

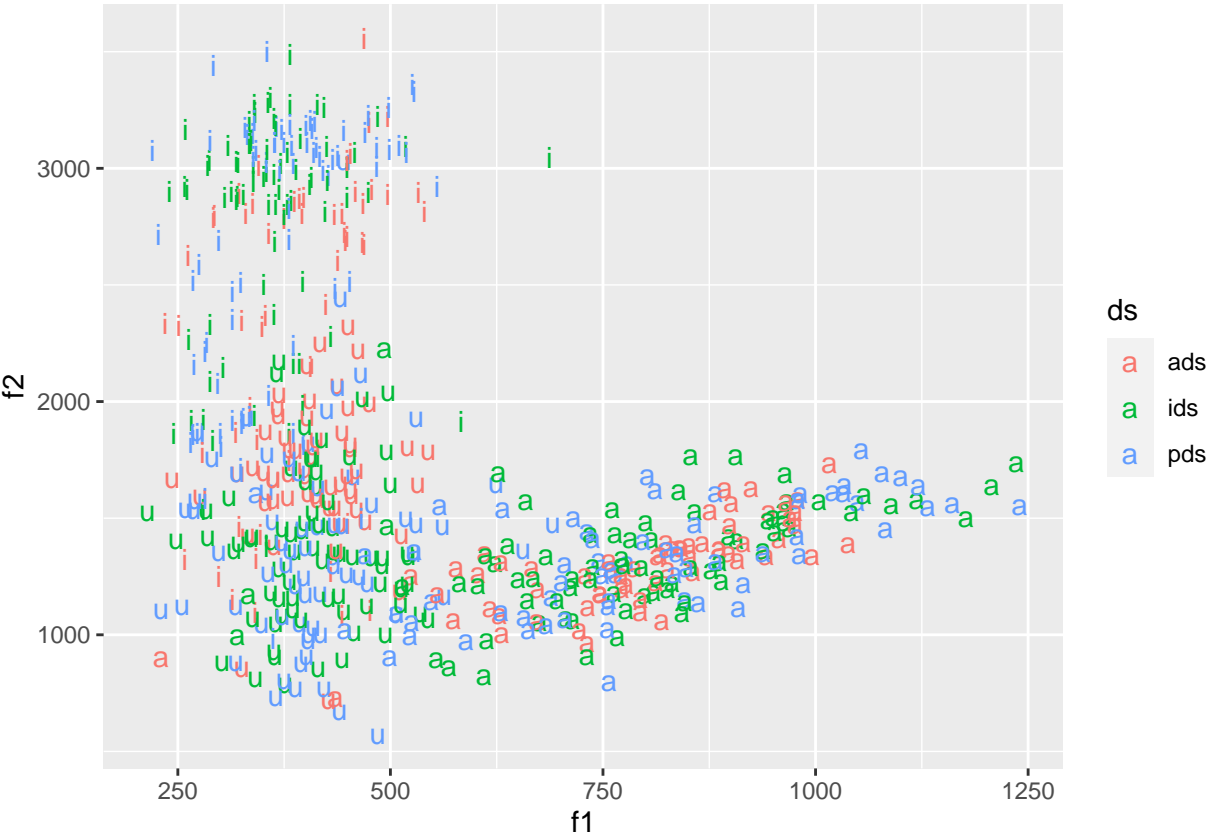
Supplementary materials: Hyperarticulation in Infant-Directed Speech as a Consequence of Vocal Emotion

Contents

Initial data cleaning	1
Additional information on main analyses	2
Duration and pitch analyses	3
F1 and F2 analyses	5
Variability analyses	8
Figure of the vowel space	11

Initial data cleaning

```
## [1] 614 11
Note there are no outliers:
## Warning: Removed 3 rows containing missing values (geom_text).
```



```
##
## ball bead boot box
```

```
## 105 209 201 99
## [1] 614 16
## `summarise()` has grouped output by 'motID', 'ds', 'v', 'stim_group'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'ds', 'v'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'motID', 'ds'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'ds'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'ds'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'ds'. You can override using the `.groups` argument.
## `summarise()` has grouped output by 'ds'. You can override using the `.groups` argument.
```

Next we calculate vowel space for each mom and register.

```
## # A tibble: 3 x 2
##   ds      vss
##   <chr>   <dbl>
## 1 ads    596848.
## 2 ids    886587.
## 3 pds    842918.
```

Additional information on main analyses

Paired contrasts in vowel space size.

```
##
## Paired t-test
##
## data: vs$vss[vs$ds == "pds"] and vs$vss[vs$ds == "ids"]
## t = -0.4956, df = 9, p-value = 0.6321
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -242997.1 155658.9
## sample estimates:
## mean of the differences
## -43669.08
##
## Cohen's d
##
## d estimate: 0.1559337 (negligible)
## 95 percent confidence interval:
## lower upper
## -0.7850539 1.0969214
##
## Paired t-test
##
## data: vs$vss[vs$ds == "ids"] and vs$vss[vs$ds == "ads"]
## t = 2.4351, df = 9, p-value = 0.03767
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## 20572.94 558905.61
## sample estimates:
## mean of the differences
## 289739.3
```

```
##
## Cohen's d
##
## d estimate: -1.121556 (large)
## 95 percent confidence interval:
##      lower      upper
## -2.1322879 -0.1108244

##
## Paired t-test
##
## data: vs$vss[vs$ds == "pds"] and vs$vss[vs$ds == "ads"]
## t = 1.9906, df = 9, p-value = 0.07773
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  -33574.0 525714.4
## sample estimates:
## mean of the differences
##          246070.2

##
## Cohen's d
##
## d estimate: -0.9882865 (large)
## 95 percent confidence interval:
##      lower      upper
## -1.983551077  0.006978064
```

Duration and pitch analyses

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Vowel.Duration ~ ds * target + (1 + ds | motID)
## Data: dat
##
## REML criterion at convergence: -1202.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.5120 -0.5243 -0.0814  0.3421  5.3534
##
## Random effects:
## Groups   Name                Variance Std.Dev. Corr
## motID    (Intercept)  0.0007915  0.02813
##          dsids        0.0049585  0.07042  0.71
##          dspds        0.0016792  0.04098  0.41 0.42
## Residual                0.0067777  0.08233
## Number of obs: 614, groups:  motID, 10
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)   0.195420   0.018230  32.341259  10.720 3.54e-12 ***
## dsids         0.071922   0.031004  23.340307   2.320  0.0294 *
## dspds         0.028832   0.025617  43.263609   1.126  0.2666
## targetbead    0.014766   0.019373 253.452590   0.762  0.4467
```

```

## targetboot      -0.025244   0.019137 254.312247  -1.319   0.1883
## targetbox       -0.007169   0.022381  84.997033  -0.320   0.7495
## dsids:targetbead 0.018547   0.025530 371.954675   0.726   0.4680
## dspds:targetbead 0.008486   0.026016 382.948878   0.326   0.7445
## dsids:targetboot -0.038286   0.025470 375.205621  -1.503   0.1336
## dspds:targetboot -0.012732   0.026305 366.612811  -0.484   0.6287
## dsids:targetbox  -0.014377   0.031213 160.492273  -0.461   0.6457
## dspds:targetbox   0.008059   0.032281 166.800408   0.250   0.8032
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids          -0.183
## dspds          -0.426  0.457
## targetbead     -0.714  0.405  0.494
## targetboot     -0.723  0.410  0.500  0.677
## targetbox      -0.658  0.365  0.448  0.616  0.624
## dsds:trgtbd    0.528 -0.567 -0.370 -0.746 -0.501 -0.449
## dspds:trgtbd   0.521 -0.300 -0.711 -0.735 -0.494 -0.445  0.552
## dsds:trgtbt    0.529 -0.571 -0.371 -0.496 -0.738 -0.449  0.675      0.365
## dspds:trgtbt   0.512 -0.296 -0.717 -0.480 -0.715 -0.435  0.360      0.686
## dsds:trgtbx    0.446 -0.525 -0.312 -0.418 -0.423 -0.681  0.605      0.308
## dspds:trgtbx   0.436 -0.250 -0.640 -0.409 -0.414 -0.666  0.304      0.603
##              dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt  0.532
## dsds:trgtbx   0.609      0.303
## dspds:trgtbx  0.305      0.613      0.467
##
## Warning: NAs introduced by coercion
##
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: Pitch ~ ds * target + (1 + ds | motID)
## Data: dat
##
## REML criterion at convergence: 6746.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.3545 -0.5564 -0.1364  0.4836  8.8010
##
## Random effects:
## Groups   Name            Variance Std.Dev. Corr
## motID    (Intercept)    348.8     18.68
##          dsids          3636.3    60.30  -0.59
##          dspds          1946.0    44.11  -0.44  0.98

```

```

## Residual          4369.5   66.10
## Number of obs: 606, groups:  motID, 10
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)   200.1587    14.7500   42.3778   13.570   <2e-16 ***
## dsids         27.1051    26.6546   24.2858    1.017   0.3192
## dspds         46.6849    22.5136   31.7025    2.074   0.0463 *
## targetbead    -2.0223    16.1501  298.5380   -0.125   0.9004
## targetboot    11.7437    15.9741  294.1606    0.735   0.4628
## targetbox     -3.3188    18.8580  117.0155   -0.176   0.8606
## dsids:targetbead 16.4764    21.4548  503.9741    0.768   0.4429
## dspds:targetbead  0.1623    21.0737  336.0349    0.008   0.9939
## dsids:targetboot 25.0384    21.4710  504.4648    1.166   0.2441
## dspds:targetboot 11.1454    21.1429  288.3700    0.527   0.5985
## dsids:targetbox  10.9551    26.8979  343.5838    0.407   0.6841
## dspds:targetbox -13.5956    25.4359  111.5193   -0.535   0.5941
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids         -0.660
## dspds         -0.630  0.768
## targetbead    -0.762  0.443  0.474
## targetboot    -0.772  0.449  0.479  0.701
## targetbox     -0.710  0.423  0.428  0.644  0.651
## dsds:trgtbd   0.595 -0.582 -0.395 -0.772 -0.546 -0.511
## dspds:trgtbd  0.562 -0.349 -0.651 -0.748 -0.517 -0.466  0.596
## dsds:trgtbt   0.597 -0.586 -0.397 -0.541 -0.765 -0.512  0.704      0.419
## dspds:trgtbt  0.554 -0.351 -0.653 -0.505 -0.730 -0.456  0.418      0.690
## dsds:trgtbx   0.536 -0.544 -0.371 -0.485 -0.491 -0.750  0.641      0.387
## dspds:trgtbx  0.485 -0.331 -0.573 -0.441 -0.445 -0.689  0.387      0.602
##              dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt  0.583
## dsds:trgtbx  0.645      0.390
## dspds:trgtbx  0.389      0.605      0.586

```

F1 and F2 analyses

```

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: f1 ~ ds * target + (1 + ds | motID)
## Data: dat
##
## REML criterion at convergence: 7352.5

```

```

##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -4.9580 -0.5054 -0.0140  0.5005  3.6533
##
## Random effects:
##      Groups   Name      Variance Std.Dev. Corr
##      motID    (Intercept) 1802     42.46
##              dsids       1336     36.55  -0.69
##              dspds       2056     45.35  -0.75  0.75
##      Residual          11086    105.29
## Number of obs: 611, groups:  motID, 10
##
## Fixed effects:
##              Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      716.49      25.49    40.48  28.106 < 2e-16 ***
## dsids             16.74      30.00    45.67   0.558  0.580
## dspds             38.90      32.50    49.79   1.197  0.237
## targetbead      -322.74      25.82   458.13 -12.498 < 2e-16 ***
## targetboot      -306.20      25.51   458.03 -12.005 < 2e-16 ***
## targetbox        146.59      31.04   264.54   4.723 3.78e-06 ***
## dsids:targetbead -38.79      33.04   424.12  -1.174  0.241
## dspds:targetbead -55.05      34.15   492.90  -1.612  0.108
## dsids:targetboot -12.69      32.94   417.43  -0.385  0.700
## dspds:targetboot -35.35      34.39   447.67  -1.028  0.305
## dsids:targetbox  -12.15      40.21   148.61  -0.302  0.763
## dspds:targetbox  -37.64      42.66   239.88  -0.882  0.378
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids          -0.731
## dspds          -0.736  0.602
## targetbead     -0.707  0.579  0.550
## targetboot     -0.716  0.586  0.557  0.701
## targetbox      -0.666  0.535  0.516  0.652  0.659
## dsds:trgtbd    0.538 -0.758 -0.428 -0.767 -0.534 -0.489
## dspds:trgtbd  0.532 -0.446 -0.749 -0.753 -0.528 -0.489  0.584
## dsds:trgtbt    0.539 -0.762 -0.429 -0.528 -0.759 -0.489  0.683  0.404
## dspds:trgtbt  0.527 -0.445 -0.753 -0.516 -0.738 -0.483  0.402  0.701
## dsds:trgtbx    0.486 -0.694 -0.395 -0.476 -0.482 -0.734  0.613  0.369
## dspds:trgtbx  0.479 -0.404 -0.679 -0.469 -0.474 -0.720  0.364  0.625
##              dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt  0.569
## dsds:trgtbx  0.616  0.369

```

```

## dspds:trgtbx  0.364      0.632      0.552
## boundary (singular) fit: see ?isSingular
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: f2 ~ ds * target + (1 + ds | motID)
##   Data: dat
##
## REML criterion at convergence: 8883.4
##
## Scaled residuals:
##   Min       1Q   Median       3Q      Max
## -4.3137 -0.4833  0.0961  0.6227  3.5400
##
## Random effects:
##   Groups   Name      Variance Std.Dev. Corr
##   motID    (Intercept) 20427    142.9
##           dsids        10077    100.4   -0.54
##           dspds        26244    162.0   -0.19  0.93
##   Residual          142792    377.9
## Number of obs: 611, groups: motID, 10
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)    1199.73     88.90   39.31  13.495 2.44e-16 ***
## dsids          129.80    101.08   56.79   1.284  0.20434
## dspds          13.88    115.78   53.82   0.120  0.90504
## targetbead     1193.16     91.71  398.32  13.011 < 2e-16 ***
## targetboot      513.56     90.58  398.38   5.670 2.75e-08 ***
## targetbox       212.06    109.18  193.36   1.942  0.05355 .
## dsids:targetbead 255.72    116.74  391.69   2.191  0.02907 *
## dspds:targetbead 312.39    121.74  468.83   2.566  0.01060 *
## dsids:targetboot -462.22    116.27  384.69  -3.975 8.40e-05 ***
## dspds:targetboot -341.26    122.74  433.69  -2.780  0.00567 **
## dsids:targetbox  -149.90    137.95  146.23  -1.087  0.27899
## dspds:targetbox   44.91    151.63  224.94   0.296  0.76735
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##              (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids          -0.708
## dspds          -0.603  0.641
## targetbead     -0.714  0.600  0.539
## targetboot     -0.723  0.607  0.546  0.696
## targetbox      -0.669  0.549  0.500  0.643  0.650
## dsds:trgtbd    0.542 -0.777 -0.434 -0.768 -0.529 -0.481
## dspds:trgtbd  0.531 -0.474 -0.746 -0.747 -0.518 -0.476  0.591
## dsds:trgtbt    0.544 -0.780 -0.437 -0.524 -0.761 -0.481  0.673      0.407
## dspds:trgtbt  0.525 -0.477 -0.750 -0.505 -0.730 -0.468  0.406      0.697
## dsds:trgtbx    0.494 -0.697 -0.420 -0.475 -0.481 -0.744  0.599      0.386
## dspds:trgtbx  0.469 -0.437 -0.675 -0.451 -0.456 -0.703  0.369      0.619
##              dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids

```

```
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt 0.578
## dsds:trgtbx 0.601 0.390
## dspds:trgtbx 0.371 0.627 0.588
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular
```

Variability analyses

We first get standard deviation of f1 and f2, separating by mom and register.

`summarise()` has grouped output by 'motID', 'ds'. You can override using the `.groups` argument.

We then fit separate regressions to each?

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: f1.sd ~ ds * target + (1 | motID)
## Data: sds
##
## REML criterion at convergence: 803.1
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.5964 -0.5157  0.0173  0.4615  3.2291
##
## Random effects:
##  Groups   Name                Variance Std.Dev.
## motID    (Intercept)         95.23    9.758
## Residual                    1211.56   34.807
## Number of obs: 90, groups: motID, 10
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)    112.08     17.95   77.95   6.245 2.07e-08 ***
## dsids          -10.49     24.61   69.22  -0.426 0.671215
## dspds           37.71     24.61   69.22   1.532 0.130086
## targetbead     -62.41     20.83   73.75  -2.997 0.003716 **
## targetboot     -69.92     20.83   73.75  -3.357 0.001247 **
## targetbox      -50.30     23.06   77.33  -2.181 0.032210 *
## dsids:targetbead  21.06     29.12   69.22   0.723 0.472112
## dspds:targetbead -15.93     29.12   69.22  -0.547 0.586190
## dsids:targetboot  19.44     29.12   69.22   0.667 0.506734
## dspds:targetboot -11.49     29.12   69.22  -0.394 0.694478
## dsids:targetbox  111.52     31.77   69.22   3.510 0.000794 ***
## dspds:targetbox   70.58     31.77   69.22   2.221 0.029616 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```



```

##          (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids      -0.686
## dspds      -0.686  0.500
## targetbead -0.836  0.591  0.591
## targetboot -0.836  0.591  0.591  0.721
## targetbox  -0.771  0.534  0.534  0.664  0.664
## dsds:trgtbd  0.580 -0.845 -0.423 -0.699 -0.499 -0.451
## dspds:trgtbd  0.580 -0.423 -0.845 -0.699 -0.499 -0.451  0.500
## dsds:trgtbt  0.580 -0.845 -0.423 -0.499 -0.699 -0.451  0.714      0.357
## dspds:trgtbt  0.580 -0.423 -0.845 -0.499 -0.699 -0.451  0.357      0.714
## dsds:trgtbx  0.531 -0.775 -0.387 -0.458 -0.458 -0.689  0.655      0.327
## dspds:trgtbx  0.531 -0.387 -0.775 -0.458 -0.458 -0.689  0.327      0.655
##          dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt  0.500
## dsds:trgtbx  0.655      0.327
## dspds:trgtbx  0.327      0.655      0.500

## boundary (singular) fit: see ?isSingular

## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: f2.sd ~ ds * target + (1 | motID)
## Data: sds
##
## REML criterion at convergence: 1019.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -2.7122 -0.5822 -0.0900  0.4701  3.3161
##
## Random effects:
## Groups Name Variance Std.Dev.
## motID (Intercept) 0 0.0
## Residual 20638 143.7
## Number of obs: 90, groups: motID, 10
##
## Fixed effects:
##              Estimate Std. Error    df t value Pr(>|t|)
## (Intercept)    121.25     71.83   78.00   1.688  0.09541 .
## dsids           80.26    101.58   78.00   0.790  0.43189
## dspds           42.89    101.58   78.00   0.422  0.67400
## targetbead     488.77     84.99   78.00   5.751 1.65e-07 ***
## targetboot      65.34     84.99   78.00   0.769  0.44435
## targetbox     -45.07     92.73   78.00  -0.486  0.62831
## dsids:targetbead -396.78    120.20   78.00  -3.301  0.00145 **
## dspds:targetbead -212.95    120.20   78.00  -1.772  0.08035 .
## dsids:targetboot -29.54    120.20   78.00  -0.246  0.80654

```

```

## dspds:targetboot    50.50    120.20    78.00    0.420    0.67553
## dsids:targetbox     31.85    131.14    78.00    0.243    0.80876
## dspds:targetbox     21.80    131.14    78.00    0.166    0.86843
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##          (Intr) dsids  dspds  trgtbd trgtbt trgtbx dsds:trgtbd dspds:trgtbd
## dsids          -0.707
## dspds          -0.707  0.500
## targetbead     -0.845  0.598  0.598
## targetboot     -0.845  0.598  0.598  0.714
## targetbox      -0.775  0.548  0.548  0.655  0.655
## dsds:trgtbd    0.598 -0.845 -0.423 -0.707 -0.505 -0.463
## dspds:trgtbd  0.598 -0.423 -0.845 -0.707 -0.505 -0.463  0.500
## dsds:trgtbt    0.598 -0.845 -0.423 -0.505 -0.707 -0.463  0.714      0.357
## dspds:trgtbt  0.598 -0.423 -0.845 -0.505 -0.707 -0.463  0.357      0.714
## dsds:trgtbx    0.548 -0.775 -0.387 -0.463 -0.463 -0.707  0.655      0.327
## dspds:trgtbx  0.548 -0.387 -0.775 -0.463 -0.463 -0.707  0.327      0.655
##          dsds:trgtbt dspds:trgtbt dsds:trgtbx
## dsids
## dspds
## targetbead
## targetboot
## targetbox
## dsds:trgtbd
## dspds:trgtbd
## dsds:trgtbt
## dspds:trgtbt  0.500
## dsds:trgtbx  0.655      0.327
## dspds:trgtbx  0.327      0.655      0.500
## optimizer (nloptwrap) convergence code: 0 (OK)
## boundary (singular) fit: see ?isSingular

```

Figure of the vowel space

