 3.030% (3 / 99) 0
## 4 of locally unvoiced frames: 0 (0 / 72) 0
## 5 of locally unvoiced frames: 1.042% (1 / 96) 0
## 6 of locally unvoiced frames: 1.000% (1 / 100) 0
## degree.of.voice.breaks degree
## 1 0 of voice breaks: 0 (0 seconds / 0.229018 seconds)
## 2 0 of voice breaks: 0 (0 seconds / 0.176274 seconds)
## 3 0 of voice breaks: 0 (0 seconds / 0.444099 seconds)
## 4 0 of voice breaks: 0 (0 seconds / 0.330119 seconds)
## 5 0 of voice breaks: 0 (0 seconds / 0 seconds)
## 6 0 of voice breaks: 0 (0 seconds / 0.449857 seconds)
## jitter.local jitter.local.abs jitter.rap jitter.ppq5
## 1 --undefined-- --undefined-- --undefined-- --undefined--
## 2 1.74 85.486 0.746 0.376
## 3 --undefined-- --undefined-- --undefined-- --undefined--
## 4 0.626 27.845 0.241 0.253
## 5 --undefined-- --undefined-- --undefined-- --undefined--
## 6 0.448 20.622 0.222 0.175
## shimmer.local shimmer.local.db shimmer.apq3 shimmer.apq5
## 1 --undefined-- --undefined-- --undefined-- --undefined--
```

```
## 2      4.275      0.442      1.14      1.762
## 3 --undefined-- --undefined-- --undefined-- --undefined--
## 4      1.327      0.117      0.543      0.625
## 5 --undefined-- --undefined-- --undefined-- --undefined--
## 6      1.751      0.163      0.865      0.784
##      shimmer.apq11 mean.autocorr mean.NHR mean.HNR      F1      F2      F3
## 1 --undefined--      0.878      0.179      12.707 483.544 892.193 3164.547
## 2      4.392      0.962      0.053      18.742 483.544 892.193 3164.547
## 3 --undefined--      0.902      0.140      15.992 579.219 2386.550 3061.336
## 4      1.38      0.979      0.023      20.417 579.219 2386.550 3061.336
## 5 --undefined--      0.974      0.052      25.633 459.312 2321.976 2681.153
## 6      0.979      0.979      0.038      26.296 459.312 2321.976 2681.153
##      F4 gender noise single tone phonation creaky
## 1 3701.005      0      78      0      B2      creaky      1
## 2 3701.005      0      78      0      B2      creaky      1
## 3 4024.072      0      78      0      C2      creaky      1
## 4 4024.072      0      78      0      C2      creaky      1
## 5 3764.261      0      78      0      A1      modal      0
## 6 3764.261      0      78      0      A1      modal      0
```

```
logit_gender = glm(gender ~ mean.F0 + total.duration + intensity + mean.HNR, family = "binomial", data = voice_reports)
summary(logit_gender)
```

```
##
## Call:
## glm(formula = gender ~ mean.F0 + total.duration + intensity +
##      mean.HNR, family = "binomial", data = voice_reports)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.0389 -0.0104  0.1600  0.4089  3.6153
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)  -10.326029  0.682930 -15.120  <2e-16 ***
## mean.F0       -0.037658  0.001378 -27.328  <2e-16 ***
## total.duration -4.282263  0.485318  -8.824  <2e-16 ***
## intensity      0.333715  0.013984  23.865  <2e-16 ***
## mean.HNR      -0.103735  0.010847  -9.563  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 4259.1  on 3785  degrees of freedom
## Residual deviance: 2030.6  on 3781  degrees of freedom
## AIC: 2040.6
##
## Number of Fisher Scoring iterations: 6
```

Logistic Regression on Creaky

```
logit_creaky = glm(creaky ~ mean.F0 + total.duration + intensity + spectraltilt + number.pulses + mean
summary(logit_creaky)
```

```
##
## Call:
## glm(formula = creaky ~ mean.F0 + total.duration + intensity +
##      spectraltilt + number.pulses + mean.HNR, family = "binomial",
##      data = voice_reports)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -3.3908  -0.5292   0.0479   0.5794   3.0066
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    3.201521    0.513323   6.237 4.46e-10 ***
## mean.F0         0.018511    0.001155  16.027 < 2e-16 ***
## total.duration -1.491809    0.393382  -3.792 0.000149 ***
## intensity      -0.003770    0.007247  -0.520 0.602949
## spectraltilt   -0.110813    0.006679 -16.592 < 2e-16 ***
## number.pulses   0.002771    0.001741   1.591 0.111564
## mean.HNR       -0.470632    0.015475 -30.413 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##      Null deviance: 5247.9  on 3785  degrees of freedom
## Residual deviance: 2897.3  on 3779  degrees of freedom
## AIC: 2911.3
##
## Number of Fisher Scoring iterations: 6
```

Multinomial Regression to predict the Noise Level.

```
## Use the multinom function from the nnet package (Ref: https://stats.idre.ucla.edu/r/dae/multinomial-
library("nnet")
# Use the 78 noise level as the reference level
voice_reports$noise2 <- relevel(voice_reports$noise, ref = "78")
multinom_noise <- multinom(noise2 ~ mean.F0 + total.duration + intensity + spectraltilt, data=voice_rep

## # weights:  18 (10 variable)
## initial value 4159.346125
## iter  10 value 2581.712398
## iter  20 value 2500.771170
## final value 2500.770889
## converged

summary(multinom_noise)

## Call:
## multinom(formula = noise2 ~ mean.F0 + total.duration + intensity +
##      spectraltilt, data = voice_reports)
##
## Coefficients:
##      (Intercept)      mean.F0 total.duration  intensity spectraltilt
## 0      23.98251 -0.013331533      -5.795162 -0.3457656 -0.06686426
```

```
## 90    -18.31800  0.006286322      2.800752  0.2429637  0.01129598
##
## Std. Errors:
##      (Intercept)      mean.F0 total.duration  intensity spectraltilt
## 0      0.9973863  0.0013025075      0.4981253  0.01486610  0.006887869
## 90     0.8839808  0.0008520673      0.3566817  0.01183026  0.005179322
##
## Residual Deviance: 5001.542
## AIC: 5021.542
```

```
# The result in general supports our predictions regarding the relationship
# between relative noise levels
# and F0, duration, intensity, etc.
```

```
# For instance,
# A one-unit increase in mean F0 is associated with the decrease in the
# log odds of quiet vs. 78 noise level in the amount of 0.0133
# A one-unit increase in mean F0 is associated with the increase in the
# log odds of 90 noise vs. 78 noise in the amount of 0.006
```

```
# A one-unit increase in duration is associated with the decrease in the
# log odds of quiet vs. 78 noise level in the amount of 5.795
# A one-unit increase in duration is associated with the increase in the
# log odds of 90 noise vs. 78 noise in the amount of 2.80
```

```
# A one-unit increase in intensity is associated with the decrease in the
# log odds of quiet vs. 78 noise level in the amount of 0.35
# A one-unit increase in intensity is associated with the increase in the
# log odds of 90 noise vs. 78 noise in the amount of 0.24
```

```
## Going to double check this result
# A one-unit increase in spectraltilt is associated with the decrease in the
# log odds of quiet vs. 78 noise level in the amount of 0.066
# A one-unit increase in spectraltilt is associated with the increase in the
# log odds of 90 noise vs. 78 noise in the amount of 0.011
```

Clean up undefined values to prepare for Classification

```
## Method 1: Simply drop values that are undefined in jitter and shimmer variables
voice_reports_clean <- voice_reports[!(voice_reports$jitter.local==" --undefined-- " | voice_reports$shimmer.local==" --undefined-- ") , ]

# Convert two variables to numeric
voice_reports_clean$jitter.local <- as.numeric(voice_reports_clean$jitter.local)
voice_reports_clean$shimmer.local <- as.numeric(voice_reports_clean$shimmer.local)

summary(voice_reports_clean)
```

```
##      sound.name      total.duration      intensity      spectraltilt
## Length:1894      Min.      :0.0430      Min.      :47.04      Min.      : -44.880
## Class :character  1st Qu.:0.2092      1st Qu.:60.63      1st Qu.: -26.650
## Mode  :character  Median :0.2980      Median :64.76      Median : -17.773
##                      Mean      :0.3164      Mean      :64.52      Mean      : -19.752
##                      3rd Qu.:0.4100      3rd Qu.:69.17      3rd Qu.: -13.379
##                      Max.      :0.7790      Max.      :80.55      Max.      :  2.476
```

```

##      median.F0      mean.F0      sd.F0      min.F0
## Min.   : 64.1    Min.   : 65.06   Length:1894   Min.   : 53.19
## 1st Qu.:117.1    1st Qu.:120.01   Class :character 1st Qu.: 89.66
## Median :142.0    Median :144.38   Mode  :character Median :115.21
## Mean   :152.8    Mean   :156.54                   Mean   :123.25
## 3rd Qu.:177.5    3rd Qu.:184.03                   3rd Qu.:149.36
## Max.   :570.8    Max.   :435.42                   Max.   :281.04
##      max.F0      number.pulses      number.periods      mean.periods
## Min.   : 68.75    Min.   : 4.00    Min.   : 3.00    Length:1894
## 1st Qu.:142.09    1st Qu.: 25.00    1st Qu.: 24.00    Class :character
## Median :169.10    Median : 39.00    Median : 37.50    Mode  :character
## Mean   :202.04    Mean   : 45.37    Mean   : 44.17
## 3rd Qu.:230.61    3rd Qu.: 62.00    3rd Qu.: 61.00
## Max.   :598.15    Max.   :151.00    Max.   :150.00
##      sd.period      fraction.of.locally.unvoiced.frames      fraction
## Length:1894      Min.   : 0.000      Length:1894
## Class :character 1st Qu.: 0.000      Class :character
## Mode  :character Median : 0.000      Mode  :character
##                      Mean   : 2.325
##                      3rd Qu.: 1.923
##                      Max.   :47.945
##      number.of.voice.breaks      degree.of.voice.breaks      degree
## Min.   :0.000      Min.   : 0.000      Length:1894
## 1st Qu.:0.000      1st Qu.: 0.000      Class :character
## Median :0.000      Median : 0.000      Mode  :character
## Mean   :0.104      Mean   : 1.272
## 3rd Qu.:0.000      3rd Qu.: 0.000
## Max.   :3.000      Max.   :45.979
##      jitter.local      jitter.local.abs      jitter.rap      jitter.ppq5
## Min.   : 0.1560    Length:1894    Length:1894    Length:1894
## 1st Qu.: 0.8492    Class :character  Class :character  Class :character
## Median : 1.5280    Mode  :character  Mode  :character  Mode  :character
## Mean   : 2.3710
## 3rd Qu.: 3.0100
## Max.   :19.6740
##      shimmer.local      shimmer.local.db      shimmer.apq3      shimmer.apq5
## Min.   : 0.891    Length:1894    Length:1894    Length:1894
## 1st Qu.: 3.456    Class :character  Class :character  Class :character
## Median : 5.298    Mode  :character  Mode  :character  Mode  :character
## Mean   : 6.645
## 3rd Qu.: 8.218
## Max.   :62.405
##      shimmer.apq11      mean.autocorr      mean.NHR      mean.HNR
## Length:1894      Min.   :0.6020    Min.   :0.0007    Min.   : 1.991
## Class :character 1st Qu.:0.8820    1st Qu.:0.0220    1st Qu.:11.755
## Mode  :character Median :0.9500    Median :0.0630    Median :16.238
##                      Mean   :0.9232    Mean   :0.1144    Mean   :16.349
##                      3rd Qu.:0.9800    3rd Qu.:0.1727    3rd Qu.:20.741
##                      Max.   :0.9990    Max.   :0.7550    Max.   :34.233
##      F1      F2      F3      F4      gender
## Min.   : 201.0    Min.   : 514.6    Min.   :1860    Min.   :2873    0: 473
## 1st Qu.: 380.2    1st Qu.: 907.9    1st Qu.:2599    1st Qu.:3526    1:1421
## Median : 473.0    Median :1584.1    Median :2722    Median :3694
## Mean   : 552.9    Mean   :1498.7    Mean   :2744    Mean   :3734

```

```
## 3rd Qu.: 768.4    3rd Qu.:1958.7    3rd Qu.:2865    3rd Qu.:3888
## Max.      :1192.0    Max.      :2805.6    Max.      :3458    Max.      :4950
## noise     single tone      phonation    creaky    noise2
## 0 :631     0:947    A1:287     breathy:288    0:934    78:631
## 78:631     1:947    A2:288     creaky :960    1:960    0 :631
## 90:632          B1:359    modal   :646          90:632
##                      B2:384
##                      C1:288
##                      C2:288
```

Classification using SMV (ref <https://medium.com/@ODSC/build-a-multi-class-support-vector-machine-in-r-abcdd4b7dab6>)

```
library(e1071)
set.seed(777)
n <- nrow(voice_reports_clean)
ntrain <- round(n*0.75) # 75% for training set
tindex <- sample(n, ntrain)
train <- voice_reports_clean[tindex,c("total.duration", "intensity",
                                       "spectraltilt", "mean.F0", "jitter.local",
                                       "shimmer.local", "mean.HNR", "gender",
                                       "noise", "F1", "F2", "tone")]
test <- voice_reports_clean[-tindex,c("total.duration", "intensity",
                                       "spectraltilt", "mean.F0", "jitter.local",
                                       "shimmer.local", "mean.HNR", "gender",
                                       "noise", "F1", "F2", "tone")]

# Some factors cause any error probably due to not having the same levels between train and test?
svm_model <- svm(tone ~ total.duration + intensity + spectraltilt + mean.F0 + jitter.local
                + shimmer.local + mean.HNR + gender + noise + F1 + F2, data=train,
                method="C-classification", kernel="radial",
                gamma=0.1, cost=10)

summary(svm_model)

##
## Call:
## svm(formula = tone ~ total.duration + intensity + spectraltilt +
##      mean.F0 + jitter.local + shimmer.local + mean.HNR + gender +
##      noise + F1 + F2, data = train, method = "C-classification", kernel = "radial",
##      gamma = 0.1, cost = 10)
##
##
## Parameters:
##   SVM-Type:  C-classification
##   SVM-Kernel: radial
##      cost:   10
##
## Number of Support Vectors: 1049
##
## ( 152 224 177 123 159 214 )
##
##
## Number of Classes: 6
```

```
##
## Levels:
##  A1 A2 B1 B2 C1 C2
prediction <- predict(svm_model, test)
confusion <- table(test$stone, prediction)
confusion
```

```
##      prediction
##      A1 A2 B1 B2 C1 C2
##  A1 55  5  9  0  0  0
##  A2  3 61 11  1  1  0
##  B1  4  9 68  5  6  7
##  B2  2  0  5 71  9 16
##  C1  1  1  6  8 51  2
##  C2  0  0  4  9  2 42
```