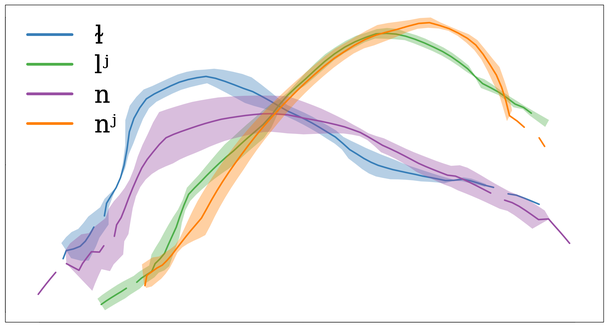
ultrapolaRplot: A free/open-source R library for plotting tongue traces

Yana Outkin youtkin1@swarthmore.edu
Jonathan N. Washington jwashin1@swarthmore.edu
Swarthmore College

Introduction

- R library for plotting tongue traces
- complements / uses data from UltraTrace annotation tool
- free/open-source license (GPLv3)
- simple to use!
- highly configurable!
- in CRAN! to use: `install.packages('ultrapolaRplot')`

Simple example: (Russian palatal dataset)




```
library(ultrapolaRplot) # assumed henceforth

rawTraces <- loadTraces('../palatals/', 'cons')
polarTraces <- makeTracesPolar(rawTraces)
plotTraces(rawTraces, polarTraces,
     pdf.filename="palatals.pdf")
```

Basics

- descriptive: mean tongue traces, standard deviation bands

  Washington (2016), Washington & Washington (2018), Washington (2019)
- analytical: ~~SSANOVA, GAMs~~ not currently supported

  (narrow confidence intervals deceptive)
- radial/polar coordinate system (more precise)

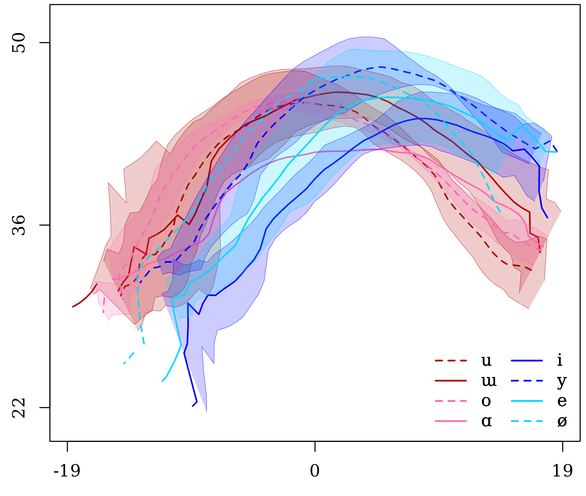
  Mielke (2015), Heyne & Derrick (2015)

SWARTHMORE

Free/open-source R library for plotting tongue traces

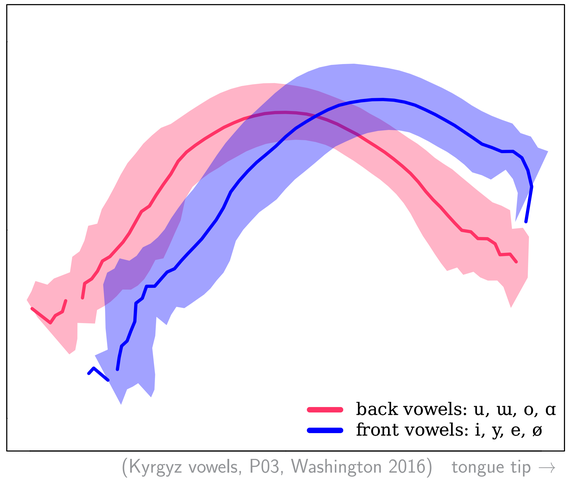
Scan with mobile camera
to access the documentation and source code
& download the poster

https://github.com/SwatPhonLab/ultrapolaRplot




```
rawTraces <- loadTraces('../P03/', 'vowels', c('u', 'ɯ',
   'o', 'ɑ', 'i', 'y', 'e', 'ø'))
polarTraces <- makeTracesPolar(rawTraces)
plotTraces(rawTraces, polarTraces, palette =
   c("#B30000", "#B30000", "#FF69B5", "#FF69B5",
   "#0000FF", "#0000FF", "#00D8FF", "#00D8FF"),
   legend.position = "bottomright", points.display =
   FALSE, bands.lines = TRUE, bands.fill = TRUE,
   transparency = 0.2, mean.lines = TRUE, means.styles =
   c(2,1,2,1,1,2,1,2), plot.labels = TRUE, plot.ticks =
   TRUE, legend.size = 1, legend.linewidth = 1.5,
   means.linewidth = 1.5, tick.size = 1,
   bands.linewidth = 0.2, pdf.filename="P03.pdf")
```

← **advanced styling**



(Kyrgyz vowels, P03, Washington 2016) tongue tip →

```
rawTraces <- loadTraces('../P03/', categoriesAll =
   list(c('u', 'ɯ', 'o', 'ɑ'), c('i', 'y', 'e', 'ø')),
   mergeCategories = TRUE)
polarTraces <- makeTracesPolar(rawTraces,
   origin.algorithm = "BottomMean")
plotTraces(rawTraces, polarTraces, pdf.filename =
   "P03_combined.pdf", maskCategories = c("back
   vowels: u, ɯ, o, ɑ", "front vowels: i, y, e,
   ø"), legend.position = "bottomright", palette =
   c("#FF3366", "#0000FF"))
```

↑ **grouping categories**

Implementation

loadTraces()

- Reads `metadata.json` (UltraTrace data) and TextGrids
- Allows data selection via interval, tier, and layer labels

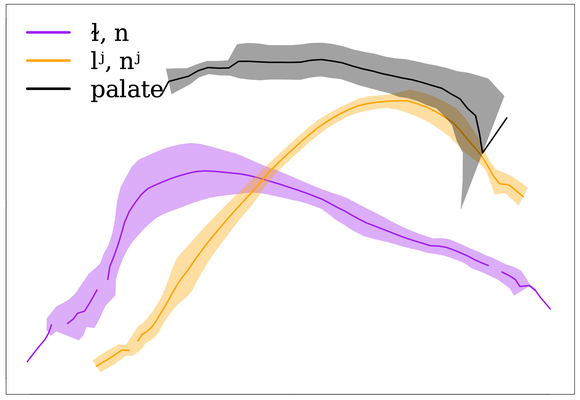
makeTracesPolar()

- Polar coordinate conversion
- Options for estimating or specifying transducer origin

plotTraces()

- Plots mean lines and standard deviation bands
  (samples traces every $n°$, finds polar coordinate intersects)
- Customizable raw annotations, colors, transparency, labels

Example of advanced data selection:




```
rawTraces <- loadTraces('../palatals/', tiernameAll =
   c("cons","cons", "" ), categoriesAll = list(c("ɬ","n"),
   c( "lʲ", "nʲ" ), c("")), layersAll = c('tongue',
   'tongue', 'palate'), mergeCategories = TRUE)
polarTraces <- makeTracesPolar(rawTraces, scaling.factor =
   592/412, origin.algorithm = "BottomMean")
plotTraces(rawTraces, polarTraces, palette = c("purple",
   "orange", "black"), maskCategories = c("ɬ, n", "lʲ,
   nʲ", "palate"), pdf.filename = "RusPal_alllevels.pdf")
```

Future work

- Difference plots (difference between categories)

  Washington (2016), Washington & Washington (2018), Coretta (2020)
- Different annotation formats (data input)
- Additional plotting options:
  - algorithms used in SSANOVA and GAMs
  - panel/grid layout; legend font; different axis units
  - transducer origin directly from DICOM?
- Remove need for `makeTracesPolar()`
- Filtering data after loading (more efficient)

Conclusion

- Versatile tool
  - Lowers entry bar for ultrasound speech research
  - Useful tool for experienced researchers
- Usable in qualitative research
- Free/Open Source Software (GNU GPL v3)